A TEXTBOOK OF

Agricultural Entomology

David V. Alford

Blackwell Science

A Textbook of Agricultural Entomology

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Preface

This book offers students of applied entomology and zoology an introduction to the insects and mites of agricultural or horticultural importance in the British Isles and in other parts of northwestern Europe.

In Part I, insects and mites are described in general terms, usually down to family level. The primary intention is to provide background information on the features of the main groups of pests and beneficial species (e.g. parasites, parasitoids and predators), largely using descriptive characters capable of appreciation without undue experience or the need for specialist equipment other than a hand lens or a low-power microscope.

In Part II, emphasis is placed on pests of field, glasshouse, orchard and plantation crops. Owing to limitations of space, cursory mention only is made of the vast range of pests found on ornamental plants and forest trees; however, pests of several minor crops that may on occasions require the attention of crop protectionists and practitioners are included, especially where published information on them is limited or not readily available. Within the various orders, individual families are treated in the same systematic sequence as described in Part I; however, within each family (for ease of reference) the various genera are considered alphabetically, without regard to their systematic hierarchy. Within genera, the main pest species are described and details provided of their biology, host range and economic importance; where appropriate, these entries are followed by additional entries or notes on other species. For clarity of presentation, synonyms for names of the pests are excluded from the text. However, frequently used alternative names (not all of which are strictly synonyms) are cross-referenced in the general index; this should enable readers to trace pests known to them, or cited in other literature, under different names. Names of authorities for species are given in full but abbreviated (as shown) for Fabricius (F.) and Linnaeus (L.). Within the text, plants are referred to under their common name if a crop or under their scientific name if a wild host; the scientific names of crops and the common names of wild plants are listed on pages 271 *et seq.* and 275 *et seq.*, respectively.

Details of pest control measures are deliberately excluded from the text, as these all too rapidly become outdated; also, general statements on pest control measures were not thought to be of great value in a book such as this. Readers requiring information on pest control or pest management should consult more specific (ideally, regularly revised) books, booklets or leaflets produced by agrochemical companies, extension services and other bodies - examples of publications dealing with pest control on UK crops include: the *Pest and Disease Management Handbook* (published by Blackwell Science and BCPC); and *The UK Pesticide Guide* (published annually by CAB International and BCPC). Matters such as pest population growth and development have also been excluded from the present book, as these were considered more appropriate for discussion within a publication dealing with the principles of pest management.

In compiling this account of crop pests, I am indebted to numerous friends and colleagues, either for their help in obtaining material or for their guidance on specific issues. Particular thanks are offered to my wife and to D.J. Carter, B.J. Emmett, A.W. Jackson, M.J. Lole, D. MacFarlane, Mrs H.M. Maher, Dr W. Powell, H. Riedel, Dr G. Rimpel, P.R. Seymour, S.J. Tones, R.A. Umpelby and J.E.B. Young. Most of the illustrations have been based on specimens in my own collection. Other invaluable sources of material included the insect collections formerly housed in the now disbanded ADAS Entomology Departments at Bristol, Cambridge and Starcross - regrettably, these reference collections (all of which included important material dating back to the 1920s and beyond) no longer exist. Finally, I am indebted to Professor T. Lewis CBE for his critical appraisal of the final manuscript and suggestions for its improvement.

David V. Alford
Cambridge
May 1999

PART I

The Main Groups of Insects and Mites

Insects

Insects form a major class of organisms within the phylum Arthropoda. All arthropods have segmented bodies, with a hard exoskeleton or body shell and jointed limbs, but insects (class Insecta) are typified by the presence of three pairs of true legs, usually two pairs of wings and a body divided into three distinct regions: head, thorax and abdomen **(Fig.** 1) (cf. Acari, p. 75).

EXTERNAL FEATURES

The often tube-like *body* of an insect is composed of a series of segments: six in the head, three in the thorax and up to 11 in the abdomen. Each segment is formed from up to four more or less horny plates called sclerites - a dorsal tergum, a ventral sternum and two lateral pleura (pleura are absent from the insect abdomen). These plates and the various adjacent body segments may be fused together rigidly or joined by soft, flexible membranes that allow for body movement. The body appendages, such as the legs, are formed as outgrowths from the pleura. Where fusion has occurred (particularly in the head) the segments, or their individual components, are not always distinguishable; in the thorax, the sclerites are themselves often subdivided into smaller plates.

The body of an insect is covered by a protective three-layered skin (cuticle) formed from chitin and protein. Depending upon its precise composition and thickness, the cuticle may be soft and flexible or hard and rigid; according to requirements, it may or may not be permeable or waterproof. Following its deposition, the cuticle becomes more or less hardened and darkened by the addition of melanin, during a process called sclerotization. Pre-adult (immature) insects usually moult from one growth stage to the next, sloughing off or bursting out of the 'old' cuticle and replacing it with a larger one; each moult is called an ecdysis. Except in certain very primitive forms, the cuticle of an adult insect is not replaceable. External features of the cuticle (e.g. details of punctation and sculpturing in adult beetles) are often characteristic of the species. Further, the insect body is often adorned with bristles, hairs, scales, setae or spines, and these cuticular outgrowths are also of considerable help in identifying groups or individual species. Immediately beneath the cuticle lies an almost continuous single layer of cells (the epidermis); it is the epidermis that secretes the cuticle. Some epidermal cells are differentiated into glands that may secrete compounds to the outside via ducts that end in characteristic cuticular pores. Glandular secretions include pheromones, silk, wax and other products.

The insect *head* is essentially a capsule which encloses the brain and bears the usually external (ectognathous) mouthparts, the eyes and a pair of sensory antennae. The mouthparts comprise five basic sections: an 'upper lip' (labrum), the

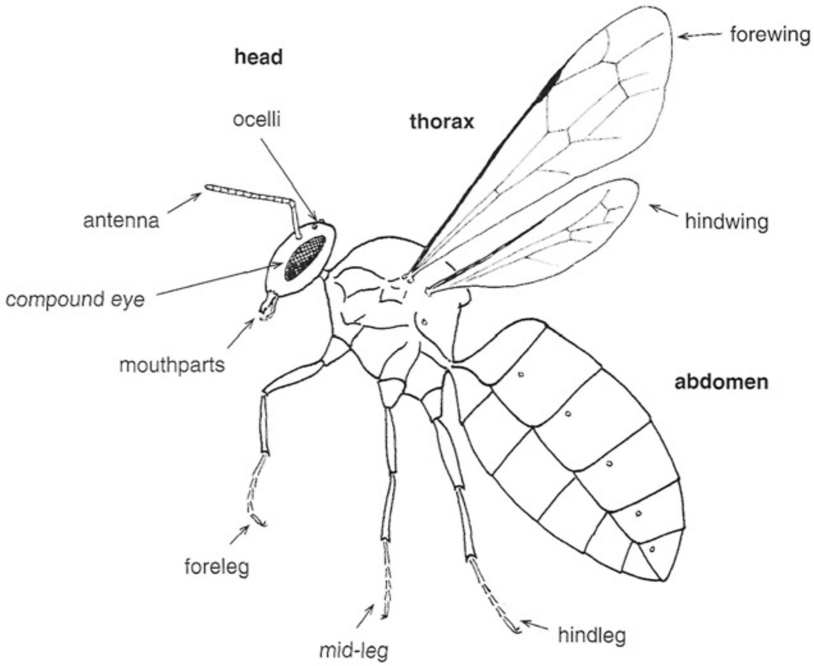


Fig. 1 General structure of an insect.

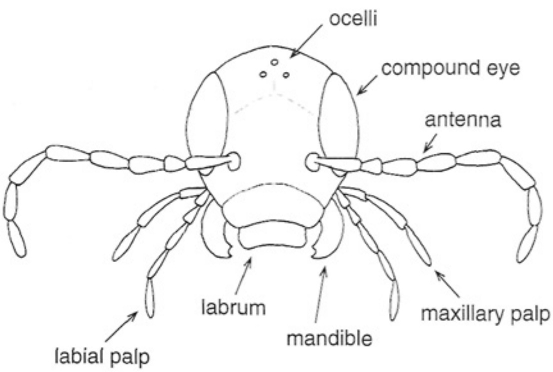


Fig. 2 Frontal view of the head of a generalized insect.

lower (ventral) surface of which forms the epipharynx; a tongue-like hypopharynx; the jaws (mandibles); the paired maxillae and a 'lower lip' (labium). The mouthparts may include up to two pairs of sensory, feeler-like palps (labial palps and maxillary palps) **(Fig.** 2). Various pairs of glands (labial glands, mandibular glands, maxillary glands and thoracic glands) are also associated with the mouthparts. The basic biting mouthparts of an insect may be modified considerably for piercing, lapping or sucking **(Fig.** 3). Piercing mouthparts, as in aphids and other Hemiptera, include a hollow, needle-like stylet (or stylet bundle), formed from the mandibles and the maxillae; the piercing stylet is partly guided by the labium, which forms a long, supportive rostrum (see **Fig.** 3a); some insects with such mouthparts inject toxic saliva into plants and can cause extensive galling. Many insects have a pair of large, multifaceted compound eyes. Insects may also possess simple eyes (ocelli) which, in adults, may occur as a set of three on the top of the head to form an ocellar triangle. Antennae are present in most adults and in many immature insects; they are, however, often inconspicuous in the latter. The antennae are often slender and feeler-like, but the individual components or subdivisions (the so-called 'segments' or antennomeres - the former term widely used as a term of convenience) are sometimes much elaborated; the number of antennal segments ranges from one to over a

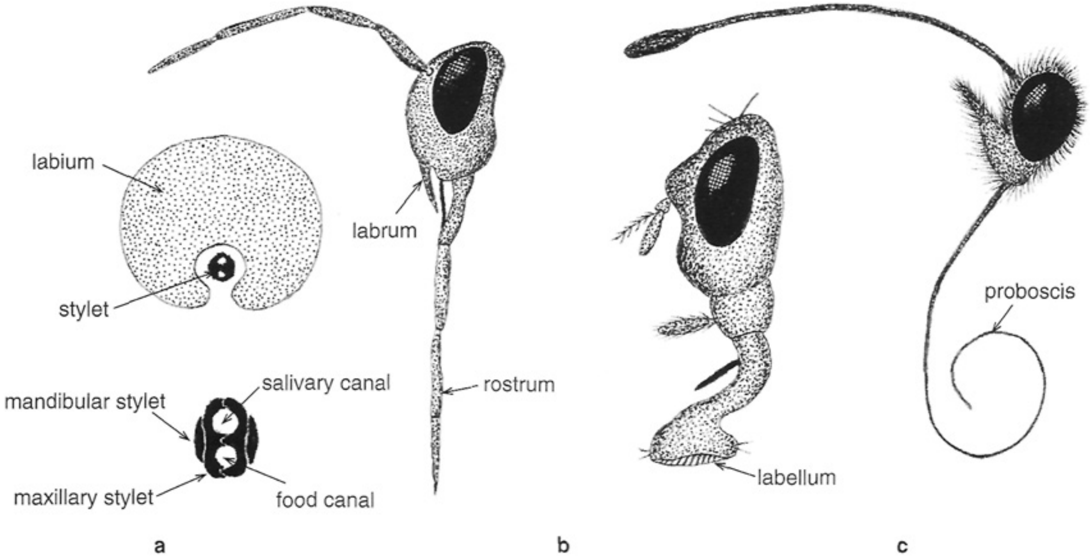


Fig. 3 Examples of insect mouthparts: (a) piercing mouthparts of an hemipterous bug. including transverse sections through the rostrum (above) and feeding stylet (= stylet bundle) (below): (b) lapping mouthparts of a house fly; (c) sucking mouthparts of a butterfly.

hundred. The basal segment (the scape) is often elongate and separated by an often distinct segment (called the pedicel) from the rest of the antenna, which forms the flagellum (the segments of which are called flagellomeres). Various types of antennae are recognizable (see. for example, **Fig.** 4).

The muscle-filled insect *thorax* is composed of three segments: prothorax. mesothorax and metathorax. The prothorax is often very large (as in cockroaches, crickets and many beetles) and the dorsal section (called the pronotum) may be shield-like and cover much or all of the head. In some insects (e.g. flies), the mesothorax forms the bulk of the thorax and the prothorax and metathorax are much reduced. In many insects, the hind part of one of the thoracic segments forms a distinct dorsal scutellum and, sometimes, a postscutellum (see Fig. 112).

Each thoracic segment bears a pair of jointed legs. Each leg has four main components: coxa, femur, tibia and tarsus; there is also a small segment, called the trochanter, lying between the coxa and femur **(Fig.** 5). In some insects (e.g. agromyzid flies), the basal part of the tibia may be distinctly coloured and is often called the 'knee". The tarsus is typically multisegmented and terminates in a small pad (the arolium), located between a pair of small tarsal claws. Although insect legs have the same basic structure, they are often considerably modified. The forelegs, for example, may be raptorial (modified for grasping) as in mantises. or fossorial (modified for digging) as in mole crickets; the hindlegs are often saltatory (modified for jumping), as in grasshoppers and flea beetles. Fine details of leg structure (e.g. in beetles, the number of tarsal segments) are often useful for distinguishing between groups of insects.

Adults of most insects also possess one or two pairs of *wings:* a pair of forewings arising from the mesothorax and a pair of hindwings arising from the metathorax. The base of the wings may be covered by scale-like lobes (the tegulae) or, as in certain flies, protected by membranous folds (the squamae). Wing-coupling arrangements for four-winged insects vary considerably. For example, in some instances (e.g. aphids and

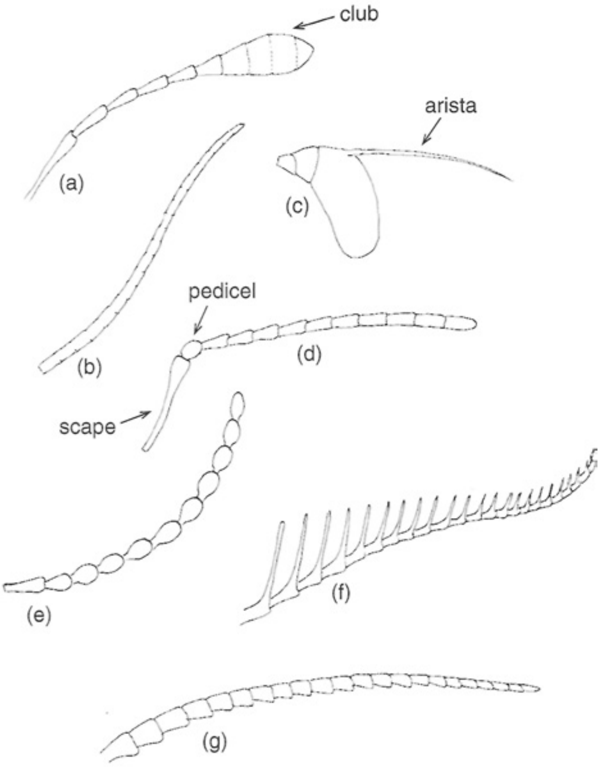


Fig. 4 Examples of insect antennae: (a) clavate; (b) filiform; (c) aristate; (d) geniculate; (e) moniliform; (f) pectinate; (g) serrate.

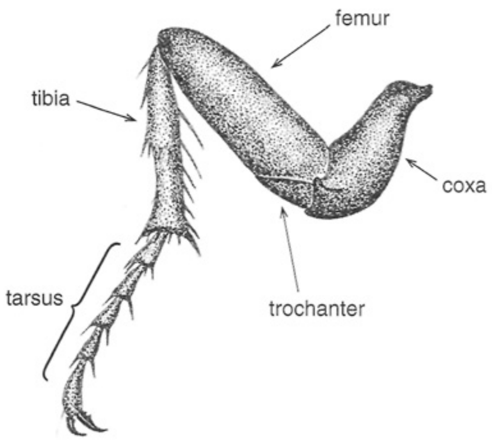


Fig. 5 Segmentation of the leg of an insect, based on the mid-leg of an adult chafer.

bees) a series of hooks (hamuli) on the leading edge (costal margin or costa) of the hindwing interlock with a fold in the trailing edge (dorsal margin or dorsum) of the forewing; in Lepidoptera, the wings may be held together in flight by a frenulum (a long bristle or long bristles arising from the hindwing which interlock with a retaining hook - the retinaculum - or a set of small bristles on the underside of the forewing) or by a jugum (a narrow lobe projecting from near the base of the forewing).

The basic arrangement of veins in the wing has undergone considerable modification in the various insect orders, and details of wing venation often form the basis for distinguishing between groups and, sometimes, individual species. The venation of a generalized wing is composed of six main elements: costa (C), sub-costa (Sc), radius (R), media (M), cubitus (Cu) and anal (A). Wings of some insects also include a pigmented patch (pterostigma), usually located near the apex. Some wing veins may be fused or absent, whereas others may be subdivided or distinctly forked. The radius, for example, often branches to produce a curved radial section (Rs) which may itself branch more than once before

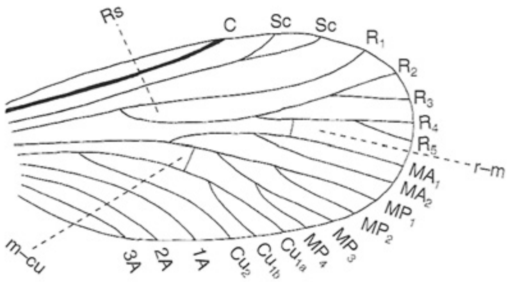


Fig. 6 Diagram to show the main veins of a generalized insect wing.

reaching the wing margin **(Fig.** 6). The costal vein and, usually, the anal veins, however, are unbranched. Cross-veins (e.g. m-cu, which links the media with the cubitus) may occur. Areas of the wing membrane delimited by veins are called cells; these may extend to the wing margin (open cells) or may be entirely surrounded by veins (closed cells). Wings have also undergone considerable structural modification. In beetles, cockroaches and earwigs, for example, the forewings are no longer used in flight but have become hardened, leathery flaps known as elytra (beetles and earwigs) or tegmina (cockroaches, etc.); these protect the membranous hindwings which are folded away beneath them when not in use. The forewings (hemelytra) of certain bugs (Heteroptera) are hardened but have a membranous tip. In true flies (Diptera). where only the forewings are used for flying, the hindwings have become reduced to small, drumstick-like balancing organs called halteres.

The many-segmented *abdomen* is formed from a series of up to 11 dorsal sclerites called tergites and ventral sclerites called sternites, joined by more or less flexible intersegmental membranes. The anterior and posterior segments are often fused or much reduced in size, particularly in adults. The eleventh abdominal segment, for example, is usually very small and inconspicuous; it is totally absent in the higher (most advanced) insects. Some primitive insects (Protura and Collembola) have fewer than ten abdominal segments; Collembola never possess more than six abdominal segments. Abdominal appendages occur on most segments of primitive insects (subclass Apterygota) but are restricted to the hind-most segments of members of the subclass Pterygota. Those of the eighth and ninth segment form the genitalia, including (when present) the female ovipositor and the male claspers. Microscopic features of male and female genitalia are often used by specialists to identify, or to distinguish between, species. Some adult and immature insects possess a pair of cerci, formed from appendages on the last abdominal segment. Cerci are particularly well developed in less-advanced insects (e.g. cockroaches, crickets, earwigs, mayflies) but are usually absent from members of more-advanced groups. Hump-like or sucker-like outgrowths from the ventral body wall of immature insects sometimes form so-called false legs (prolegs or pseudopods); otherwise, ambulatory abdominal appendages, which are commonplace in many arthropods, are wanting in insects.

INTERNAL FEATURES

The body cavity of an insect (haemocoel) extends throughout the head, thorax and abdomen and also reaches into the appendages. It is filled with a pale, often colourless, blood-like fluid called haemolymph. This bathes the internal organs and tissues, and is circulated by a tube-like heart which runs mid-dorsally from the head to the tip of the abdomen.

The *nervous system* consists of a brain, with close connections to the compound eyes, the antennae and the mouthparts, and a central nerve cord that extends back mid-dorsally through the thorax and abdomen. The nerve cord includes a series of swellings (ganglia) from which arise various lateral nerves. The brain occupies much of the head and is the main co-ordinating centre of the body; the ganglia, however, control many activities (such as movement of the appendages) independent of the brain.

The *alimentary tract* is, essentially, a long, often much modified, tube stretching from the mouth to the anus. There are three main sections: foregut, mid-gut and hindgut, located mainly within the abdomen. The foregut includes a crop within which recently ingested food accumulates. Digestion and absorption of nutriment occurs within the mid-gut, whereas the hindgut is concerned with the absorption of water and the storage of waste material prior to defaecation. The insect gut includes a large number of long, whitish, blind-ending tubules (Malpighian tubules), which arise from between the mid- and the hindgut; these tubules collect waste material from the body fluids and pass them into the gut. The haemocoel also contains an often large organ, known as the fat body, which forms whitish, yellowish or brownish groups or layers of cells. The fat body is concentrated mainly in the abdomen and serves various functions, including the synthesis and storage of fat, glycogen (= carbohydrate) and protein.

The *respiratory system* includes a series of small branching tubes (tracheae) and microscopic tubules (tracheoles), which maintain contact with the internal body organs and tissues. The tracheal system may either be open or closed. The former opens to the outside through a series of valve-like pores (spiracles), which occur along either side of the insect; the spiracles are sometimes located on characteristic respiratory processes. Various types of respiratory system are recognizable, including:

- **amphipneustic** - spiracles present on the prothoracic and anal segments only (typical of many dipterous larvae);
- **apneustic** - spiracles absent, i.e. tracheal system closed (typical of aquatic insects which breathe through gills);
- **holopneustic** - spiracles present on the mesothorax, metathorax and abdominal segments 1-8 (typical of most adult insects and many nymphs and larvae);
- **metapneustic** - spiracles present only on the anal segment (typical of certain dipterous larvae, including leatherjackets, mosquito larvae and syrphid larvae);
- **propneustic** - spiracles present only on the prothoracic segment (as in mosquito pupae).

Some insects are devoid of both spiracles and a tracheal system (e.g. Collembola and larvae of certain endoparasitoids); these forms are termed atracheate.

In females, the *reproductive system* is composed of a pair of ovaries, each subdivided into numerous egg-forming tubules called ovarioles. Other features include a pair of colleterial glands (often called cement glands) and a sac-like spermatheca in which, after mating, sperm is stored. The ovaries unite to form a central oviduct that opens to the outside through a genital pore on the ninth abdominal segment. Eggs are usually deposited through an ovipositor but in some insects the tip of the female abdomen is constricted into a tube-like oviscapt and an ovipositor is wanting. In some insects (e.g. bees and wasps), the ovipositor has lost its egg-laying function and, instead, serves as a sting. Male insects possess two testes, each of which opens via a long duct (vas deferens) into a seminal vesicle in which sperm is stored. The seminal vesicles (vesicula seminalis), along with a pair of accessory glands, open into a single ejaculatory duct which extends to a gonopore located on the eighth abdominal segment.

DEVELOPMENT AND GROWTH

Insects usually develop to adulthood through an egg and several pre-adult feeding stages (instars), either as nymphs or as larvae. Viviparous insects, however, give rise directly to live nymphs or larvae and omit an egg stage.

Many insects reproduce sexually; in others, males may be extremely rare or are unknown and reproduction without a sexual phase (i.e. parthenogenesis) is normal. Members of some groups (e.g. many aphids) reproduce parthenogenetically and viviparously throughout the spring and summer but, after a sexual phase, lay eggs (the overwintering stage) prior to the onset of winter. Parthenogenetic reproduction in which only female offspring are produced is termed thelytokous parthenogenesis (thelytoky) - as found in aphids, certain Diptera and a few Coleoptera; parthenogenetic reproduction in which unfertilized eggs give rise only to males is termed arrhenotokous parthenogenesis (arrhenotoky) - as found in some scale insects, whiteflies and various Hymenoptera; parthenogenetic reproduction in which both sexes arise from unfertilized eggs is termed amphitokous parthenogenesis (amphitoky) - as found in a few Thysanoptera. Thysanoptera also exhibit arrhenotoky and thelytoky. In a few insects, notably certain gall midges, the adult and pupal stage is omitted from the life-cycle and larvae give rise parthenogenetically to further larvae; this process is termed larval paedogenesis. Pupal paedogenesis occurs where (again, as in certain gall midges) embryos arise within a 'pupa', which differs from a 'normal' pupa and is termed a hemi-pupa (see p. 173).

In the less advanced (hemimetabolous) insects, development through the pre-adult (nymphal) stages to adulthood is gradual and usually involves only partial or incomplete metamorphosis, without a pupal stage (Fig. 7). In the more advanced (holometabolous) insects, metamor-

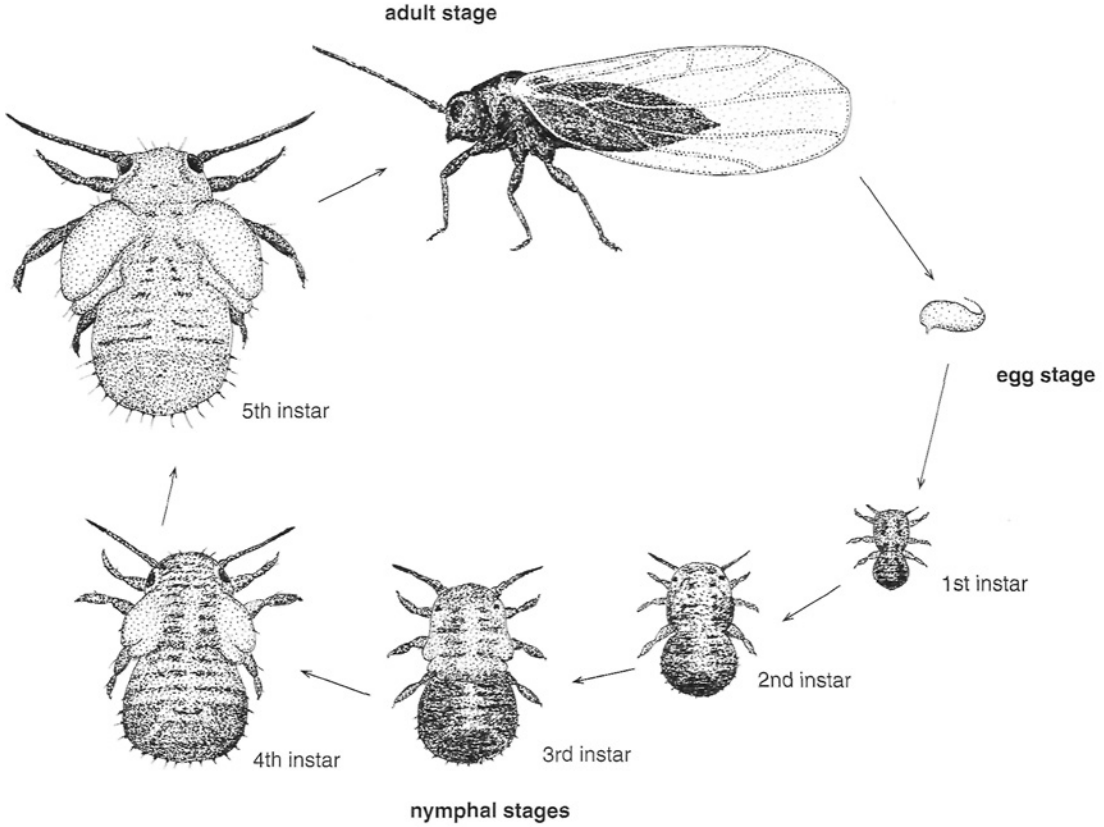


Fig. 7 Life-cycle of a hemimetabolous insect, based on a psyllid - family Psyllidae (not to scale).

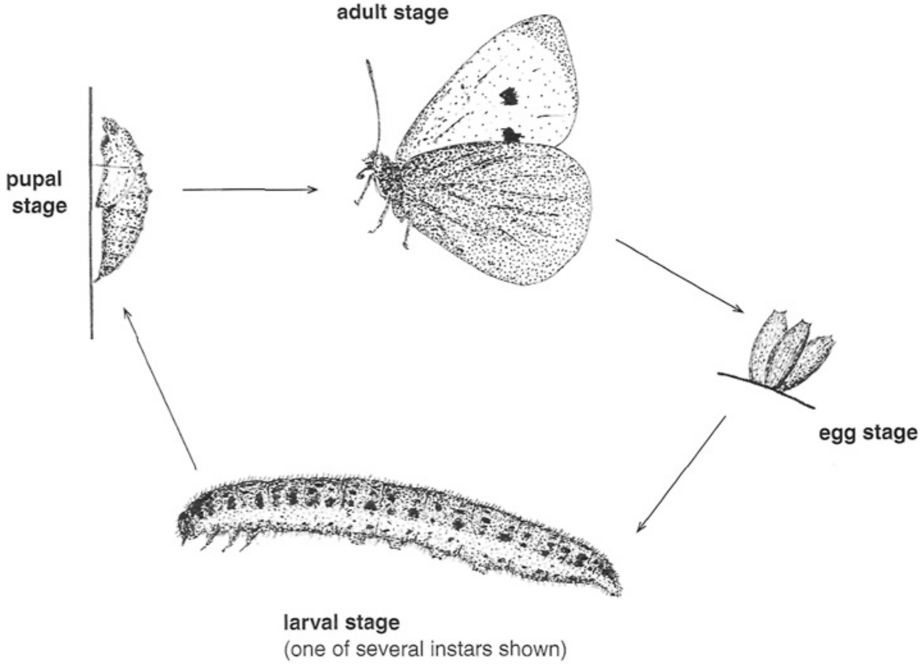


Fig. 8 Life-cycle of a holometabolous insect, based on a butterfly - family Pieridae (not to scale).

phosis from the final larval instar to the adult occurs during a quiescent, non-feeding pupal stage **(Fig.** 8). In some groups, final-instar larvae enter a non-feeding prepupal phase, often overwintering as such and finally pupating in the spring.

Insect eggs vary considerably in appearance. For example, they may be spherical, oval, hemispherical, cigar-shaped, flask-shaped or sausage-shaped; they are sometimes flattened, fried-egg-like structures (e.g. Lepidoptera: Tortricidae). The outer, protective, waterproof shell (chorion) may be smooth or distinctly patterned (often reticulated or ribbed), and a distinct pore (micropyle) is sometimes visible. Eggs of phytophagous insects are often laid on host plants (or inserted within plant tissue) and are frequently cryptically coloured; they may be deposited singly or in small or large groups, and are sometimes protected by secretions, scales or body hairs from the egg-laying female. In some insects (e.g. cockroaches) the eggs are laid in protective sclerotized cases called oothecae.

When ready to hatch, the young insect usually bites or bursts its way out of the egg, sometimes with the aid of shell-bursting cuticular spines; first-instar larvae of some insects (e.g. certain hymenopterous endoparasitoids) have a distinct caudal process which functions as an egg-tooth. In some instances (e.g. as in the honey bee) the chorion may be dissolved away. Eggs of certain insects (e.g. Hemiptera: Miridae) have a distinct operculum **(Fig.** 9) which, at egg hatch, opens to allow the first-instar nymph to escape.

The hard external skeleton of an insect prevents steady growth. Instead, pre-adult insects develop through several moults (usually from four to ten), when the 'old' outer skeleton (i.e. the cuticle) is replaced by an initially flexible one, during a process known as ecdysis. The stages between ecdyses are known as instars.

Insect nymphs are usually structurally similar in appearance to the adult but lack wings. Second-instar (and or later-instar) nymphs of winged insects typically possess distinct external

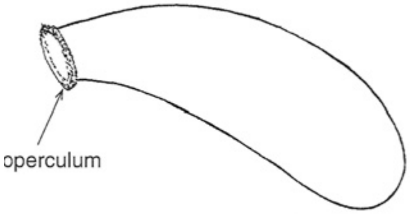


Fig. 9 Example of an insect egg, order Hemiptera: family Miridae.

wing pads (= wing buds), which increase proportionately in size at each moult until the fully winged adult (imago) stage is reached (see Fig. 7).

Insect larvae are typically of quite different appearance from adults and, unlike nymphs, they lack compound eyes; larvae may, however, have one or more simple eyes (often called 'ocelli' but more strictly known as stemmata) on either side of the head. At each moult, the head capsule is replaced by a larger one, and reference to the width of the head capsule is often of value in distinguishing between instars as this (unlike body length) remains constant throughout the duration of any particular instar (see **Fig.** 10). In many insects, the appearance of some or all of the instars may be very different; nevertheless, specific descriptions tend to be based upon the most frequently and usually most readily observed, final-instar stage.

Insect larvae vary considerably in body form but may be divided generally into four main types **(Fig. 11):**

- **apodous** - legless, often maggot-like larvae;
- **campodeiform** - elongate, dorsoventrally flattened larvae with well-developed antennae and thoracic legs;
- **eruciform** - often caterpillar-like larvae with a more-or-less cylindrical body, well-developed thoracic legs and hump-like (or more obvious) false legs (prolegs or pseudopods) on the abdomen; such larvae sometimes have a sucker-like pseudopod on the hind-most abdominal segment (as in some chrysomelid beetle larvae);

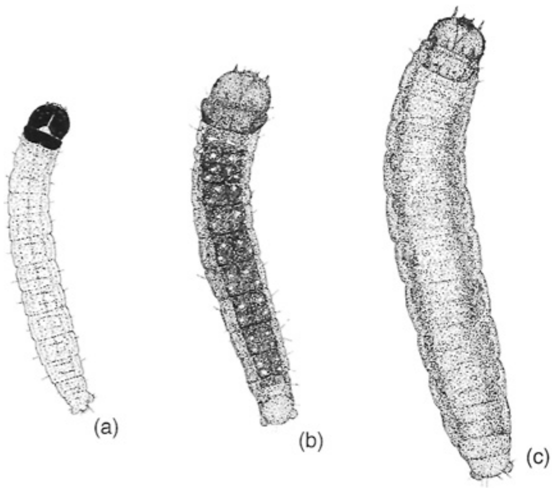


Fig. 10 Relationship between the size of the body and the width of the head capsule during the later stages of growth of an insect larva - *Acleris comariana,* family Tortricidae: (a) penultimate instar; (b) newly moulted final instar; (c) fully grown final instar.

- **scarabaeiform** - larvae with a thick, fleshy (often C-shaped) body, well-developed head and thoracic legs but no abdominal prolegs.

The body hairs or setae of nymphs and larvae may arise from distinctive plates, pinacula, and tubercles or from wart-like verrucae. Details of these features are often useful for distinguishing between species, as are external features of the respiratory openings (spiracles) and, when present, the respiratory processes which bear the spiracles.

Insect pupae are of two main types **(Fig.** 12): exarate - some or all appendages (e.g. antennae, legs, mouthparts, wing buds) free, i.e. not fastened to the body; obtect - appendages fastened to the body.

The pupae of many Diptera develop within a sclerotized, barrel-like puparium **(Fig.** 13). The latter is formed from, and maintains features (such as characteristic respiratory processes) of, the cast-off skin of the final-instar larva. The pupae of many Lepidoptera often bear a distinctive cremaster (a series of hooks or spines, often borne on a distinctive cremastal

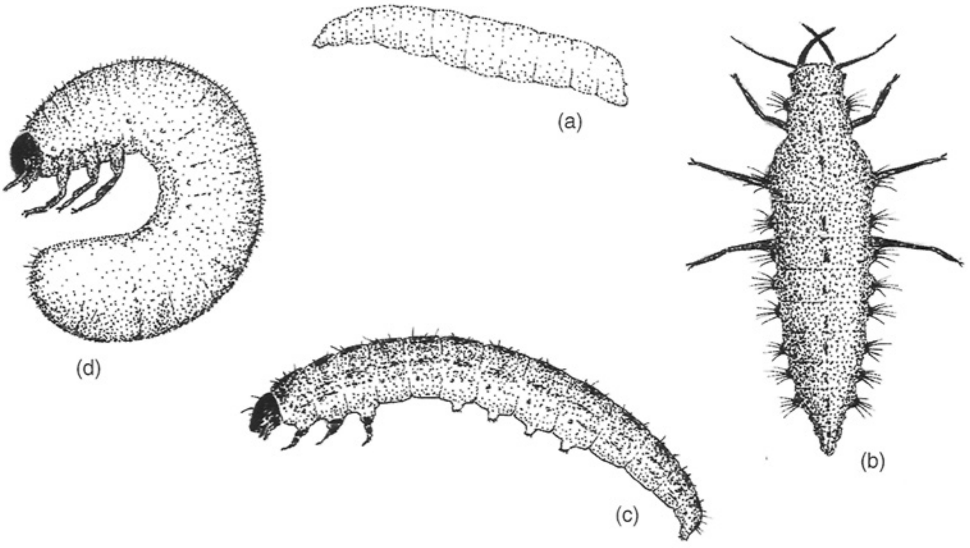


Fig. 11 Types insect larvae: (a) apodous. e.g. fly maggot; (b) campodeiform, e.g. lacewing larva; (c) eruciform, e.g. moth caterpillar; (d) scarabaeiform, e.g. chafer grub.

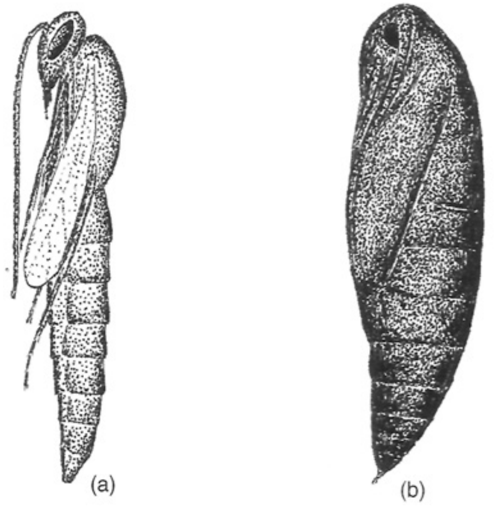


Fig. 12 Types of insect pupae: (a) exarate; (b) obtect.

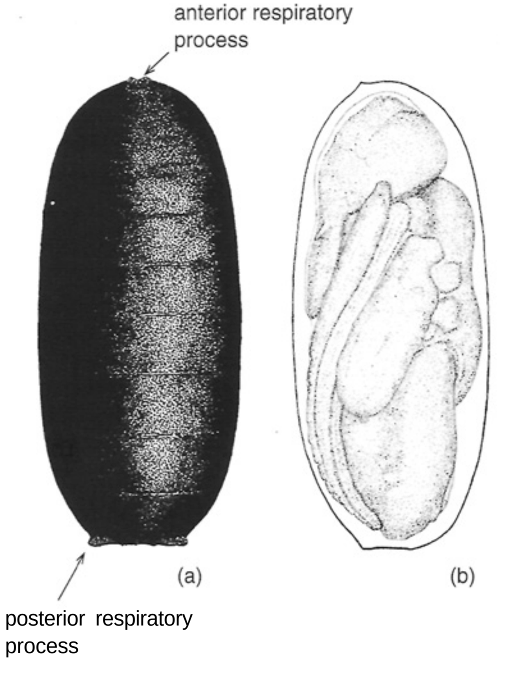


Fig. 13 (a) Puparium of an anthomyiid fly; (b) cross-section to show pupa within.

outgrowth) at the tip of the abdomen. Features of the cremaster, which serves to attach the pupa to a silken pad or to strands of silk, can be helpful for distinguishing between species (see Fig. 283).

CLASSIFICATION OF THE CLASS INSECTA

Various classifications have **been** proposed for insects and no one system has received universal acceptance. Some authorities, for example, employ the term Hexapoda, which they apply to the Diplura, Protura and CoUembola; the term Insecta is then limited to the so-called 'true insects', from which the Hexapoda are excluded because of certain primitive relationships and features - members of these groups, for example, all have endognathous mouthparts. **Table 1** shows a simplified, convenient classification to include all insect orders. Features of the main groups of insects of agricultural or horticultural significance in northern Europe are summarized below.

Table 1 Classification of the class Insecta.

Subclass APTERYGOTA (primitive, wingless insects)	
Order Thysanura	Bristletails. silverfish
Order Diplura	Diplurans
Order Protura	Proturans
Order CoUembola	Springtails (p. 14 *et seq.:* p. 87 *et seq.)*
Subclass PTERYGOTA (more advanced, usually winged, insects)	
Division *EXOPTERYGOTA* (hemimetabolous insects in which wings develop externally during several nymphal stages)	
Order Ephemeroptera	Mayflies
Order Odonata	Damselflies. dragonfiies
Order Plecoptera	Stoneflies
Order Grylloblattodea	Grylloblattodeans or rock crawlers - *absent from Europe*
Order Saltatoria	Crickets, grasshoppers, locusts (p. 15 *et seq.)*
Order Phasmida	Stick-insects, leaf-insects
Order Dermaptera	Earwigs (p. 16 *et seq:.* p. 89 *et seq.)*
Order Embioptera	Embiopterans or webspinners - *no British species and very few in continental Europe*
Order Dictyoptera	Cockroaches, mantids (p. 17 *et seq.)*
Order Isoptera	Termites or 'white ants' - *no British species*
Order Zoraptera	Zorapterans - *minute insects of uncertain relationship; absent from Europe*
Order Psocoptera	Psocids or booklice (p. 17 *et seq.)*
Order Phthiraptera	Lice (p. 18 *et seq.)*
Order Hemiptera	True bugs (p. 19 *et seq:.* p. 96 *et seq.)*
Order Thysanoptera	Thrips (p. 29 *et seq:.* p. 89 *et seq.)*
Division ENDOPTERYGOTA (holometabolous insects in which wings develop internally and complete metamorphosis from larva to adult occurs during a quiescent, non-feeding, pupal stage)	
Order Neuroptera	Alder flies, ant-lions, lacewings, snake flies (p. 30 *et seq.)*
Order Coleoptera	Beetles (p. 33 *et seq:.* p. 126 *et seq.)*
Order Strepsiptera	Stylopids
Order Mecoptera	Scorpion flies
Order Siphonaptera	Fleas
Order Diptera	True flies (p. 42 *et seq.;* p. 163 *et seq.)*
Order Lepidoptera	Butterflies, moths (p. 52 *et seq.;* p. 202 *et seq.)*
Order Trichoptera	Caddis flies (p. 65 *et seq:* p. 94 *et seq.)*
Order Hymenoptera	Ants, bees, sawflies, wasps, etc. (p. 66 *et seq.;* p. 245 *et seq.)*

ORDER COLLEMBOLA (SPRINGTAILS)

Small, soft-bodied, wingless insects with mouthparts endognathous and adapted primarily for biting; antennae usually 4-segmented; compound eyes absent; legs 4-segmented; abdomen 6-segmented, bearing a sucker-like ventral tube (collophore) on the first segment and usually a forked saltatory appendage (furcula) on the fourth (see **Figs 14 and 15),** with its retaining hook (retinaculum) on the third; no cerci, no Malpighian tubules and, usually, no tracheae. Metamorphosis slight; immature stages similar in appearance to adult, but smaller, with a constant number of segments throughout their development.

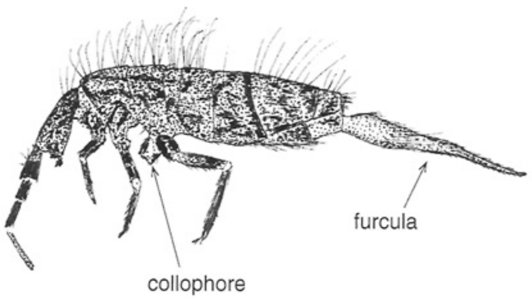


Fig. 14 A springtail - superfamily Entomobryoidea (xl5).

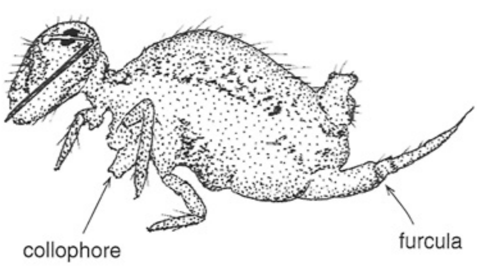


Fig. 15 A springtail, *Sminthurus viridis* - superfamily Symphypleona (x20).

Suborder ARTHROPLEONA

Body more or less elongate, the thoracic and abdominal segments usually distinctly separated: head usually prognathous.

Superfamily ENTOMOBRYOIDEA

Pronotum very small, often invisible from above (Fig. 14); body often hairy and mottled with brown. Abundant insects in leaf litter, and assisting in its breakdown; no species are of pest status.

Superfamily PODUROIDEA

Pronotum well developed, setose and clearly visible from above; cuticle usually granular or tuberculate.

1. **Family HYPOGASTRURIDAE** (p. 87)

Springtails with biting mouthparts; head obliquely prognathous; pseudocelli absent.

EXAMPLE: *Hypogastrura* spp. (gunpowder-mites).

2. **Family ONYCHIURIDAE** (p. 87 *et seq.)*

Soil-inhabiting springtails with biting mouthparts; ocelli absent but antennae with complex sensory organs and pseudocelli present on the thoracic and abdominal tergites; no saltatory appendage. Onychiurids feed mainly on the roots of plants but some species are predators of nematodes.

EXAMPLE: *Onychiurus* spp. (white blind springtails).

Suborder SYMPHYPLEONA

Body more or less globular, the thoracic and first four abdominal segments fused together (Fig. 15); head hypognathous, with mouthparts directed ventrally.

3. Family SMINTHURIDAE (p. 88 *et seq.)*

Antennae long, never shorter than head, and typically geniculate between the third and fourth segments; ocelli present.

EXAMPLES: *Bourletiella hortensis* (garden springtail); *Sminthurus viridis* (lucerne-flea).

ORDER SALTATORIA (CRICKETS, GRASSHOPPERS, ETC.)

Medium-sized to large, stout-bodied insects; head large, and usually hypognathous, with chewing mouthparts; compound eyes large; pronotum large and saddle-like; usually two pairs of wings, the forewings typically thickened (leathery) and called tegmina; either or both pairs of wings may be reduced (= brachypterous) or absent (= apterous); tarsi usually 3- or 4-segmented; hindlegs usually much enlarged and adapted for jumping; cerci 1-segmented. Metamorphosis incomplete; development includes egg and nymphal stages.

Suborder ENSIFERA (crickets)

Antennae many-segmented, often longer than body; tarsi 3- or 4-segmented; ovipositor, if present, usually elongate.

Superfamily GRYLLOIDEA

Tarsi 3-segmented; ovipositor usually needle-like; cerci long; males stridulate by rubbing the forewings together.

1. Family GRYLLOTALPIDAE (mole crickets)

Robust-bodied, with forelegs greatly enlarged and modified for digging (**Fig.** 16); antennae shorter than body; eyes reduced; ovipositor vestigial.

EXAMPLE: *Gryllotalpa gryllotalpa* (mole cricket).

2. Family GRYLLIDAE (true crickets)

Relatively broad-bodied, with a tympanal organ located on each front femur; antennae longer than body; forewings relatively short and held mainly horizontally when in repose.

EXAMPLE: *Acheta domesticus* (house cricket).

Superfamily TETTIGONIOIDEA (bush-crickets)

Tarsi 4-segmented; wings often reduced; cerci short, those of males curved upwards; ovipositor broad and robust (**Fig.** 17); males stridulate by rubbing the forewings together; tympanal organs, when present, located on the fore tibiae. Mainly tropical and of little or no economic importance in northern Europe.

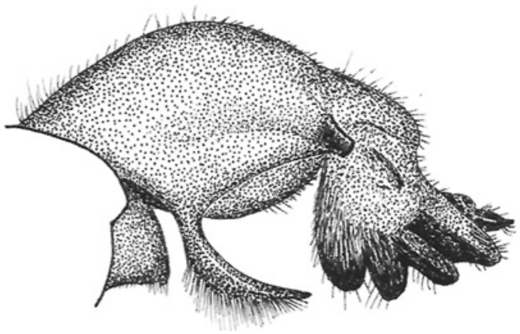


Fig. 16 Foreleg of a mole cricket - family Gryllotalpidae.

3. Family TETTIGONIIDAE

EXAMPLE: *Leptophyes punctatissima* (spotted bush-cricket).

Suborder CAELIFERA (grasshoppers and locusts)

Antennae shorter than body and with fewer than 30 segments; ovipositor, if present, short and robust.

Superfamily ACRIDOIDEA

Tarsi usually 3-segmented; ovipositor present.

4. Family ACRIDIDAE

The largest family, encompassing locusts and short-horned grasshoppers; antennae short and stout; pronotum with a median ridge; tympanal organs located in the sides of the abdomen; individuals stridulate by rubbing the hindlegs against the forewings. Although of significance as crop pests in many warmer parts of the world (the devastation caused by locusts being legendary), no species are of economic importance in northern Europe.

ORDER DERMA] ERA (EARWIGS)

Elongate, omnivorous insects with mouthparts prognathous, adapted for biting and chewing; forewings modified into very short, leathery elytra; hindwings semi-circular and membranous, with a radial venation; legs short, tarsi 3-segmented; anal cerci usually modified into a pair of forceps-like pincers (**Fig.** 18); ovipositor reduced or absent. Metamorphosis incomplete; development includes egg and nymphal stages, the latter being similar in appearance to adults but smaller and less strongly sclerotized.

Suborder FORFICULINA

Earwigs with well-developed eyes.

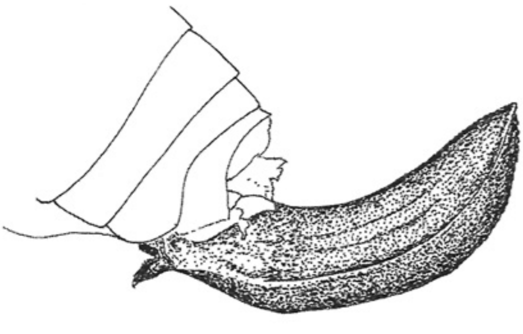


Fig. 17 Ovipositor of a bush-cricket - family Tettigoniidae.

1. Family FORFICULIDAE (p. 89)

Second tarsal segment expanded (heart-shaped) - cylindrical in the other European families: Labiduridae and Labiidae.

EXAMPLE: *Forficula auricularia* (common earwig).

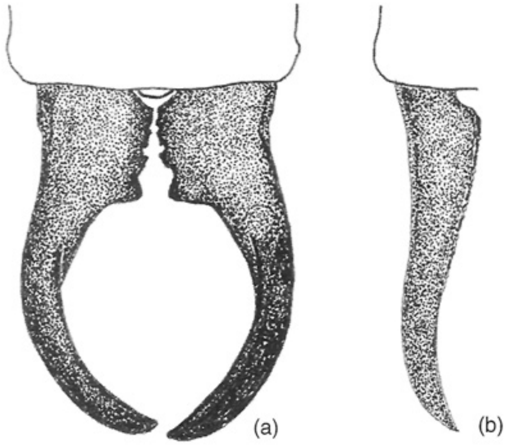


Fig. 18 Anal cerci of an earwig: (a) female; (b) male - left cercus.

ORDER DICTYOPTERA (COCKROACHES AND MANTIDS)

Small to large, stout-bodied but rather flattened insects with a large pronotum and two pairs of wings, the thickened (leathery) forewings called tegmina; hindwings large and folded longitudinally (fan-like), and hidden beneath the tegmina when in repose; chewing (mandibulate) mouthparts; antennae very long and thread-like (filiform); legs robust and spinose, the front pair sometimes raptorial (suborder Mantodea = mantids); tarsi usually 3- or 4-segmented; cerci usually many segmented. Metamorphosis incomplete; development includes egg and nymphal stages, the former laid in a capsule-like ootheca.

Suborder BLATTODEA (cockroaches)

Head hypognathous and more or less covered by the broad, shield-like pronotum; coxae large and abutting; forelegs not raptorial.

1. Family BLATTIDAE

Middle and hind femora armed with numerous strong spines that form a similar arrangement on both the anterior and posterior ventral margins.

EXAMPLES: *Blatta orientalis* (common cockroach), *Periplaneta americana* (American cockroach).

2. Family BLATTELLIDAE

Mainly small-bodied species (but some exceptionally large); middle and hind femora armed with numerous strong spines which form a similar arrangement on both the anterior and posterior ventral margins.

EXAMPLE: *Blattella germanica* (German cockroach).

3. Family BLABERIDAE

Mainly large-bodied species, with a variable arrangement of femoral spines; viviparous or ovoviviparous.

EXAMPLE: *Pycnoscelus surinamensis* (Surinam cockroach).

ORDER PSOCOPTERA (PSOCIDS)

Minute or small, soft-bodied insects with long, filiform antennae; wings, when present, membranous with relatively few cross-veins and often with a pigmented pterostigma (**Fig.** 19); wings held in a sloping roof-like posture when in repose; head relatively large, often with protruding compound eyes; ocelli present or absent: tarsi 2- or 3-segmented; cerci absent; body and appendages sometimes clothed in scales. Metamorphosis incomplete; nymphs similar in appearance to adults but smaller.

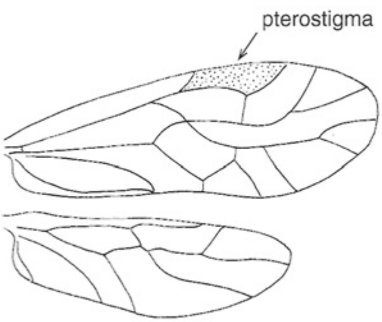


Fig. 19 Wing venation of an alate psocid - order Psocoptera.

Suborder TROCTOMORPHA

Antennae 11- to 17-segmented, the flagellum annulated; tarsi 3-segmented.

1. Family LIPOSCELIDAE

Flattened dorsoventrally, minute, oval-bodied and usually apterous; hind femora broad.

EXAMPLE: *Liposcelis bostrychophilus* (stored product psocid).

ORDER PHTHIRAPTERA (LICE)

Minute or small, flat-bodied, apterous ectoparasites of warm-blooded vertebrates, especially birds; head large and broad; eyes reduced or absent, ocelli absent; mouthparts mandibulate, large and prominent; antennae 3- to 5-segmented; thorax with a distinct pro thorax; legs stout, tarsi 1- or 2-segmented, with one or two claws; cerci absent. Metamorphosis slight.

Suborder MALLOPHAGA (biting and chewing lice)

Superfamily AMBLYCERA

Antennae short, 4- or 5-segmented (the third segment pedunculate), each concealed in a groove at the side of the head; maxillary palps 2- to 5-segmented; labial palps 1-segmented or absent.

1. Family MENOPONIDAE

Antennae 4- or 5-segmented; maxillary palps 4-segmented; labial palps present. Associated with birds, including poultry.

EXAMPLES: *Menacanthus* spp. (lesser chicken body lice), *Menopon gallinae* (chicken shaft louse).

Superfamily ISCHNOCERA

Antennae 3- to 5-segmented, relatively long (the third segment filiform) and not concealed; maxillary palps absent; labial palps present.

2. Family PHILOPTERIDAE

Legs with two tarsal claws. Associated with birds, including poultry.

EXAMPLES: *Chelopistes meleagridis* (large turkey louse), *Cuclotogaster heterographus* (chicken head louse), *Goniodes gigas* (large chicken louse).

3. Family TRICHODECTIDAE

Legs with just one tarsal claw; body of female cylindrical; body of male short and broad. Associated with mammals.

EXAMPLES: *Bovicola bovis* (cattle biting louse), *Werneckiella equi* (horse biting louse).

Suborder ANOPLURA (sucking lice)

Minute or small, apterous ectoparasites of mammals; body flattened dorsoventrally; head conical and relatively narrow; antennae filiform, 3- to 5-segmented; eyes reduced and sometimes absent; mouthparts beak-like, adapted for piercing skin and sucking blood, and retractable into head when not in use; thoracic segments fused, with no obvious prothorax; legs robust; tarsi 1-segmented, each with a large claw. Metamorphosis slight.

4. Family HAEMATOPINIDAE (wrinkled sucking lice)

Surface of abdomen distinctly wrinkled; paratergal plates present.

EXAMPLES: *Haematopinus eurysternus* (short-nose cattle louse), *Haematopinus suis* (pig louse).

5. Family LINOGNATHIDAE (smooth sucking lice)

Abdomen membranous, without paratergal plates.

EXAMPLES: *Linognathus ovillus* (sheep sucking louse), *Solenopotes capillatus* (blue cattle louse).

ORDER HEMIPTERA (TRUE BUGS)[1]

Minute to large insects, usually with two pairs of wings and piercing, suctorial, needle-like mouthparts; forewings frequently partly or entirely hardened (leathery). Metamorphosis usually gradual and incomplete.

Suborder HETEROPTERA

Adults usually with two pairs of wings; forewings (hemelytra) with a leathery basal area and a membranous tip, the former often divided into a clavus, corium, cuneus and embolium (Fig. 20); hindwings membranous; forewings, when in repose, overlapping and held flat over the body; head porrect; rostrum (= beak) arising from front of head and flexibly attached; body usually flattened dorsoventrally; pronotum large; tarsi usually 3-segmented. Eggs usually rounded or flask-shaped, and often with a distinct operculum (see Fig. 9). Includes phytophagous and predacious species.

Series CRYPTOCERATA

Truly aquatic bugs, with antennae concealed in depressions under the head. Includes backswimmers (family Notonectidae), water boatmen (family Corixidae) and water scorpions (family Nepidae), but no members of agricultural significance.

Series GYMNOCERATA

Bugs with conspicuous, freely moveable antennae. Includes a wide range of phytophagous and blood-sucking species, many of considerable economic importance.

Series GYMNOCERATA - AMPHIBICORISAE

Entirely predatory bugs, adapted to life on the surface of water; body with a ventral coating of water-repellent hairs. Includes pond skaters (family Gerridae) and various other families, but no members of agricultural significance.

Series GYMNOCERATA - GEOCORISAE (terrestrial bugs)

Predatory and phytophagous bugs, adapted to a variety of terrestrial habitats; body without a

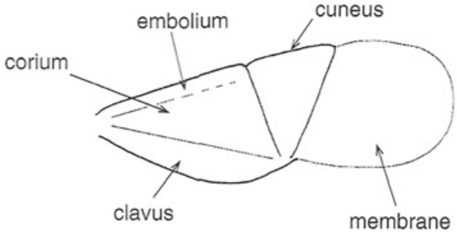


Fig. 20 Generalized structure of the forewing (hemelytron) of a bug - suborder Heteroptera.

[1] The suborders HETEROPTERA and HOMOPTERA are often regarded as orders and the term Hemiptera abandoned.

ventral coating of water-repellent hairs. Includes many pests and predators of agricultural significance.

Superfamily PENTATOMOIDEA (shield bugs)

Medium-sized to large insects, with lateral margins of head concealing the antennal bases; antennae usually 5-segmented; ocelli usually present; rostrum 4-segmented; scutellum large (often huge), U-shaped or triangular; tarsi 2- or 3-segmented; pulvilli present. Includes both phytophagous and predacious species.

1. Family ACANTHOSOMATIDAE

Shield bugs with 2-segmented tarsi.

EXAMPLE: *Acanthosoma haemorrhoidale* (hawthorn shield bug).

2. Family PENTATOMIDAE (shield bugs)

Tarsi 3-segmented and usually without strong spines; scutellum usually not reaching to tip of abdomen.

EXAMPLES: *Nezara viridula* (green stink bug), *Pentatoma rufipes* (forest bug).

Superfamily COREOIDEA

3. Family LYGAEIDAE (ground bugs)

Small, phytophagous, mainly brownish bugs, although sometimes marked with bright red; ocelli present; rostrum 4-segmented; scutellum triangular; forewings without a cuneus, the membrane with several long veins (**Fig.** 21).

EXAMPLE: *Gastrodes abietum* (spruce bug).

4. Family PIESMATIDAE (p. 96)

Small, flattened, elongate-oval insects, with ocelli present in macropterous forms; median part of head distinctly bifid anteriorly (**Fig.** 22): rostrum 4-segmented; pronotum and corium of forewing reticulate; membrane of forewing distinct and with several more or less parallel veins (**Fig.** 23); scutellum exposed (i.e. not covered by the pronotum); tarsi 2-segmented; pulvilli present. Entirely phytophagous and associated mainly with Chenopodiaceae (beet, etc.).

EXAMPLE: *Piesma quadratum* (beet leaf bug).

Superfamily TINGOIDEA

5. Family TINGIDAE (lace bugs)

Flattened, phytophagous bugs without ocelli, the pronotum and wings with a reticulate, lace-like pattern (**Fig.** 24); membrane of forewing indistinct; scutellum usually completely covered by the pronotum; tarsi 2-segmented; body often

Fig. 22 Head of a leaf bug - family Piesmatidae.

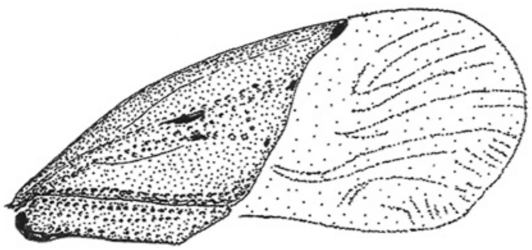


Fig. 21 Forewing (hemelytron) of a ground bug - family Lygaeidae.

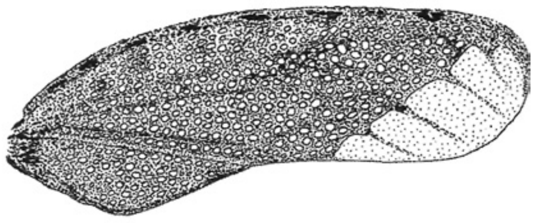


Fig. 23 Forewing (hemelytron) of a leaf bug - family Piesmatidae.

ornamented either with spines or distinctive fiat outgrowths.

EXAMPLES: *Corythucha ciliata* (sycamore lace bug), *Stephanitis rhododendri* (rhododendron bug).

Superfamily CIMICOIDEA

6. Family NABIDAE (damsel bugs)

Slender-bodied, relatively long-legged, predatory bugs, with a curved, 4-segmented rostrum; antennae thin, 4- or 5-segmented; ocelli present; forewings without a cuneus; forelegs more or less raptorial; tarsi 3-segmented.

EXAMPLES: *Aptus mirmicoides* (ant damsel bug), *Himacerus apterus* (tree damsel bug).

7. Family ANTHOCORIDAE

Small, elongate-oval, flattened, predatory bugs; rostrum straight, 3-segmented and held against body when in repose; ocelli present; forewings with both a cuneus and an embolium (**Fig.** 25); tarsi 3-segmented.

EXAMPLES: *Anthocoris nemorum* (common flower bug), *Orius vicinus* (raspberry bug).

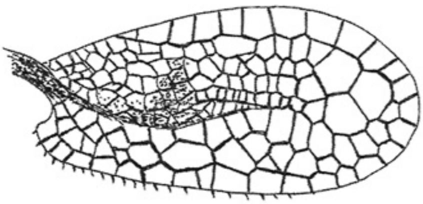


Fig. 24 Forewing (hemelytron) of a lace bug - family Tingidae.

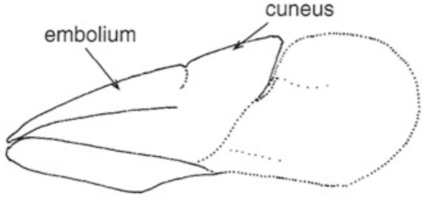


Fig. 25 Forewing (hemelytron) of a predatory bug - family Anthocoridae (genus *Orius).*

8. Family MICROPHYSIDAE

Similar to anthocorids but rostrum 4-segmented and tarsi 2-segmented; females usually brachypterous; abdomen swollen (**Fig.** 26); ocelli absent.

EXAMPLE: *Loricula elegantula.*

9. Family MIRIDAE (capsid bugs)

(p. 96 *et seq.)*

A very large group of small to medium-sized, usually delicate, soft-bodied, very active bugs; ocelli absent; rostrum 4-segmented; cuneus usually present and embolium indistinct (**Fig.** 27); tarsi usually 3-segmented. Includes phytophagous and predatory species.

EXAMPLES: Mirinae - *Lygus rugulipennis* (tarnished plant bug), *Lygocoris pabulinus* (common green capsid); Orthotylinae - *Blepharidopterus angulatus* (black-kneed capsid); Phylinae - *Psallus ambiguus* (red apple capsid).

Suborder HOMOPTERA

Adults with forewings either hardened (leathery) or membranous throughout; hindwings membranous; wings, when in repose, usually held over the body in a sloping, roof-like posture;

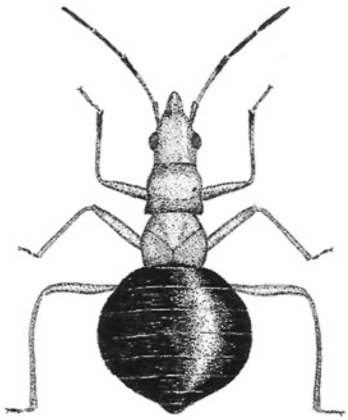


Fig. 26 A predatory bug, *Loricula elegantula* - family Microphysidae (x25).

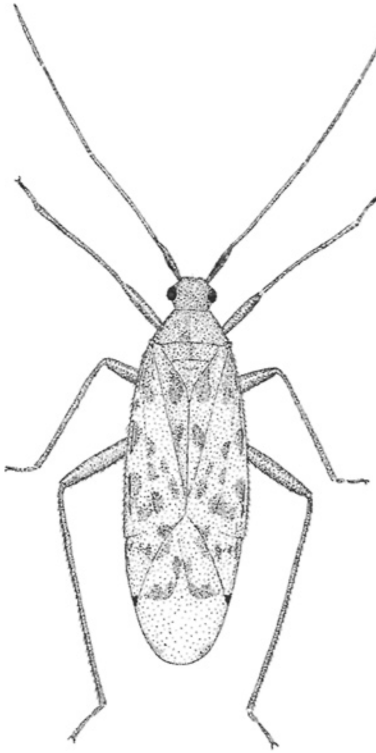


Fig. 27 A capsid (mirid) bug, *Malacocoris chlorizans* - family Miridae (xlO).

Fig. 28 Antenna of a leafhopper - family Cicadellidae.

pronotum usually small; rostrum (beak) arising from posterior part of head. Eggs usually sausage-shaped, and often white, yellowish or black. All members are phytophagous.

Series AUCHENORRHYNCHA

Antennae very short, but with a terminal arista **(Fig.** 28); rostrum clearly arising from the head; tarsi 3-segmented.

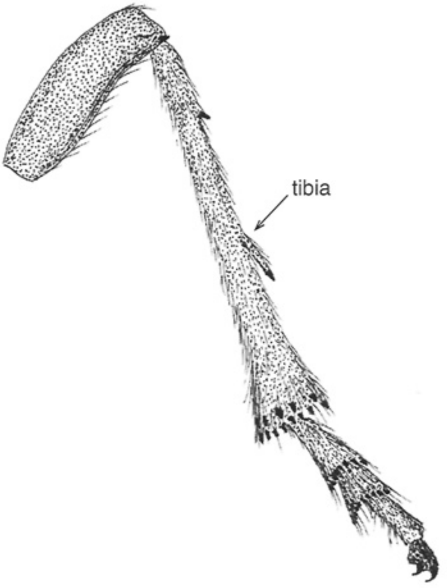


Fig. 29 Hindleg of a froghopper - family Cercopidae.

Superfamily CICADOMORPHA

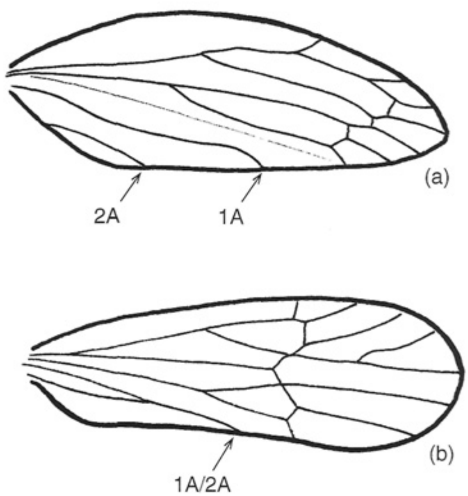
Antennae arise from between the pair of compound eyes.

10. Family CERCOPIDAE (froghoppers)

(p. 98 *et seq.)*

Small to medium-sized, very active bugs with the hindlegs adapted for jumping; ocelli (two) present in adults; adults of some species are superficially frog-like; hind tibiae cylindrical and bearing just a few stout spines **(Fig.** 29) (cf. family Cicadellidae); veins 1A and 2A of forewings separate throughout their length **(Fig. 30a)** (cf. family Delphacidae). Nymphs develop within a protective mass of froth (often called 'cuckoo-spit'), a secretion produced from the anus and through which air bubbles are forced from a special canal by abdominal contractions.

EXAMPLES: Aphrophorinae - *Philaenus spumarius* (common froghopper); Cercopinae - *Cercopis vulnerata* (red & black froghopper).



1A/2A

Fig. 30 Forewings: (a) of a froghopper - family Cercopidae; (b) of a leafhopper - family Delphacidae.

11. Family CICADELLIDAE (leafhoppers)
(p. 99 *etseq.)*

Small insects, with hindlegs of the very active adults adapted for jumping; ocelli (two) present or absent; hind tibiae angular and bearing one or more rows of spines **(Fig.** 31) (cf. family Cercopidae); veins 1A and 2A of forewings separate (see Fig. 30a) (cf. family Delphacidae); female ovipositor adapted for lacerating plant tissue into which eggs are laid. Nymphs active and free-living.

EXAMPLES: Aphrodinae - *Aphrodes bicinctus* (strawberry leafhopper); Evacanthinae - *Evacanthus interruptus* (hop leafhopper); Typhlocybinae - *Eupteryx melissae* (chrysanthemum leafhopper).

Superfamily FULGOROMORPHA

Antennae arise from below the compound eyes.

12. Family DELPHACIDAE (planthoppers)
(p. 101)

Leafhoppers characterized by the large, moveable apical spur on each hind tibia **(Fig.** 32); veins 1A and 2A of forewings Y-shaped, being united distally **(Fig. 30b).**

EXAMPLE: *Javesella pellucida* (cereal leafhopper).

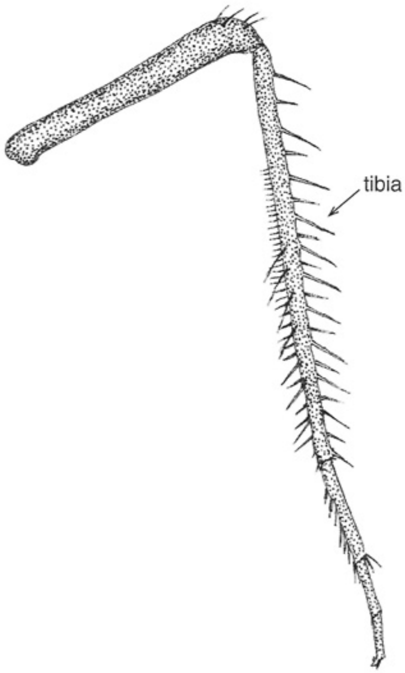


Fig. 31 Hindleg of a leafhopper - family Cicadellidae.

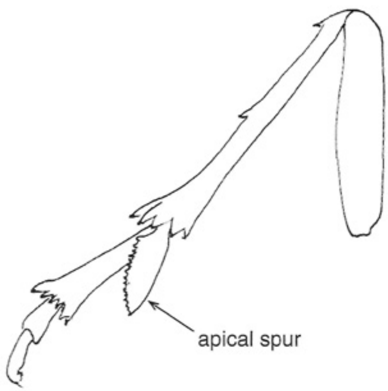


Fig. 32 Hindleg of a leafhopper - family Delphacidae.

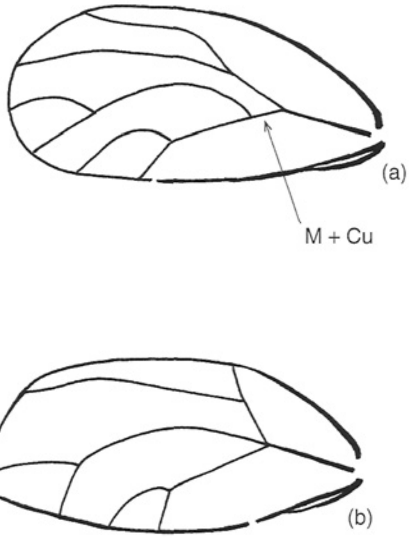


Fig. 33 Outline and venation of forewing of a psyllid: (a) family Psyllidae; (b) family Triozidae.

Series STERNORRHYNCHA (= PHYTOPHTHIRES)

Antennae long and thread-like, without a distinct arista (but apical segment often with a narrow terminal process); rostrum appearing to arise from between the forelegs; tarsi 1- or 2-segmented. Includes several groups of agricultural or horticultural significance.

Superfamily PSYLLOIDEA (jumping plant-lice)

Very active, cicada-like bugs with the hindlegs strongly developed and adapted for jumping; front of head often with a pair of forwardly projecting genal cones; antennae 10-segmented; hindwings small, thinner and more membranous than forewings.

13. Family PSYLLIDAE (psyllids)

(p. 101 *et seq.)*

Adult forewings rounded apically, vein M + Cu present **(Fig. 33a).** Nymphs relatively broad-bodied; wing pads rounded **(Fig. 34).**

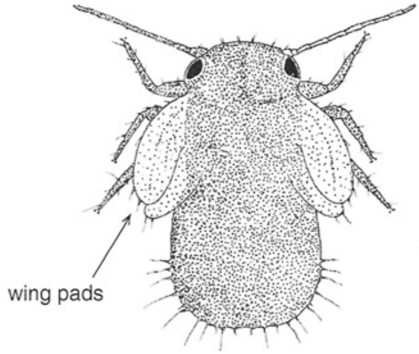


Fig. 34 Nymph of a psyllid, *Psylla* sp. - family Psyllidae (x25).

EXAMPLES: *Psylla mail* (apple sucker), *Psyllopsis fraxini* (ash leaf gall sucker).

14. Family TRIOZIDAE (p. 103)

Adult forewings angular apically, vein M + Cu absent **(Fig. 33b).** Nymphs relatively narrow-bodied; wing pads angular.

EXAMPLE: *Trioza apicalis* (carrot sucker).

Superfamily ALEYRODOIDEA (whiteflies)

15. Family ALEYRODIDAE (whiteflies)

(p. 103 *et seq.)*

Small, moth-like insects more or less coated with an opaque, white, waxy powder; antennae 7-segmented; wings soft, rounded and with a reduced venation **(Fig.** 35); tarsi 2-segmented. Nymphs fiat and scale-like. Development includes a quiescent, scale-like, non-feeding pseudo-pupal stage. The insects, especially nymphs, excrete vast quantities of honeydew.

EXAMPLE: *Aleyrodes proletella* (cabbage whitefiy).

Superfamily APHIDOIDEA (aphids)

Insects with often complex life histories, the various groups most readily distinguished by features of the 1- to 6-segmented antennae, the siphunculi and the cauda **(Fig.** 36); tarsi 2-

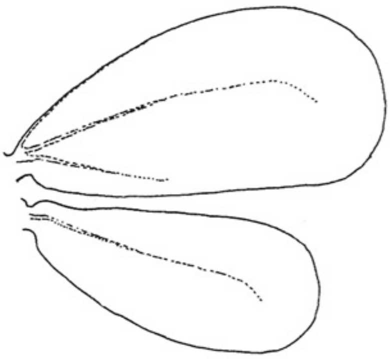


Fig. 35 Wing venation of a whitefly - family Aleyrodidae.

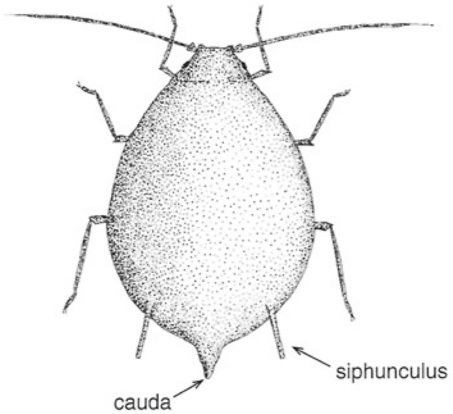


Fig. 36 General structure of an apterous aphid - superfamily Aphidoidea.

segmented, each with a pair of claws; wings, when present, membranous.

16. Family LACHNIDAE

Aphids with the terminal process of the antennae very short (Fig. 37a); siphunculi usually short, very hairy cones; cauda broadly rounded; Rs vein of forewing present (see Fig. 39), Cu_1 and Cu_2 veins usually noticeably divergent.

EXAMPLES: *Cinara pilicornis* (brown spruce aphid), *Maculolachnus submacula* (rose

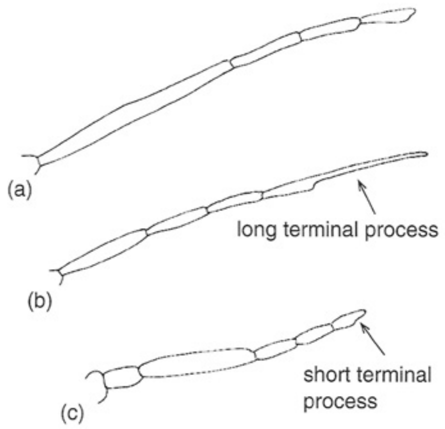


Fig. 37 Antennae of aphids: (a) family Lachnidae; (b) Chaitophoridae; (c) Pemphigidae.

root aphid), *Tuberolachnus salignus* (large willow aphid).

17. Family CHAITOPHORIDAE

Aphids with the body and legs bearing long hairs; terminal process of antennae very long (Fig. **37b);** siphunculi pore-like or stumpy; cauda knob-like or rounded; Rs vein of forewing present.

EXAMPLES: *Chaitophorus beuthani* (osier leaf aphid), *Periphyllus californiensis* (Californian maple aphid).

18. Family DREPANOSIPHIDAE

Aphids with the terminal process of the antennae of variable length; siphunculi usually stumpy or broadly conical but sometimes pore-like or long and swollen; cauda knob-like or rounded; subanal plate prominent, often divided into two lobes **(Fig.** 38); Rs vein of forewing present.

EXAMPLES: *Eucallipterus tiliae* (lime leaf aphid), *Phyllaphis fagi* (beech aphid).

19. Family APHIDIDAE (aphids)
(p. 104 *et seq.)*

Aphids with the terminal process of the antennae of variable length; compound eyes multi-

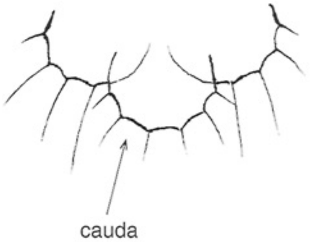


Fig. 38 Cauda and bilobed subanal plate - family Drepanosiphidae.

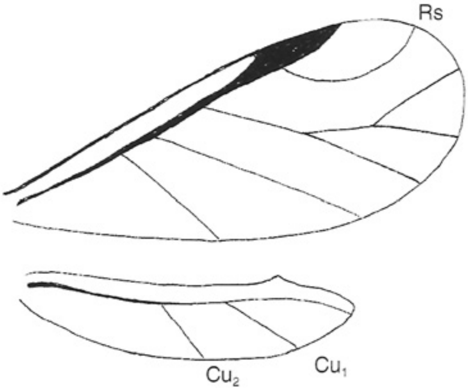


Fig. 39 Venation of an alate aphid - family Aphididae.

faceted; siphunculi varying from short to very long cylinders, sometimes noticeably tapered or swollen and often flanged apically; cauda broadly tongue-shaped to finger-shaped; Rs vein of forewing present, forewings and hindwings with Cu_t and Cu_2 and origins of these veins well separated **(Fig.** 39). Many species show an alternation of generations, having a primary (winter) host upon which asexual and sexual reproduction occurs and eggs are laid, and a secondary (summer) host upon which development is entirely asexual, parthenogenetic and viviparous. Migration between these alternate hosts is usually achieved following the production of winged forms. Aphids are commonly known as 'blackflies' or 'greenflies'.

EXAMPLES: *Aphis fabae* (black bean aphid), *Brevicoryne brassicae* (cabbage aphid),

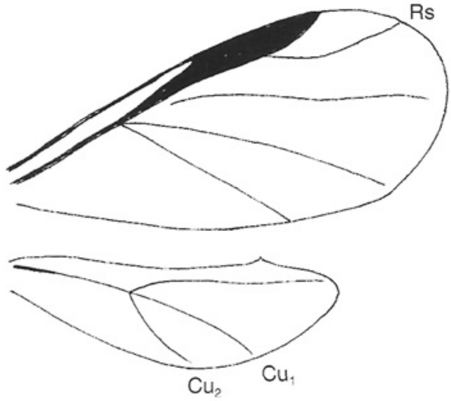


Fig. 40 Venation of an alate aphid - subfamily Pemphiginae.

Myzus persicae (peach/potato aphid),[2] *Rhopalosiphum padi* (bird-cherry aphid), *Sitobion avenae* (grain aphid).

20. Family PEMPHIGIDAE (p. 121 *et seq.)*

Aphids with the terminal process of the antennae short **(Fig. 37c);** antennae of winged forms often (e.g. subfamily Pemphiginae) with annulated segments **(Fig.** 40); compound eyes reduced to three facets; siphunculi stumpy cones, pore-like or absent; cauda broadly rounded; body often with groups of well-developed wax glands; venation varies according to subfamily but Rs vein of forewing present and origins of

[2] For many years, common names of certain heteroecious species of aphid (i.e. those with different winter and summer host plants) have included reference to both kinds of host, separated by a hyphen, that of the primary (winter) host having priority (e.g. willow-carrot aphid). This introduces potential confusion with common names hyphenated for other reasons (e.g. bird-cherry aphid). In recognition of this problem, some authors have used either an 'em' or an 'en' dash between the alternate host names but this subtlety is not always followed, probably being largely overlooked or misunderstood. In view of these difficulties, and to avoid ambiguity, a solidus (forward slash) is used in the present work to delineate primary and secondary hosts in such common names.

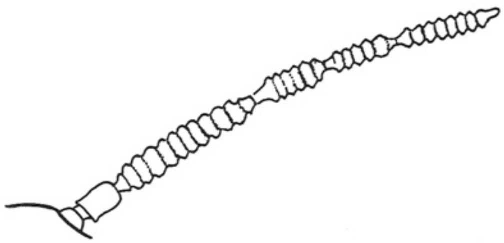


Fig. 41 Antenna of an alate aphid - subfamily Pemphiginae.

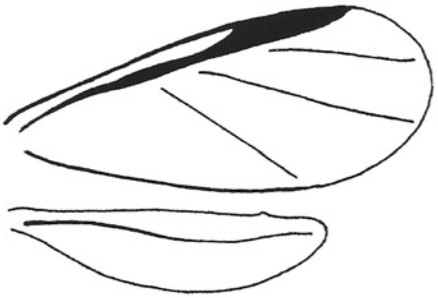


Fig. 42 Venation of an alate adelgid - family Adelgidae.

Cu_1 and Cu_2 veins on forewings and hindwings close-set and noticeably divergent: subfamily Pemphiginae - venation of forewing reduced **(Fig.** 41) (cf. Fig. 39). Associated primarily with trees and shrubs, often forming galls, but some species migrating in summer to herbaceous plants or grasses, including certain crops.

EXAMPLES: Eriosomatinae - *Eriosoma lanigerum* (woolly aphid); Pemphiginae - *Pemphigus bursarius* (lettuce root aphid).

21. Family ADELGIDAE

Entirely conifer-feeding, aphid-like insects; unlike true aphids, antennal segments short and wing venation reduced: Rs vein of forewing absent; hindwings often with just one, unbranched vein **(Fig.** 42); siphunculi absent; females entirely oviparous and covered in flocculent masses of wax; alates with five antennal segments. Life-cycles are very complex, often involving a variety of different morphs and alternation of host plants.

EXAMPLES: Adelginae - *Adelges abietis* and *A. viridis* (spruce pineapple-gall aphids); Pineinae - *Pineus pini* (Scots pine adelges).

22. Family PHYLLOXERIDAE (phylloxerans) (p. 123)

A small group of insects, structurally similar to adelgids but alates with just three antennal segments and wings held flat when in repose; wax (if present) never flocculent.

EXAMPLES: *Viteus vitifoliae* (grape phylloxera), *Phylloxera glabra* (oak leaf phylloxera).

Superfamily COCCOIDEA (scale insects)

A diverse group, demonstrating considerable sexual dimorphism. Larsi, if present, usually 1-segmented and with a single claw (cf. superfamily Aphidoidea). Males often rare or absent; if present, typically short-lived, small or minute; mouthparts vestigial; apterous or with just one pair of wings; body often terminates in a caudal spine and a longer pair of cerci **(Fig.** 43). Adult females wingless, usually sedentary and apodous; often scale-like or cushion-shaped. First-instar nymphs (crawlers) **(Fig.** 44) often very mobile, later instars usually becoming more or less sedentary. Many species excrete considerable quantities of honeydew.

23. Family DIASPIDIDAE (armoured scales) (p. 123)

Body of female protected by a hard, scale-like (often more or less circular or mussel-shaped) covering **(Fig. 45a)** formed from wax and cast-off nymphal skins; legs absent; hind segments of body fused to form a pygidium **(Fig. 45b).** Male scales (if present) typically smaller and narrower than those of females, and often distinctly ribbed longitudinally.

EXAMPLES: *Aulacaspis rosae* (rose scale), *Lepidosaphes ulmi* (mussel scale).

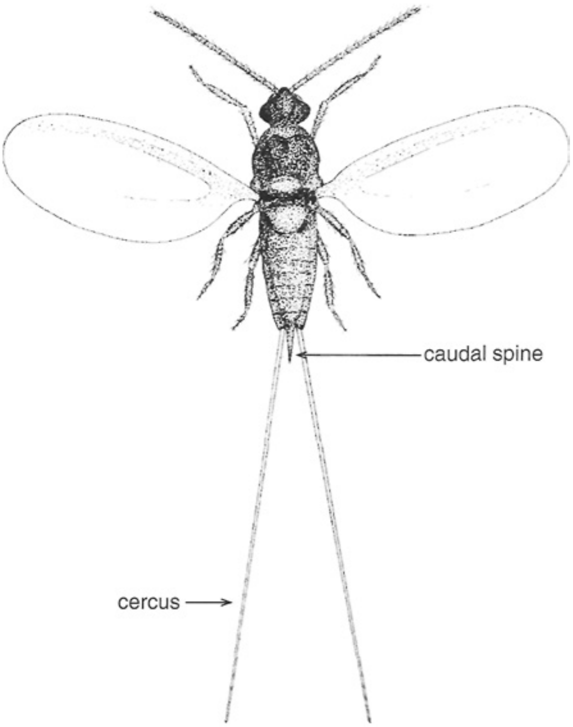


Fig. 43 Adult male of a scale insect, *Pulvinaria ribesiae* - superfamily Coccoidea (x35).

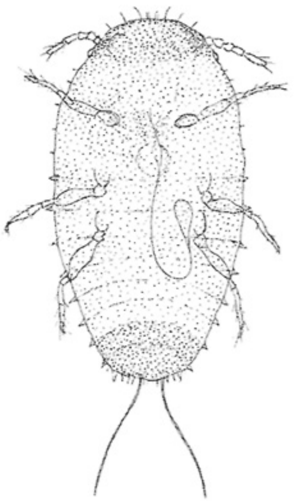


Fig. 44 First-instar nymph of a scale insect, *Lepidosaphes ulmi* - superfamily Coccoidea (xlOO).

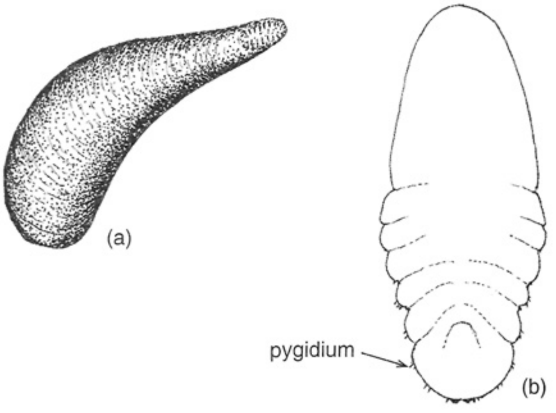


Fig. 45 A scale insect, *Lepidosaphes ulmi* - family Diaspididae: (a) adult female scale (xf 5); (b) ventral view of adult female (x30).

24. Family COCCIDAE (soft scales)

(p. 123 *et seq.)*

Body of female cushion-shaped and protected by an often tortoise-shaped, flexible or rigid, waxen scale; legs present or absent. Development often parthenogenetic. Male scales (if present) similar in appearance to those of females but usually smaller and narrower.

EXAMPLES: *COCCUS hesperidum* (brown soft scale), *Parthenolecanium corni* (brown scale), *Pulvinaria regalis* (horse-chestnut scale).

25. Family PSEUDOCOCCIDAE (mealybugs) (p. 125 *et seq.)*

Small to medium-sized insects; males rare and in many species unknown. Females elongate-oval and superficially woodlouse-like, with distinct body segmentation and relatively well-developed legs, but with poorly developed antennae; body more or less covered by a flocculent or mealy, waxen secretion.

EXAMPLES: *Pseudococcus affinis* (glasshouse mealybug), *Rhizoecus falcifer* (root mealybug).

ORDER THYSANOPTERA (THRIPS)

Minute or small, slender-bodied insects with a distinct head, a well-developed prothorax and a long, narrow, 11-segmented abdomen (the first segment greatly reduced and the last modified in association with the external genitalia); cerci absent; wings, when present, very narrow, membranous and strap-like, with few or no veins and marginal fringes of long setae; antennae short, 6- to 10-segmented; tarsi 1- or 2-segmented, each with a protrusible terminal vesicle (the arolium). Mouthparts asymmetrical and adapted for piercing. Metamorphosis gradual; development intermediate between that of hemimetabolous and holometabolous insects, and including an egg, two nymphal and two or three inactive stages (propupae and pupae);[3] nymphs similar in appearance to adults but wingless, less strongly sclerotized and with fewer antennal segments; the non-feeding propupae (**Fig.** 46) and pupae have conspicuous wing pads, and lack the tarsal vesicles found in nymphs and adults; in pupae, the antennae are folded back over the thorax.

Suborder TERHEBRANTIA

Thrips with a saw-like ovipositor; tip of abdomen conical in female (**Fig.** 47a), bluntly rounded in male; wings typically bearing numerous microtrichia; forewings with at least one longitudinal vein extending to the apex. Development includes egg, two nymphal and single propupal and pupal stages. Eggs soft-shelled and usually more or less reniform.

1. Family AEOLOTHRIPIDAE (banded thrips) (p. 89 *et seq.)*

Similar to members of the family Thripidae (q.v.) but forewings usually rounded at the apex and with several cross-veins (**Fig.** 48), antennae usually 9-segmented, body not flattened and ovipositor curving upwards; wings often colour-banded. Includes both phytophagous and predatory species.

EXAMPLE: *Aeolothrips tenuicornis* (banded-wing flower thrips).

2. Family THRIPIDAE (p. 90 *et seq.)*

A large and important group of sap-feeding thrips, including many injurious species; the

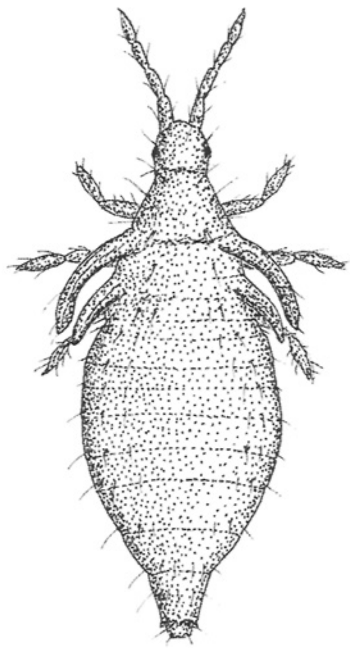


Fig. 46 Propupa of a thrips - family Thripidae.

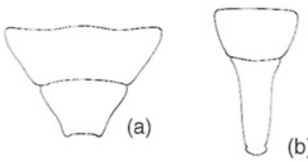


Fig. 47 Tip of the abdomen of a female thrips: (a) suborder Terebrantia; (b) suborder Tubulifera.

[3] Presumably in response to the presence of a 'pupal' stage in the life-cycle, some entomologists refer to the active juvenile stages of thrips as 'larvae'. However, this ignores clearly defined structural differences between insect 'larvae' and 'nymphs' which hold sway in the present work (see p. 11).

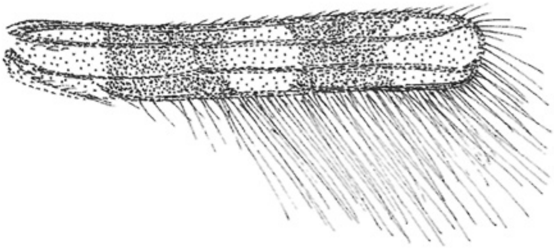


Fig. 48 Forewing of a thrips - family Aeolothripidae.

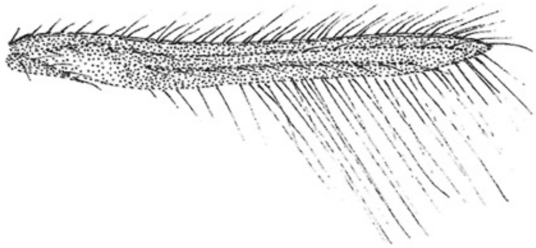


Fig. 49 Forewing of a thrips - family Thripidae.

main family of thrips in temperate regions. Forewings usually pointed at apex and each with three longitudinal veins, from which arise numerous, often large, setae (**Fig.** 49); antennae usually 7- or 8-segmented (rarely 6- or 9-segmented), the last one to three segments forming a thin style; body flattened; female with a downward-curving ovipositor.

EXAMPLES: *Frankliniella occidentalis* (western flower thrips),[4] *Thrips tabaci* (onion thrips).

Suborder TUBULIFERA

Forewings without longitudinal veins and female without an ovipositor; tenth abdominal segment tubular in both sexes **(Fig. 47b).** Development includes an egg, two nymphal, one propupal and two pupal stages. Eggs elongate-oval, hard-shelled and often sculptured.

3. Family PHLAEOTHRIPIDAE
(p. 94)

A mainly tropical family, associated primarily with dead wood or leaf litter (but including some predatory and leaf-feeding species), the insects feeding on fungal hyphae, fungal spores or the breakdown products of fungal decay. Some phytophagous species cause noticeable galls on host plants.

EXAMPLES: *Haplothrips tritici* (wheat thrips), *Liothrips vaneeckei* (lily thrips).

ORDER NEUROPTERA (LACEWINGS, ETC.)

Small to large, soft-bodied, often predatory insects with biting mouthparts; wing venation complex, the veins tending to fork near the wing margins; antennae usually long and slender. Metamorphosis complete; development includes egg, larval (three), prepupal and pupal stages.

Suborder MEGALOPTERA (alder flies and snake flies)

Medium-sized, lacewing-like, predatory insects, with branches of wing veins usually not bifurcated near the wing margins (but if so then prothorax exceptionally long and slender). Larvae elongate, with biting mouthparts; head and prothorax large, both strongly sclerotized. Pupae naked, i.e. pupation occurs without forming a cocoon. Includes ant-lions (family Raphidiidae) but no economically important predators of agricultural significance.

Suborder PLANIPENNIA

Small to large predatory insects with branches of wing veins usually clearly bifurcated near the wing margins. Larvae with suctorial mouthparts

[4] Students and other readers should note there is no such word as 'thrip'.

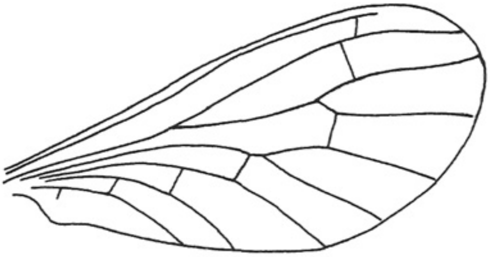


Fig. 50 Forewing venation of a powdery lacewing - family Coniopterygidae.

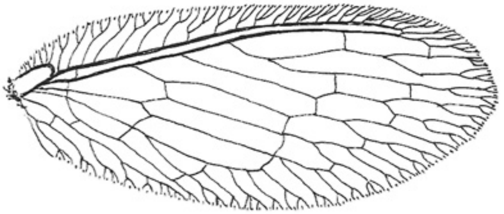


Fig. 52 Forewing venation of a brown lacewing - family Hemerobiidae.

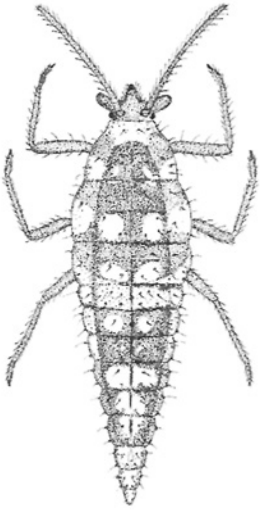


Fig. 51 Larva of a powdery lacewing, *Conwentzia psociformis* - family Coniopterygidae (xl5).

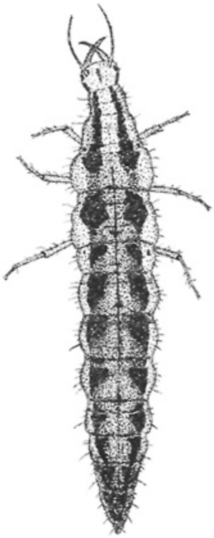


Fig. 53 Larva of a brown lacewing, *Hemerobius humulinus* - family Hemerobiidae (x7).

and large, toothed mandibles. Pupation occurs within a silken cocoon.

1. Family CONIOPTERYGIDAE (powdery lacewings)

Small, delicate, whitefly-like lacewings with white, mealy wings; hindwings sometimes vestigial; venation reduced and with few cross-veins, the veins not bifurcating near the wing margin **(Fig.** 50); antennae filiform and many-segmented; compound eyes large; ocelli absent. Larvae more or less pyriform, being distinctly tapered posteriorly; antennae 2-segmented and hairy; legs long and slender **(Fig.** 51).

EXAMPLES: *Coniopteryx tineiformis, Conwentzia pineticola, Semidalis aleyrodiformis.*

2. Family HEMEROBIIDAE (brown lacewings)

Usually small to medium-sized, greyish or brownish lacewings with moniliform antennae; wing with numerous cross-veins and the veins typically bifurcating near the wing margin **(Fig.** 52). Eggs without a mucous stalk. Larvae fusiform, without tubercles; body hairs short and simple; mandibles untoothed **(Fig.** 53).

EXAMPLES: *Eumicromus paganus, Hemerobius humulinus.*

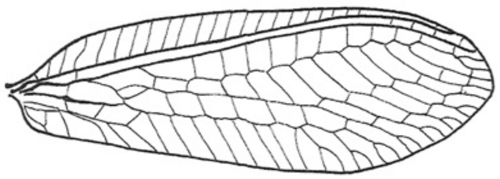


Fig. 54 Forewing venation of a green lacewing - family Chrysopidae.

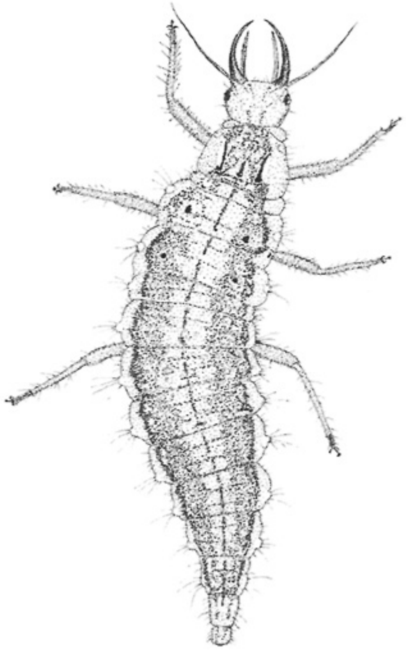


Fig. 55 Larva of a green lacewing, *Nineta flava* family Chrysopidae (x7).

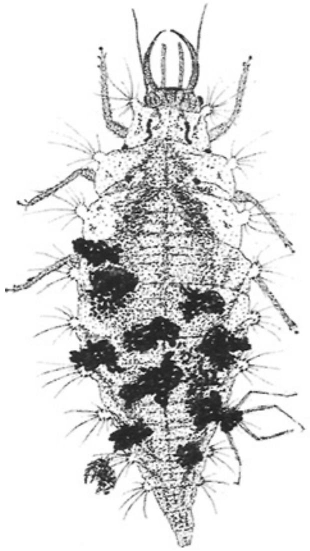


Fig. 56 Larva of a green lacewing, *Chrysopa* sp., with remains of prey camouflaging the body (x7).

3. Family CHRYSOPIDAE (green lacewings)

Medium-sized to large, usually green lacewings; antennae filiform and typically longer than forewings; wings with few longitudinal veins and with relatively few veins bifurcating near the wing margin (Fig. 54) (cf. Fig. 52); compound eyes prominent and brilliantly metallic. Eggs laid at the tips of threads of mucus that rapidly harden to form a stalk. Larvae fusiform, with prominent tubercles and setae (Fig. 55); body hairs often hooked, enabling the dried remains of prey to be carried around as camouflage **(Fig.** 56).

EXAMPLES: *Chrysopa perla* (pearly green lacewing), *Chrysoperla carnea* (common green lacewing).

ORDER COLEOPTERA (BEETLES)

Minute to large insects with biting mouthparts; forewings modified into horny or leathery elytra which usually meet in a straight line along the back; hindwings membranous and folded beneath the elytra when in repose, but often reduced or absent; prothorax normally large and mobile. Metamorphosis complete. Eggs usually spherical, oval, egg-shaped or sausage-shaped. Larvae usually with a distinct head and with three pairs of thoracic legs, but sometimes apodous; often campodeiform or eruciform and, occasionally, scarabaeiform. The largest insect order, with over 250000 species worldwide.

Suborder ADEPHAGA

A large group of mainly predacious beetles. Adults with the hind coxae fused rigidly to the metasternum (i.e. immovable) and extending posteriorly to the hind margin of the first visible abdominal sternite; antennae 11-segmented and usually filiform or moniliform. Larvae usually with claw-bearing tarsi.

Superfamily CARABOIDEA

1. Family CARABIDAE (ground beetles)
(p. 126 *et seq.)*

A large family of fast-moving, mainly nocturnal beetles with a characteristic body shape **(Fig.** 57), most ground beetles being readily recognized as such on sight; each elytron usually with nine longitudinal ridges, separated by distinct furrows or series of punctures; elytra sometimes fused to form a rigid body shield; exoskeleton usually black, but often with a metallic sheen. Larvae campodeiform, with ten abdominal segments; tarsi with one or two claws; mandibles pincer-like and powerful; cerci present on the ninth abdominal segment. Adults and larvae of most species are carnivorous, and several are important predators of crop pests; some species are phytophagous, several feeding on plant seeds.

EXAMPLES: *Bembidion* spp. (brassy ground beetles), *Harpalus rufipes* (strawberry seed beetle), *Pterostichus* spp. (strawberry ground beetles), *Trechus* spp., *Zabrus tenebrioides* (cereal ground beetle).

Suborder POLYPHAGA

Adults with the hind coxae attached to the metasternum but usually movable and, although extending posteriorly, rarely ever reaching as far as the hind margin of the first visible abdominal sternite; antennae extremely variable in appearance. Larvae with indistinct tarsi and just one tarsal claw.

Superfamily HYDROPHILOIDEA

A small group of mainly aquatic beetles. Antennae each terminating in a small, pubescent club **(Fig.** 58) and typically shorter than the often very long maxillary palps.

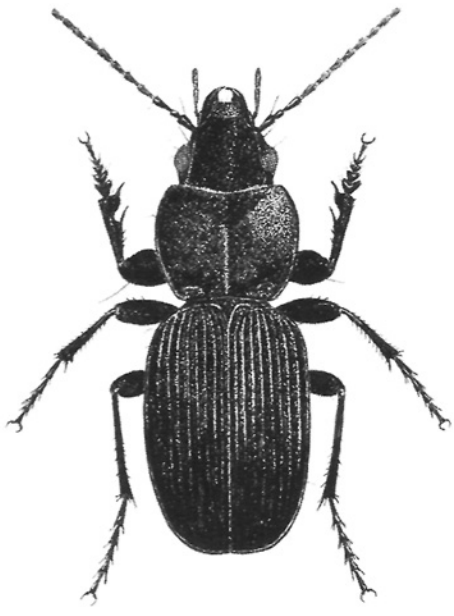


Fig. 57 A ground beetle, *Pterostichus madidus* - family Carabidae (x4).

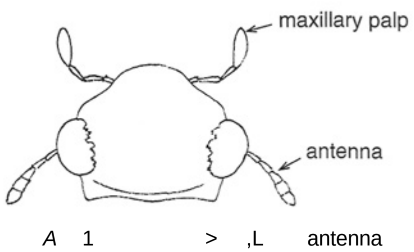


Fig. 58 Head of a mud beetle - superfamily Hydrophiloidea.

2. Family HYDROPHILIDAE (mud beetles) (p. 127 *et seq.)*

A large group of aquatic and terrestrial beetles, most species feeding on decaying vegetation; maxillary palps often very long. Larvae usually with anal cerci; some species are predacious.

EXAMPLE: *Helophorus nubilis* (wheat shoot beetle).

Superfamily STAPHYLINOIDEA

A very large group of elongate, mainly predatory beetles, usually with the elytra truncated and exposing at least three abdominal segments **(Fig.** 59). Hindwings well developed but hidden beneath the elytra when in repose; antennae 10- or 11-segmented, filiform or clavate; abdomen often terminating in a pair of styliform appendages.

3. Family SILPHIDAE (burying beetles)
(p. 128 *et seq.)*

Often broad-bodied beetles with strongly clubbed antennae. Most species are scavengers, feeding on decaying organic matter, and some are renowned for burying animal carcasses. Larvae of variable form, those of some species undergoing hypermetamorphosis and changing from one distinct form to another.

EXAMPLE: *Aclypea opaca* (beet carrion beetle).

4. Family STAPHYLINIDAE (rove beetles)

A very large family of mainly small, usually black beetles but some species brightly coloured (e.g.

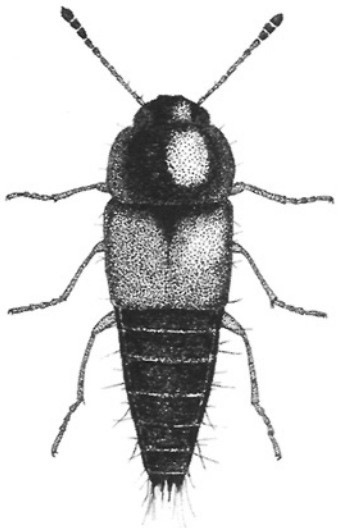


Fig. 59 A rove beetle, *Tachyporus hypnorum* - family Staphylinidae (xl5).

Tachyporus spp., see Fig. 59) and a few relatively large (e.g. *Staphylinus olens*, the devil's coach-horse beetle). Many species are predacious but most are associated with decaying organic matter; larvae of some species of *Aleochara* are parasitic on pupae of certain Diptera, e.g. Anthomyiidae. Larvae campodeiform, similar in appearance to those of the family Carabidae but with just one tarsal claw.

EXAMPLES: Aleocharinae - *Aleochara* spp. (small-headed rove beetles); Omaliinae - *Oligota flavicornis* (minute predatory rove beetle); Lachyporinae - *Tachyporus* spp.

Superfamily SCARABAEOIDEA

Antennae usually 10-segmented, with a variable number of the apical segments expanded on one side to form a lamellate club **(Fig.** 60); stout-bodied, with the eighth abdominal tergite drawn into a more or less pointed pygidium. Larvae scarabeiform and often strongly C-shaped, with the last two to four abdominal segments noticeably swollen **(Fig.** 61); head with powerful jaws; eyes usually absent; thoracic legs strong but not used for walking; cerci absent; many species are dung- or soil-inhabiting; others (family Lucanidae) feed in decaying wood.

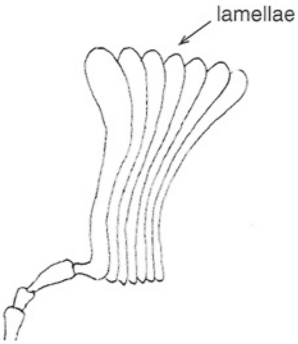


Fig. 60 Antenna of a chafer beetle - superfamily Scarabaeoidea.

Fig. 61 A chafer grub - family Scarabaeidae.

5. Family SCARABAEIDAE (chafers, dung beetles, etc.) (p. 129 *et seq.)*

An exceedingly large family of often large to very large, convex beetles; adults often brightly coloured, with a metallic sheen; antennae 8- to 10-segmented; abdomen with six visible sternites. Larvae typical of the superfamily; features of the anal segment (including the shape of the anal slit and the distribution of chitinized spines which are often arranged in a distinctive pattern) are often useful for distinguishing between species. Chafer larvae are soil-inhabiting and sluggish; they feed on decaying vegetable matter and plant roots.

EXAMPLES: Cetoniinae - *Cetonia aurata* (rose chafer); Melolonthinae - *Amphimallon solstitialis* (summer chafer), *Melolontha melolontha* (cockchafer); Rutelinae - *Phyllopertha hordeola* (garden chafer).

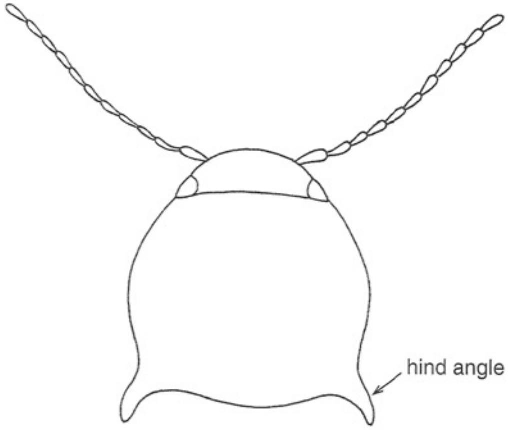


Fig. 62 Head and pronotum of a click beetle - superfamily Elateroidea.

Superfamily ELATEROIDEA

Elongate beetles with the head largely retracted into the thorax; pronotum usually with acute and projecting hind angles **(Fig. 62).**

6. Family ELATERIDAE (click beetles) (p. 132 *et seq.)*

A large family of phytophagous beetles; adults possess the ability to propel themselves into the air with an audible click by articulating the body between the pro- and mesothorax (there being a distinctive, peg-like 'spring' - the prosternal process - located between the first two pairs of legs); tibiae with two spurs. Larvae elongate, cylindrical and strongly sclerotized (commonly known as 'wireworms'); antennae and legs short; ninth abdominal segment with a pair of sensory dorsolateral pits (subfamily Elaterinae); tenth abdominal segment forming a ventral pseudopod **(Fig.** 63).

EXAMPLES: Athoinae - *Athous haemorrhoidalis* (garden click beetle); Ctenicerinae - *Ctenicera* spp. (upland click beetles); Elaterinae - *Agriotes* spp. (common click beetles).

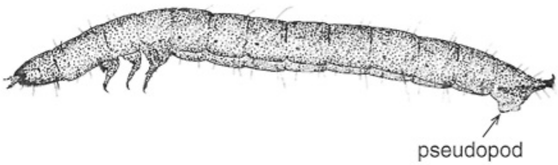


Fig. 63 A wireworm, *Agriotes lineatus* - family Elateridae (x3).

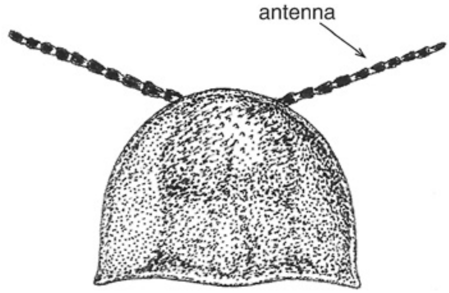


Fig. 64 Pronotum of an adult glow-worm - family Lampyridae.

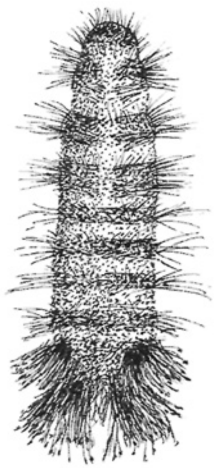


Fig. 65 Larva of a carpet beetle (= 'woolly bear'), *Anthrenus verbasci* - family Dermestidae (xf 0).

Superfamily CANTHAROIDEA

An ill-defined group of narrow, elongate, soft-bodied beetles; elytra also soft and often clothed in a short, velvet-like pubescence. Larvae and adults of some species are predacious on invertebrates.

7. Family CANTHARIDAE

A group of carnivorous, often brightly coloured, beetles; adults often congregate on umbelliferous flowers.

EXAMPLE: *Rhagonycha fulva* (soldier beetle).

8. Family LAMPYRIDAE

Beetles with luminous organs present in at least one sex; males usually winged but females often apterous and without elytra (= larviform); pronotum in both sexes shield-like and completely covering the head **(Fig.** 64). Larvae are predacious on slugs and snails.

EXAMPLE: *Lampyris noctiluca* (glow-worm).

Superfamily DERMESTOIDEA

9. Family DERMESTIDAE

Small or medium-sized beetles, the adults clothed in hairs or scales; head with a large ocellus dorsally; apical three segments of antennae forming a club; tarsi 5-segmented. Larvae very hairy **(Fig.** 65) and often called 'woolly bears'; mainly scavengers, several species causing damage to stored products.

EXAMPLES: *Anthrenus* spp. (carpet beetles), *Trogoderma granarium* (khapra beetle).

Superfamily BOSTRICHOIDEA

Adults with the pronotum extended forward as a hood over the head; most species are wood-borers, with soft-bodied, scarabeiform larvae, but some are of significance as pests of stored products. The family Anobiidae includes two notorious household pests: *Anobium punctatum* (common furniture beetle) and *Xestobium rufovillosum* (death-watch beetle).

10. Family BOSTRICHIDAE

Antennae of adult 3-segmented; pronotum distinctly hood-like. A mainly tropical family,

Fig. 66 Antenna of a clavicornid beetle - family Nitidulidae.

in northern Europe found only in imported grain.

EXAMPLE: *Rhyzopertha dominica (larva* = lesser grain borer).

Superfamily CLEROIDEA

11. Family TROGOSSITIDAE

A mainly tropical family of often predatory beetles; antennae clubbed; tarsi 5-segmented, the basal segment small, the apical segment relatively long and bearing a small lobe, visible ventrally between the claws. The European fauna includes a minor pest of stored food products, which is also partly predacious on other pests.

EXAMPLE: *Tenebroides mauritanicus* (cadelle beetle).

Superfamily CUCUJOIDEA

A varied grouping, often subdivided into the Clavicornia (antennae distinctly clubbed. **Fig.** 66; tarsal formula[3] of female never 5-5-4) and the Heteromera (antennae weakly clubbed; tarsal formula of female 5-5-4); abdomen with five visible sternites. The following families (except the Tenebrionidae) all belong to the Clavicornia.

12. Family NITIDULIDAE (p. 134 *et seq.)*

A large and varied family of mainly small beetles; elytra typically shorter than abdomen, with the last one to two abdominal tergites exposed; usually five (rarely four) tarsal segments on each leg (i.e. tarsal formula 5-5-5; rarely 4-4-4). Larvae usually cylindrical, with well-developed thoracic legs.

EXAMPLE: *Meligethes* spp. (pollen beetles).

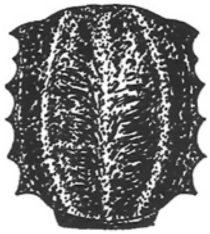


Fig. 67 Pronotum of a flat bark beetle - family Cucujidae.

13. Family CUCUJIDAE (flat bark beetles)

Small, flattened beetles with the lateral margins of the thorax often dentate **(Fig.** 67); antennae indistinctly clubbed and often filiform. Often predatory but some species associated with stored farm products.

EXAMPLE: *Cryptolestes* spp. (grain beetles).

14. Family SILVANIDAE (flat grain beetles)

Essentially similar to members of the family Cucujidae but antennae clubbed and the third tarsal segment lobed beneath.

EXAMPLES: *Ahasverus advena* (foreign grain beetle); *Oryzaephilus surinamensis* (saw-toothed grain beetle).

15. Family CRYPTOPHAGIDAE (mould beetles) (p. 135 *et seq.)*

A rather indistinct family of small beetles with distinctly clubbed antennae; elytra relatively hairy; tarsal formula of males normally 5-5-4. Many species are fungal feeders, several are associated with damp stored food pro-

[5] The number of tarsal segments on the foreleg, midleg and hindleg, respectively. Beetles with an unequal number of tarsal segments on the three pairs of legs are often described as 'heteromerous'.

ducts and some cause direct damage to field crops.

EXAMPLE: *Atomaria linearis* (pygmy mangold beetle).

16. Family BYTURIDAE (p. 136)

A small group of small, hairy, phytophagous beetles; antennae distinctly clubbed; tarsal formula 5-5-5, the tarsal claws distinctly toothed **(Fig.** 68). Larvae cylindrical, with well-developed thoracic legs; anal segment with a ventral pseudopod and a pair of dorsal processes **(Fig.** 69).

EXAMPLE: *Byturus tomentosus* (raspberry beetle).

17. Family COCCINELLIDAE (ladybirds) (p. 137)

Small to medium-sized, usually convex, hemispherical to oval beetles; head retracted into the pronotum; eyes large; antennae terminating in a 3-segmented club; mandibles bidentate apically **(Fig.** 70) (= predacious species - subfamily Coccinellinae) or with more than two apical teeth (= phytophagous species - subfamily Epilachninae); legs short; elytra often black, red or yellow, with a contrasting pattern of spots or blotches; tarsal formula 4-4-4. Larvae very active, long-legged, soft-bodied and often dark grey or blue, marked with yellow or white **(Fig.** 71); body usually setose, the setae often

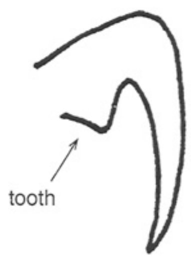


Fig. 68 Tarsal claw of a raspberry beetle - family Byturidae.

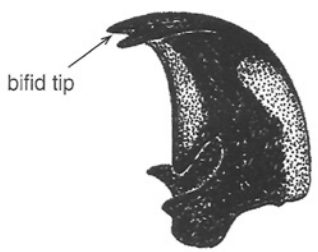


Fig. 70 Mandible of an adult ladybird - subfamily Coccinellinae.

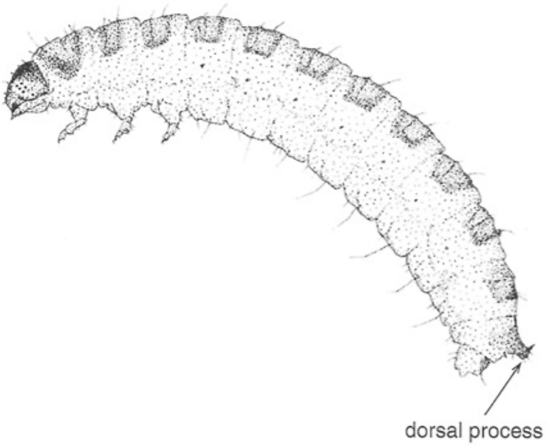


Fig. 69 Larva of a raspberry beetle, *Byturus tomentosus* - family Byturidae (x12).

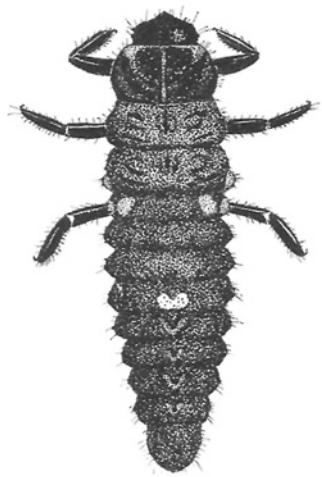


Fig. 71 Larva of a ladybird - subfamily Coccinellinae (x10).

arising from prominent tubercles; mandibles falcate. Adults and larvae of most species are predacious on aphids and other small invertebrates.

EXAMPLES: Coccinellinae - *Adalia bipunctata* (two-spot ladybird); Epilachninae - *Subcoccinella vigintiquattuorpunctata* (twentyfour-spot ladybird).

18. Family TENEBRIONIDAE

A very large family, with adults of generally dull appearance but diverse structure; most are incapable of flight and many are apterous; antennae usually weakly clubbed. Larvae are often superficially of similar appearance to those of the family Elateridae (q.v.) but antennae well developed and posterior spiracles mounted on distinct processes (**Fig.** 72). Several species are important pests in food warehouses.

EXAMPLES: Diaperinae - *Alphitobius* spp. (lesser mealworm beetles), *Latheticus oryzae* (long-headed flour beetle); Tenebrioninae - *Tenebrio* spp. (mealworm beetles); Ulominae - *Gnatocerus* spp. (horned flour beetles), *Tribolium* spp. (flour beetles).

Superfamily CHRYSOMELOIDEA

A large and varied group of mainly phytophagous beetles with 5-segmented tarsi (but the fourth segment very small and often overlooked); antennae not clubbed. Larvae usually eruciform, with well-developed thoracic legs.

19. Family CERAMBYCIDAE (long-horn beetles)

Small to very large, wood-boring beetles with very long antennae; elytra often elongated and brightly coloured. Larvae soft and fleshy, with an enlarged prothorax and much reduced, nonfunctional thoracic legs. The larvae burrow within the trunks and branches of dead or weakened trees, and are of particular importance to the timber trade.

EXAMPLES: Cerambycinae - *Aromia moschata* (musk beetle); Lamiinae - *Super da carcharias* and *S. populnea* (poplar longhorn beetles), *Tetrops praeusta* (little longhorn beetle).

20. Family BRUCHIDAE (pulse beetles) (p. 137 *et seq.)*

Seed-feeding, hunch-backed beetles with the head extended anteriorly (**Fig.** 73) but, unlike that of weevils (superfamily Curculionoidea), not forming a distinct rostrum (snout); elytra often truncated. Associated mainly with leguminous plants.

EXAMPLES: *Acanthoscelides obtectus* (dried bean beetle), *Bruchus pisorum* (pea beetle).

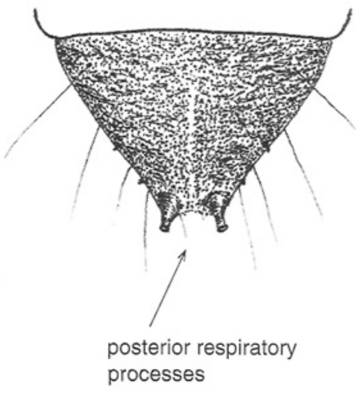


Fig. 72 Anal segment of a mealworm - family Tenebrionidae.

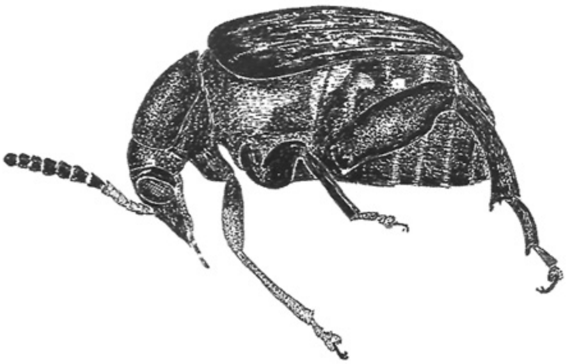


Fig. 73 A bean beetle, *Bruchus rufimanus* - family Bruchidae (x12).

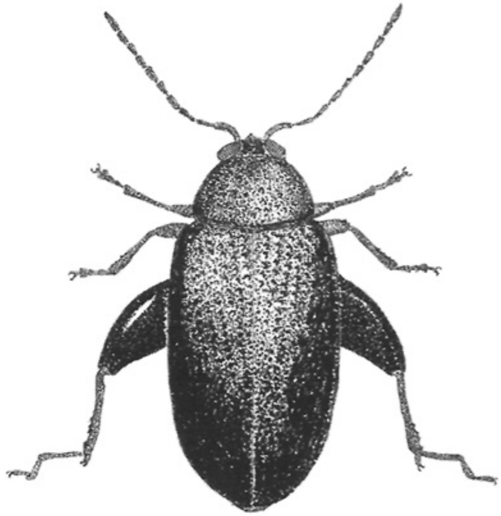


Fig. 74 A flea beetle, *Psylliodes attenuata* subfamily Halticinae (x20).

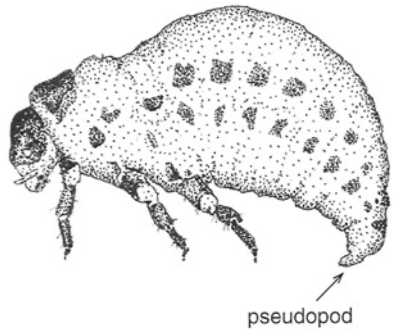
21. Family CHRYSOMELIDAE (leaf beetles) (p. 138 *et seq.)*

Small to medium-sized, generally rounded. often brightly coloured or metallic-looking beetles; third segment of tarsi often noticeable expanded and hiding the minute (and often overlooked) fourth segment; hindlegs sometimes enlarged and adapted for jumping (as in flea beetles: subfamily Halticinae) **(Fig.** 74). Larvae eruciform, usually with well-developed thoracic legs and, often, with noticeable plate-like verrucae on the thoracic and abdominal segments; anal segment often with a pseudopod **(Fig.** 75). Most species are leaf-feeders as both adults and larvae but several species have stem-boring or root-feeding larvae.

EXAMPLES: Cassidinae - *Cassida* spp. (tortoise beetles); Criocerinae - *Crioceris asparagi* (asparagus beetle); Galerucinae - *Galerucella luteola* (elm leaf beetle); Halticinae - *Aphthona euphorbiae* (large flax flea beetle).

Superfamily CURCULIONOIDEA (weevils)

A major group of phytophagous insects, with front of head forming a more or less elongated snout (the rostrum) which bears the



pseudopod

Fig. 75 Larva of a leaf beetle, *Leptinotarsa decemlineata* - family Chrysomelidae (x7).

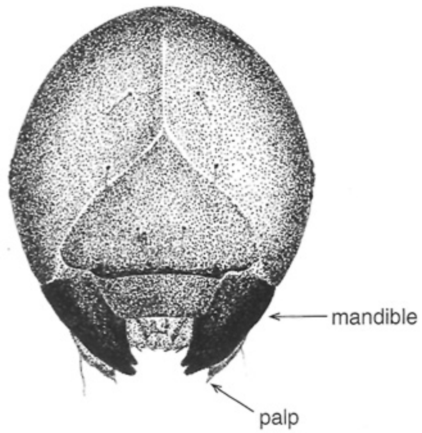


Fig. 76 Head of a weevil larva - family Curculionidae.

mouthparts and from which arise the antennae; antennae clubbed and often geniculate; includes many brightly coloured species. Larvae apodous; body usually C-shaped, with a well-defined head, strong mandibles **(Fig.** 76) and, often, a somewhat hump-backed appearance **(Fig. 77).**

22. Family ATTELABIDAE (leaf-rolling weevils) (p. 150 *et seq.)*

Small to medium-sized weevils with a distinct rostrum; antennae not geniculate and without an elongated scape, all segments being of similar length **(Fig. 78a).**

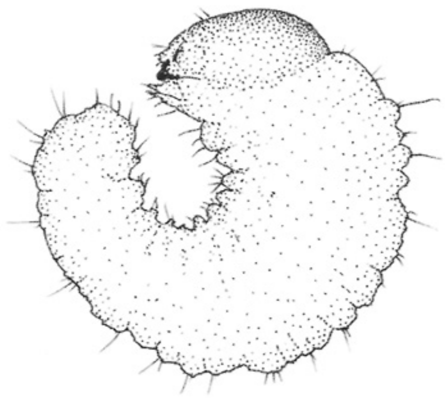


Fig. 77 A weevil larva - family Curculionidae (xl5).

EXAMPLES: Apoderinae - *Apoderus coryli* (hazel leaf roller weevil): Rhynchitinae - *Rhynchites aequatus* (apple fruit rhynchites).

23. Family APIONIDAE (p. 151 *et seq.)*

Minute to small, more or less pear-shaped weevils; antennae not geniculate, the scape elongated but only slightly longer than segments two plus three. Larvae often feed concealed within flower heads or seed capsules.

EXAMPLES: *Apion apricans* and *A. assimile* (clover seed weevils).

24. Family CURCULIONIDAE (weevils) (p. 153 *et seq.)*

The main family of weevils; adults with geniculate antennae and a very long scape **(Fig. 78b):** rostrum variable in form, sometimes exceedingly long; body often clothed in scale-like hairs.

EXAMPLES: Anthonominae - *Anthonomus pomorum* (apple blossom weevil); Brachyderinae - *Philopedon plagiatus* (sand weevil); Ceuthorhynchinae - *Ceutorhynchus assimilis* (cabbage seed weevil); Otiorhynchinae - *Otiorhynchus sulcatus* (vine weevil), *Phyllobius pyri* (common leaf weevil); Sitoninae - *Sitona lineatus* (pea & bean weevil).

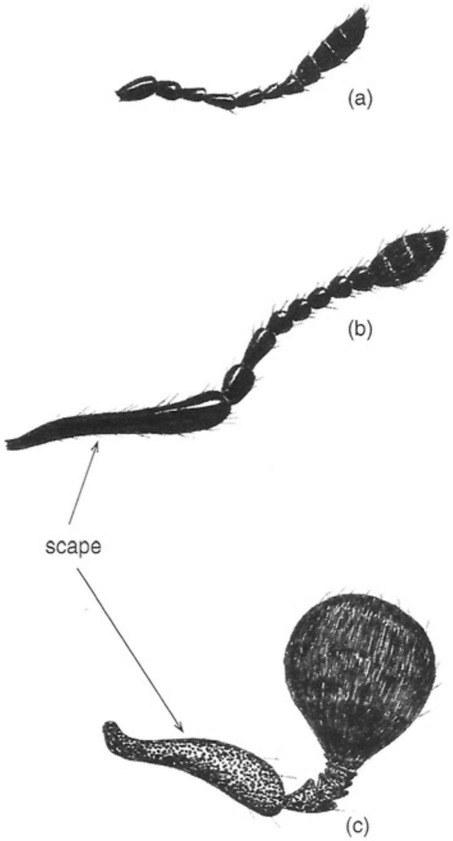


Fig. 78 Antennae of various weevils: (a) family Atellabidae: (b) family Curculionidae; (c) family Scolytidae.

25. Family SCOLYTIDAE (bark beetles)

Typically small, dull-coloured, cylindrical, wood-boring beetles **(Fig.** 79); antennae short but with a distinct scape and large, flattened apical club **(Fig. 78c);** elytra often concave posteriorly. Larvae apodous, with an enlarged thoracic region. Development occurs entirely within host plants in distinctive galleries, larvae of some species feeding on wood pulp and others upon ambrosia fungi that grow within the brood chambers.

EXAMPLES: Ipinae - *Xyleborus* spp. (ambrosia beetles); Scolytinae - *Scolytus mail* (large fruit bark beetle).

ORDER DIPTERA (TRUE FLIES)

Minute to large insects with a single pair of membranous wings, the hindwings reduced to small, drumstick-like halteres that function as balancing organs during flight; mouthparts suctorial but sometimes adapted for piercing. Metamorphosis complete. Eggs usually oval or cigar-shaped. often whitish or pale yellow, and often ornamented microscopically with a raised reticulated pattern. Larvae apodous and usually maggot-like, with a reduced, inconspicuous head.

Suborder NEMATOCERA

Adults with usually narrow bodies and slender, many-segmented antennae which lack an arista; antennae with a scape, pedicel and flagellum. the flagellar segments similar and often with whorls of hairs; maxillary palps usually 4- or 5-segmented and pendulous; wing venation with the anal cell 'open'. Larvae usually with a distinct head (but this may be retracted into the thorax) and with horizontally opposed, biting mouthparts. Pupae obtect, the adult emerging through a T-shaped slit.

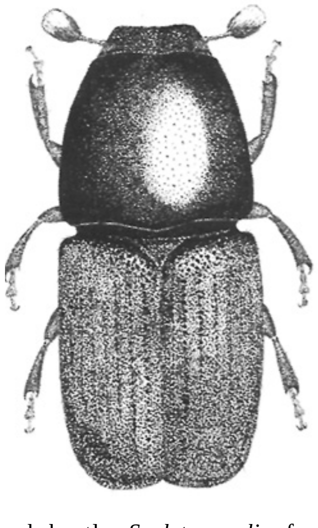


Fig. 79 A bark beetle, *Scolytus mali* - family Scolytidae (x15).

1. Family TIPULIDAE (crane flies)
(p. 163 *et seq.)*

Slow-flying insects with elongate bodies, wings and legs (the latter readily break off); ocelli absent; thorax with a distinct V-shaped suture **(Fig.** 80); wing venation includes a discal cell, and both anal veins (1A and 2A) extend to the wing margin **(Fig.** 81). Larvae fleshy but tough skinned (commonly called 'leatherjackets'); head deeply retracted and inconspicuous **(Fig.** 82); posterior end of body with often prominent papillae **(Fig. 82a);** soil-inhabiting.

EXAMPLES: *Nephrotoma appendiculata* (spotted crane fly), *Tipula oleracea* and *T. paludosa* (common crane flies).

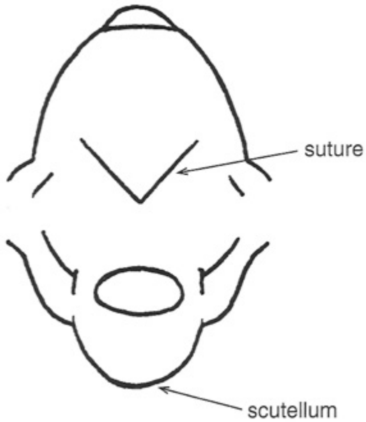


Fig. 80 Dorsal view of the thorax of a crane fly - family Tipulidae.

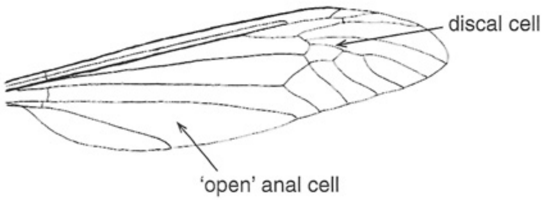


Fig. 81 Wing venation of a crane fly - family Tipulidae.

2. Family CERATOPOGONIDAE (biting midges)

Minute or small flies with piercing mouthparts and (in males) plumose or (in females) pilose antennae; ocelli absent; wings held flat over the body when in repose. Adults of some species suck the blood of vertebrates and cause considerable irritation to man and to farm animals. Larvae aquatic.

EXAMPLE: *Culicoides* spp. (biting midges).

3. Family CHIROMOMIDAE (non-biting midges)

Small, short-lived, gnat-like flies with the mouthparts poorly developed; thorax distinctly humped and often obscuring the head; antennae plumose in male, pilose in female; ocelli absent; forelegs often elongated. Larvae aquatic or inhabiting decaying organic matter.

EXAMPLE: *Metriocnemus hirticollis* (the larvae of which are often contaminants in consignments of harvested watercress).

4. Family SIMULIIDAE (black flies)

Minute, stout-bodied, short-legged, blood-sucking flies with piercing mouthparts; wings broad with thickened anterior veins; antennae 11-segmented; ocelli absent. Some species are of considerable local significance, inflicting painful 'bites' on man and on farm animals such as horses. Larvae are aquatic.

EXAMPLE: *Simulium reptans* (common black fly).

5. Family BIBIONIDAE (St. Mark's flies) (p. 165 *et seq.)*

Robust-bodied, often strongly pubescent flies; antennae arising form below the eyes **(Fig.** 83), 8- to 16-segmented but usually shorter than thorax; wings large, with strong anterior veins **(Fig.** 84); ocelli present. Larvae cylindrical, with a conspicuous head, well-developed mouthparts and often with distinct fleshy processes on the body (Fig. 85); spiracles often distinct. Larvae are particularly abundant in soil with a high organic content, and are sometimes damaging to the underground parts of plants.

EXAMPLES: *Bibio hortulanus* (March fly), *Dilophus febrilis* (fever fly).

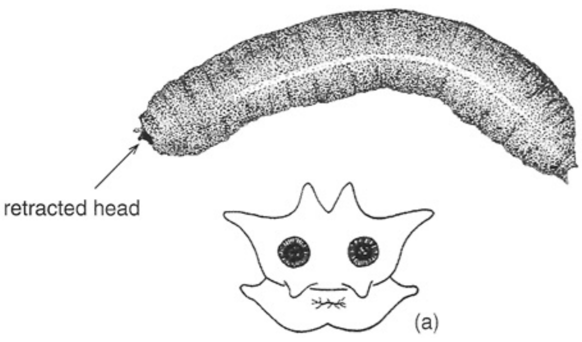


Fig. 82 A leatherjacket - family Tipulidae: (a) papillae at tip of abdomen.

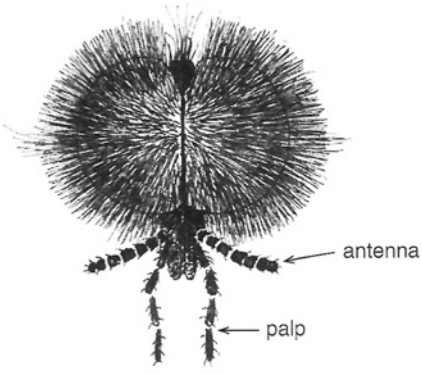


Fig. 83 Head of a St. Mark's fly - family Bibionidae.

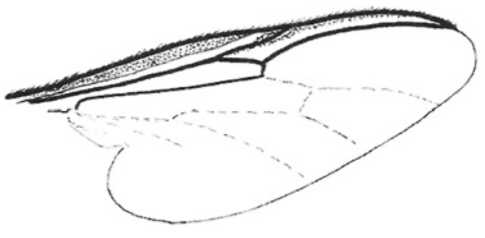


Fig. 84 Wing of a St. Mark's fly - family Bibionidae.

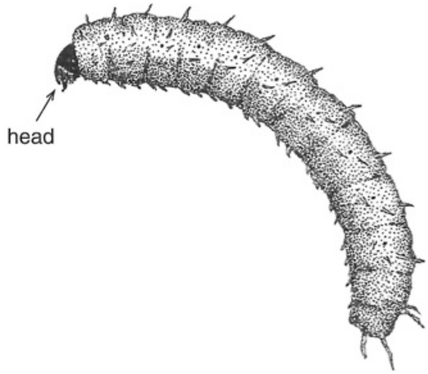
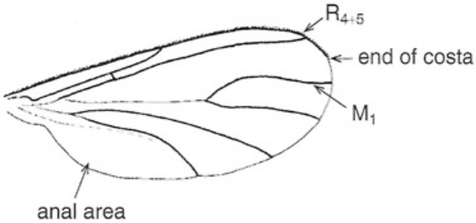


Fig. 85 Larva of a St. Mark's fly, *Bibio* sp. - family Bibionidae (x4).



anal area

Fig. 86 Wing of a sciarid fly - family Sciaridae.

6. Family SCIARIDAE (sciarid flies)
(p. 167 *et seq.)*

Small, delicate, gnat-like flies with a somewhat humped thorax; wing venation characteristic, with costa ending between R_{4+5} and M, **(Fig.** 86); antennae 16-segmented; ocelli present; compound eyes large and usually meeting above the antennae to form an 'eye-bridge'; palps usually 3-segmented **(Fig.** 87). Larvae elongate, translucent-whitish, with a conspicuous black head **(Fig.** 88).

EXAMPLES: *Bradysia brunnipes* (mushroom sciarid fly), *Pnyxia scabiei* (cucumber sciarid fly).

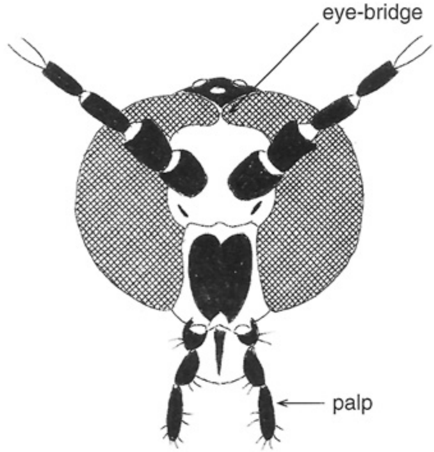


Fig. 87 Head of a sciarid fly - family Sciaridae.

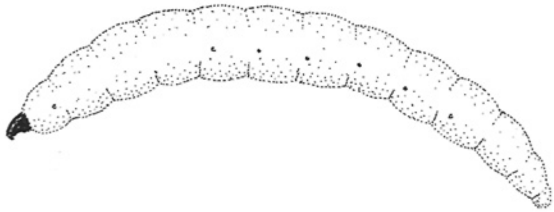


Fig. 88 Larva of a sciarid fly - family Sciaridae.

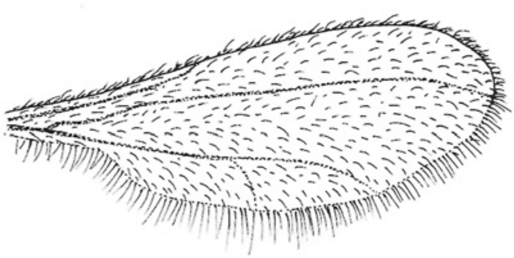


Fig. 89 Wing of a gall midge - family Cecidomyiidae.

7. Family CECIDOMYIIDAE (gall midges) (p. 168 *et seq.)*

Minute to small, delicate flies with long, moniliform antennae bearing whorls of hairs; wings broad, often hairy; venation much reduced, with few (mainly unbranched) longitudinal veins and no obvious cross-veins **(Fig.** 89); legs long and thin, the tibiae without spurs; ocelli absent. Larvae short, narrowed at both ends **(Fig.** 90), usually with a sternal spatula ('anchor process' or 'breast bone') **(Fig. 90a)** of characteristic shape for the genus or species; head reduced and

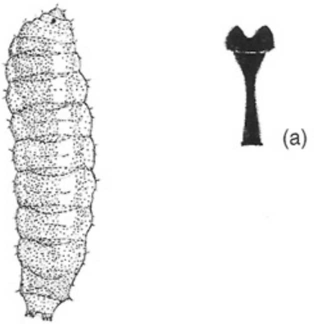


Fig. 90 Larva of a gall midge - family Cecidomyiidae: (a) sternal spatula.

inconspicuous. Most species are phytophagous, many inhabiting plant galls, but some are predacious on mites and other small invertebrates.

EXAMPLES: *Contarinia pisi* (pea midge), *Dasineura brassicae* (brassica pod midge), *Haplodiplosis marginata* (saddle gall midge), *Mayetiola destructor* (hessian fly), *Resseliella theobaldi* (raspberry cane midge), *Sitodiplosis mosellana* (orange wheat blossom midge).

Suborder BRACHYCERA

Usually stout-bodied flies with short, 3-segmented antennae which often terminate in a distinct apical style; palps 1- or 2-segmented and porrect. Larval head incomplete, generally retractile, and with vertically biting mandibles. Pupae usually obtect, the adult emerging through a straight or a T-shaped slit.

This suborder includes clegs, horse flies (family Tabanidae) and various predatory groups (e.g. families Asilidae, Dolichopodidae, Empididae and Therevidae) but no species that cause significant harm to crops.

8. Family TABANIDAE (clegs, horse flies, etc.)

Medium-sized to large, robust, blood-sucking flies with very large compound eyes; squamae large; feet with three arolia; antennae without a style but with the third segment annulated (Fig.

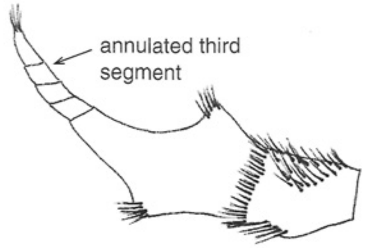


Fig. 91 Antenna of a horse fly - family Tabanidae.

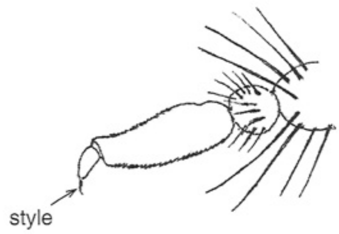


Fig. 92 Antenna of a therevid fly - family Therevidae.

91); mouthparts of females adapted for piercing and capable of inflicting a painful 'bite'. Larvae occur in damp situations, where they are carnivorous on soil-dwelling invertebrates.

EXAMPLES: *Chrysops* spp. (deer flies), *Haematopota crassicornis* and *H. pluvialis* (common clegs), *Tabanus* spp. (horse flies).

9. Family THEREVIDAE (stiletto flies)

Distinctly pubescent, thin-legged flies; antennae with a small style **(Fig.** 92); abdomen slender and pointed posteriorly; non-predatory. Larvae white, elongate and snake-like, with obvious segmentation; predacious on various soil invertebrates.

EXAMPLE: *Thereva nobilitata* (common stiletto fly).

10. Family HYBOTIDAE (dance flies)

Members of this family (formally included as a subfamily within the Empididae) are important predators of agricultural pests. The adults feed

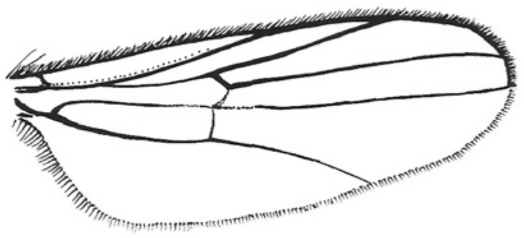


Fig. 93 Wing venation of a dance fly - family Hybotidae.

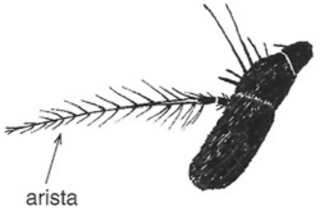


Fig. 94 Antenna of a cyclorrhaphid fly - suborder Cyclorrhapha.

mainly on Diptera (notably, Agromyzidae and Cecidomyiidae). The larvae are also predacious. Adults are characterized by their small size and rigid proboscis, and by the distinctive 'nick' (indentation) on the inner margin of the compound eyes; the tibia of each mid-leg often bears distinct spurs. Adults are distinguished from members of the Empididae largely on the basis of their wing venation - the veins usually extending to the wing margin without obvious forking (**Fig.** 93).

EXAMPLE: *Platypalpus* spp.

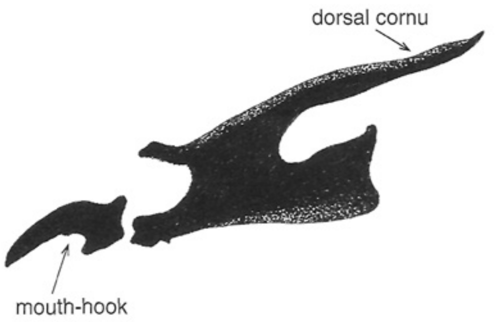


Fig. 95 Cephalopharyngeal skeleton (mouthparts) of the larva of a cyclorrhaphid fly.

11. Family DOLICHOPODIDAE (long-legged flies)

Adults are typically metallic bluish or metallic greenish, with (in males) often noticeably prominent genitalia. Most species are predacious on small insects, such as Collembola, Thysanoptera and other Diptera. The soil-inhabiting larvae are also predacious.

EXAMPLE: *Dolichopus* spp.

Suborder CYCLORRHAPHA

Adults usually with 3-segmented antennae, the third segment enlarged and bearing a simple or plumose bristle (arista) dorsally (Fig. 94); palps 1-segmented. Larvae are typical maggots, with a vestigial head and the body distinctly tapered anteriorly. The head and mouthparts are retracted into the thorax and form a usually pigmented cephalopharyngeal skeleton (Fig. 95); this structure includes a pair of black, shiny articulating mouth-hooks and is often of characteristic appearance for the family, subfamily or species. Features of the paired anterior and posterior spiracles of larvae are often helpful for distinguishing between species; also, the posterior spiracles of first-, second- and third-instar larvae usually (but not in the family Agromyzidae) each have one, two or three slit-like pores, respectively. Pupae are exarate and housed within a barrel-like puparium, formed from the cast-off skin of the final-instar larva (see Fig. 13). Adults emerge from the puparium by cutting off a more or less circular cap (the operculum).

This suborder comprises two distinct groups: the ASCHIZA and the SCHIZOPHORA. In the latter, a small balloon-like structure (the ptilinum) is projected temporarily from the front of the head of the young adult fly to aid emergence from the puparium.

Series ASCHIZA

Ptilinum absent.

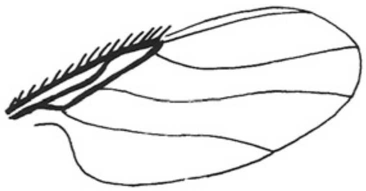


Fig. 96 Wing venation of a scuttle fly - family Phoridae.

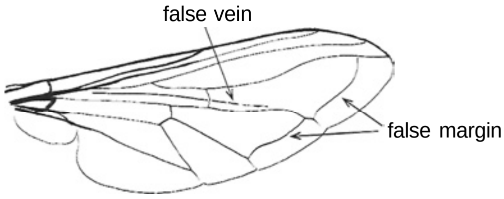


Fig. 97 Wing venation of a hover fly - family Syrphidae.

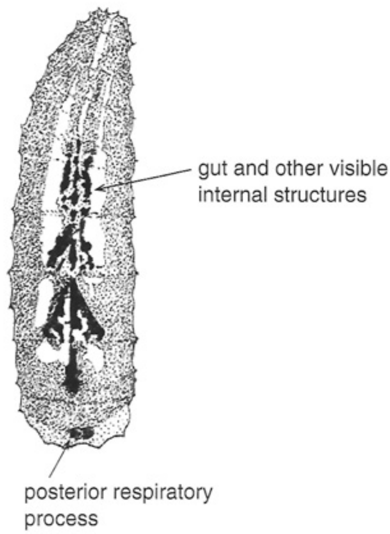


Fig. 98 Larva of a hover fly, *Syrphus ribesii* - family Syrphidae (x4).

12. Family PHORIDAE (scuttle flies) (p. 177)

Small, black or brownish-black, hump-backed flies with a characteristic wing venation, just the anterior veins being prominent and meeting the costa well before the wing tip (**Fig.** 96). Larvae are often associated with decaying organic matter, some feeding on fungi, including cultivated mushrooms.

EXAMPLE: *Megaselia* spp. (mushroom scuttle flies).

13. Family SYRPHIDAE (hover flies) (p. 177 *et seq.)*

Medium to large, often brightly coloured flies; includes various bee-like or wasp-like species, some with the ability to hover; wing venation characteristic, with a false vein and a false margin (**Fig.** 97). Larvae maggot-like, with distinct, often cone-like posterior respiratory processes; body sometimes translucent, exposing the viscera (**Fig.** 98). Larvae are of various habits, many feeding in decaying organic matter; several species are important predators of aphids.

EXAMPLES: Milesiinae - *Eumerus* spp. (small narcissus flies), *Merodon equestris* (large narcissus fly); Syrphidinae - *Scaeva pyrastri* (cabbage aphid hover fly predator), *Syrphus ribesii* (currant aphid hover fly predator).

Series SCHIZOPHORA

Ptilinum present.

Series SCHIZOPHORA - ACALYPTRATAE[6]

Squamae (the calypters) poorly developed and the transverse suture (which divides the mesonotum into a prescutum and scutum) (see later in Fig. 110) poorly developed or absent; second antennal segment ungrooved.

14. Family TEPHRITIDAE (large fruit flies) (p. 179 *et seq.)*

Wings noticeably mottled (**Fig.** 99); female with a distinct oviscapt. Larvae with a pair of rounded

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[6] Some authorities have abandoned the various subdivisions ACALYPTRATAE, CALYPTRATAE (p. 50) and PUPIPARA (p. 52).

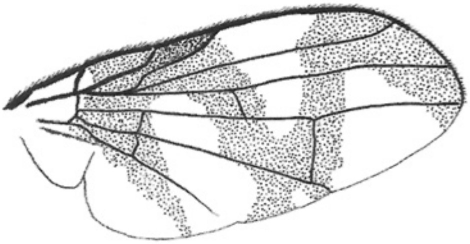


Fig. 99 Wing of a large fruit fly - family Tephritidae.

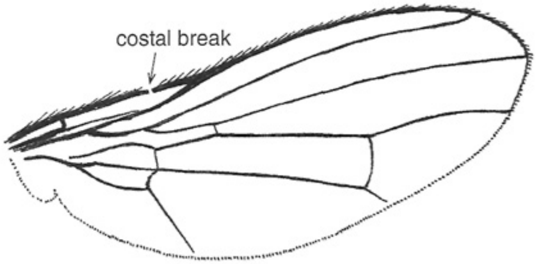


Fig. **100** Wing venation of a carrot fly - family Psilidae.

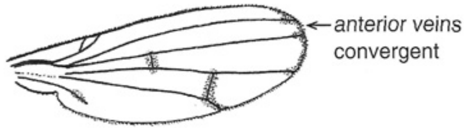


Fig. **101** Wing of an opomyzid fly - family Opomyzidae.

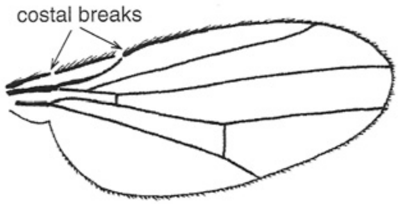


Fig. **102** Wing of a shore fly - family Ephydridae.

anal tubercles; posterior spiracles not placed on raised processes; phytophagous, including several gall-inhabiting species.

EXAMPLES: Ceratitinae - *Ceratitis capitata* (Mediterranean fruit fly); Trypetinae - *Euleia heraclei* (celery fly), *Platyparea poeciloptera* (asparagus fly), *Rhagoletis cerasi* (European cherry fruit fly).

15. Family PSILIDAE (p. 181 *et seq.)*

Small to medium-sized flies with a distinct break in the costal vein (Fig. **100)** and a distinct ocellar triangle. Larvae cylindrical, narrow-bodied and elongated; phytophagous.

EXAMPLE: *Psila rosae* (carrot fly).

16. Family SPHAEROCERIDAE (lesser dung flies) (p. 182)

A group of small to medium-sized, mainly black or dark brown flies; wings usually with two distinct costal breaks; oral vibrissae (see later in Fig. 106) long; first tarsal segment of hindlegs short, distinctly swollen and densely setose. Larvae saprophagous, typically developing amongst decaying organic matter.

EXAMPLES: *Coproica hirtula* (sometimes abundant in poultry houses); *Pullimosina heteroneura* (occasionally a nuisance in mushroom houses).

17. Family OPOMYZIDAE (p. 182 *et seq.)*

Small flies, with often mottled or spotted wings and the two anterior veins convergent (Fig. **101);** no oral vibrissae. Larvae often leaf miners or stem miners; anterior and posterior spiracles prominent but body without posterior tubercles (cf. family Anthomyiidae, p. 51).

EXAMPLES: *Geomyza tripunctata* (grass & cereal fly), *Opomyza florum* (yellow cereal fly).

18. Family EPHYDRIDAE (shore flies) (p. 184 *et seq.)*

Small, dark-bodied flies, usually associated with damp habitats; wings with two distinct costal breaks; anal cell absent **(Fig. 102).** Larvae often leaf miners or stem miners; posterior spiracles

Fig. 103 Posterior respiratory cone of a shore fly larva - family Ephydridae.

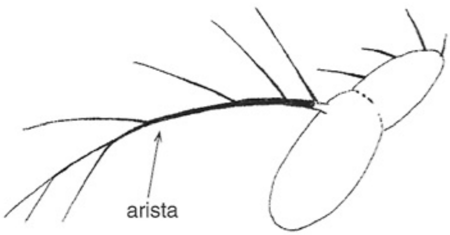


Fig. 104 Antenna of a small fruit fly - family Drosophilidae (genus *Scaptomyza).*

borne on a pair of pointed, posteriorly directed cones **(Fig. 103).**

EXAMPLES: Notiphilinae - *Hydrellia griseola (larva* = a cereal leaf miner); Ephydrinae - *Scatella* spp. (glasshouse wing-spot flies).

19. Family DROSOPHILIDAE (small fruit flies) (p. 185 *et seq.)*

Very small to small flies with bright red compound eyes; arista of antenna usually plumose and with a bifid tip **(Fig. 104);** anal cell present. Larvae maggot-like, with elongated anterior and posterior respiratory processes and anal tubercles; anterior spiracles sometimes absent.

EXAMPLES: *Drosophila* spp. (small fruit flies), *Scaptomyza flava.*

20. Family BRAULIDAE

Minute, apterous, superficially hippoboscid-like flies, adapted for life as ectoparasites of bees. Larvae plump, with distinctive anterior and posterior sensorial processes. The larvae inhabit bee colonies and feed on wax and stored pollen.

EXAMPLE: *Br aula coeca* (bee-louse).

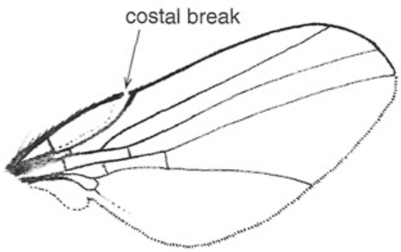


Fig. 105 Wing venation of an agromyzid fly - family Agromyzidae (genus *Cerodontha).*

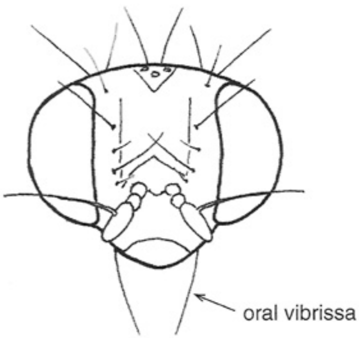


Fig. 106 Head of an agromyzid fly - family Agromyzidae.

21. Family AGROMYZIDAE (p. 186 *et seq.)*

A large family of small, mainly black or grey, often yellow-marked flies with a distinct break on the costal vein **(Fig. 105);** oral vibrissae present **(Fig. 106).** Larvae with main axis of the mouth-hooks set obliquely or at right angles to the rest of the mouthparts and each usually with two or more equally sized teeth (Fig. **107);** dorsal elements (dorsal cornu) of the cephalopharyngeal skeleton (mouthparts) undivided (= subfamily Phytomyzinae) **(Fig. 107a)** or divided into two (= subfamily Agromyzinae); anterior spiracles arising dorsally and relatively closely set; posterior spiracles prominent. The larvae usually mine within leaves or stems, often forming distinctive galleries in which two discontinuous trails of frass are visible.

EXAMPLES: Agromyzinae - *Agromyza potentillae (larva* = strawberry leaf miner),

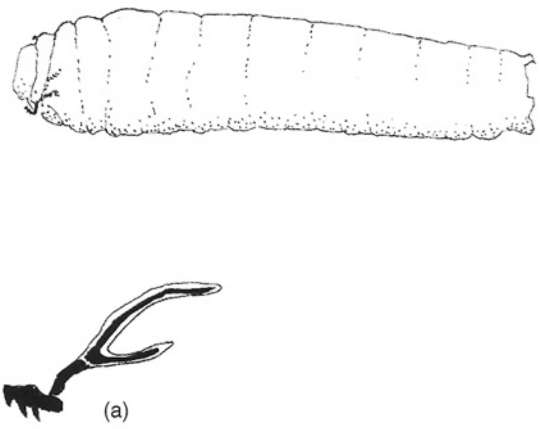


Fig. 107 Larva of an agromyzid fly - family Agromyzidae: (a) cephalopharyngeal skeleton subfamily Phytomyzinae.

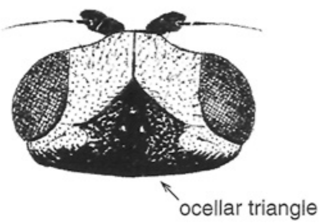


Fig. 108 Dorsal view of the head of a chloropid fly - family Chloropidae.

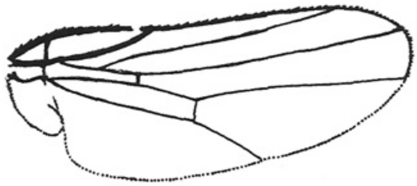


Fig. 109 Wing venation of a chloropid fly - family Chloropidae.

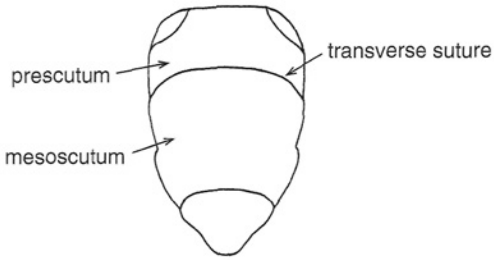


Fig. 110 Dorsal view of the thoracic sutures of a calyptrate fly - series Schizophora, Calyptratae.

Ophiomyia simplex (larva = asparagus miner); Phytomyzinae - *Cerodontha ireos (larva* = iris leaf miner), *Liriomyza trifolii (larva* = American serpentine leaf miner), *Napomyza carotae (larva* = carrot miner), *Phytomyza rufipes (larva* = cabbage leaf miner).

22. Family CHLOROPIDAE (p. 194 *et seq.)*

Minute to small flies with a bare arista, brightly coloured eyes, a very large ocellar triangle **(Fig. 108)** and reduced wing venation (no anal cell) **(Fig. 109).** Some species have predacious larvae (including *Chloropisca glabra* which feeds on root aphids) but most are phytophagous; larvae elongate, with prominent anterior and posterior spiracles but body without posterior tubercles (cf. family Anthomyiidae, p. 51).

EXAMPLES: *Chlorops pumilionis* (gout fly), *Oscinella frit* (frit fly).

Series SCHIZOPHORA - CALYPTRATAE

Squamae (the calypters) and a transverse suture **(Fig. 110)** usually well developed; second antennal segment distinctly grooved **(Fig. 111).**

23. Family OESTRIDAE

Stout-bodied flies clothed in soft hair; hypopleural bristles present; postscutellum well developed; females with an extensile oviscapt. Larvae are internal parasites of mammals and some are of considerable economic importance.

EXAMPLES: *Hypoderma* spp. (warble flies), *Oestrus ovis* (sheep nostril fly).

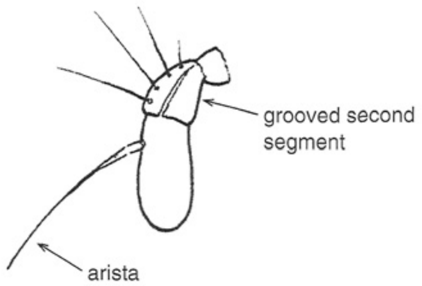


Fig. 111 Antenna of a calyptrate fly - series Schizophora, Calyptratae.

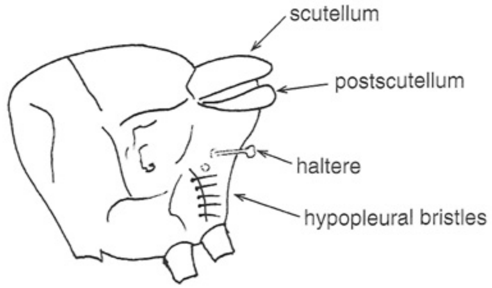


Fig. 112 Lateral view of the thorax of a parasitic fly - family Tachinidae.

24. Family GASTEROPHILIDAE

Large, relatively hairy flies with vestigial mouthparts, sharing similar features to members of the family Oestridae (q.v.) but squamae very small. Larvae are internal parasites of horses and certain other large-bodied mammals.

EXAMPLE: *Gasterophilus intestinalis* (horse bot fly).

25. Family TACHINIDAE (parasitic flies)

Adults with large squamae and resembling house flies (family Muscidae), but with a strongly developed postscutellum and with hypopleural bristles (Fig. **112)** (cf. family Anthomyiidae); arista usually bare. Larvae maggot-like but with indistinct segmentation and tapered only slightly anteriorly; anterior spiracles small; posterior spiracles conspicuous and often distinctly sclerotized; endoparasitoids, most species attacking lepidopterous larvae and pupae.

EXAMPLES: *Compsilura* spp., *Nemorilla* spp., *Pales* spp., *Phryxe* spp.

26. Family CALLIPHORIDAE (bluebottles, greenbottles, flesh flies, etc.)

A very large group of flies, including parasitic, predatory and saprophytic species; hypopleural bristles present; postscutellum indistinct or absent (cf. family Tachinidae); adults often blue or green (subfamily Calliphorinae). Larvae either scavengers or parasitoids.

EXAMPLES: *Lucilia sericata* (sheep maggot fly), *Pollenia rudis* (cluster fly), the latter a parasitoid of earthworms.

27. Family SCATHOPHAGIDAE
(p. 196 *et seq.)*

Adults without hypopleural bristles and with the lower thoracic squamae reduced to membranous folds: usually predacious on small insects. Larvae of variable habits but usually phytophagous or, including those of the well-known *Scathophaga stercoraria* (yellow dung fly), saprophagous.

EXAMPLE: *Nanna* spp. (timothy flies).

28. Family ANTHOMYIIDAE
(p. 197 *et seq.)*

A large group of house-fly-like species in which hypopleura bristles are absent (cf. family Tachinidae). Larvae (Fig. **113)** maggot-like, with often characteristic cephalopharyngeal skeleton, anterior and posterior spiracles and posterior tubercles; in common with most other groups (not family Agromyzidae, q.v.), the long axis of the mouth-hooks is more or less continuous with the rest of the mouthparts **(Fig. 113c).** Larvae mainly phytophagous.

EXAMPLES: *Delia antiqua* (onion fly), *Pegomya hyoscyami* (mangold fly).

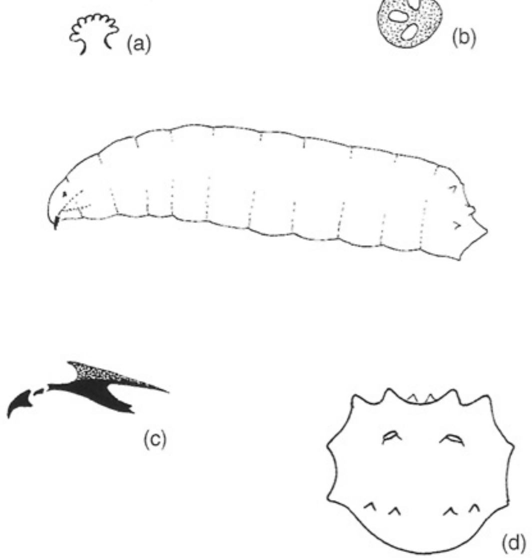


Fig. **113** Larva of an anthomyiid fly - family Anthomyiidae. (a) anterior spiracle; (b) posterior spiracle; (c) cephalopharyngeal skeleton: (d) tubercles on the anal segment.

29. Family MUSCIDAE

Small to relatively large flies, mostly resembling house flies; similar to members of the family Calliphoridae but without hypopleural bristles; squamae large and covering the halteres. Some species have piercing mouthparts and feed on the blood of mammals. Larvae of many species are carnivorous (in their second to fourth instars) and some are then useful predators of crop pests.

EXAMPLES: *Haematobosca stimulans* (cattle biting fly), *Haematobia irritans* (horn fly), *Hydrotaea irritans* (sheep head fly), *Stomoxys calcitrans* (stable fly); *Muscina stabulans* (false stable fly), the larvae of which are predators of, for example, larvae of *Ceutorhynchus pallidactylus* (cabbage stem weevil).

Series SCHIZOPHORA - PUPIPARA

Highly modified and specialized parasites of birds and mammals. Females characteristically give birth singly to virtually fully developed larvae; the latter then almost immediately pupate.

30. Family HIPPOBOSCIDAE

Dorsoventrally flattened insects, modified as external parasites of warm-blooded vertebrates; antennae 1-segmented; legs short and stout; tarsal claws strong and often dentate; wings present, vestigial or absent.

EXAMPLES: *Hippobosca equina* (forest fly), *Melophagus ovinus* (sheep ked).

ORDER LEPIDOPTERA (BUTTERFLIES AND MOTHS)

Minute to large insects with two pairs of membranous wings; cross-veins few in number; body, wings and appendages usually covered with flat scales; mouthparts suctorial, with mandibles vestigial or absent, and often forming a long, coiled proboscis. Metamorphosis complete. Eggs extremely variable in form and colour; and often sculptured with longitudinal ridges and adorned with a raised, reticulated pattern. Larvae eruciform, most often with three pairs of thoracic legs and five pairs of abdominal prolegs, the latter usually armed with crochets - prolegs usually present on abdominal segments 3-6 and 10 **(Fig. 114)** (cf. larvae of sawflies: Hymenoptera, suborder Symphyta); the prolegs on the anal segment are sometimes called anal claspers (descriptions of the arrangement of crochets on the prolegs of lepidopterous larvae usually do not apply to the anal claspers); head usually strongly chitinized, with several ocelli and with a pair of silk glands (modified salivary glands); body often with setae or longer hairs arising from distinctive plates, pinacula or verrucae, and sometimes marked with more or less complete longitudinal stripes or lines (see Fig 114); larvae typically phytophagous, often leaf-mining, rarely carnivorous.

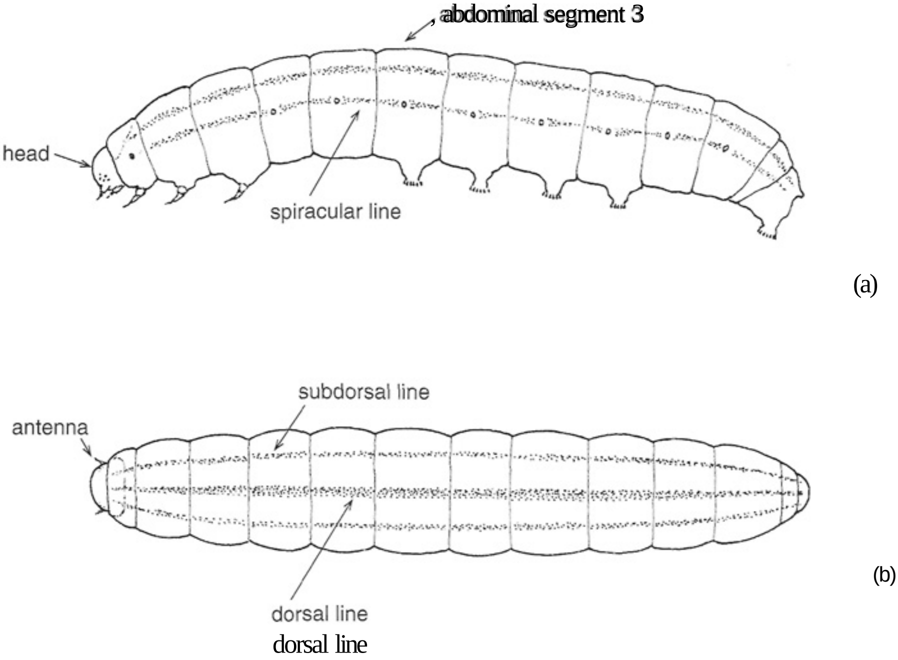


Fig. 114 Larva of a moth - order Lepidoptera: (a) lateral view; (b) dorsal view.

Suborder ZEUGLOPTERA

Adults with functional mandibles but no proboscis; venation of forewings and hindwings similar; forewings with a fibula; hindwings with costal spines but no frenulum. Larvae with eight pairs of abdominal prolegs, each proleg bearing a single terminal hook. Pupae exarate and dectious.

Superfamily MICROPTERIGOIDEA
1. Family MICROPTERIGIDAE

A small group of minute, day-flying moths with narrow, pointed wings; wings with a metallic sheen. Although at least one species *(Micropterix calthella)* is often abundant in grass meadows on flowers of *Ranunculus,* the insects are not of pest status; adults feed on pollen and the larvae on mosses and liverworts.

Suborder DACNONYPHA

Adults without functional mandibles; wings aculeate; forewings with a fibula; hindwings with costal spines. Larvae apodous. Pupae exarate, with large, curved mandibles.

Superfamily ERIOCRANIOIDEA
2. Family ERIOCRANIIDAE

A small group of minute, day-flying moths, with narrow, pointed wings; wings with a metallic sheen. Larvae are apodous leaf miners; most European species are associated with *Betula,* especially young trees.

EXAMPLE: *Eriocrania semipurpurella* (a minor pest on *Betula).*

Suborder MONOTRYSIA

Adults without functional mandibles; wings aculeate; females with one or two genital openings on the last (ninth) abdominal segment; venation of forewings and hindwings similar; forewings each with a long jugum; alternatively, minute moths with reduced hindwing venation and no jugum but, at least in males, a frenulum.

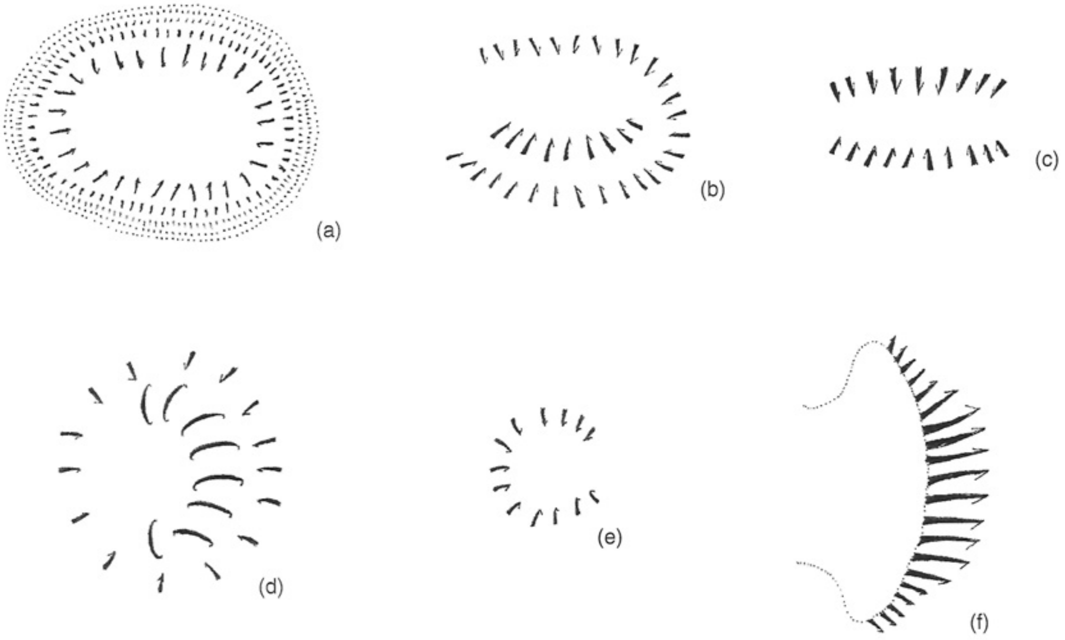


Fig. 115 Examples of the arrangement of crochets on the abdominal prolegs of lepidopterous larvae: (a) a multiserial circle - family Hepialidae; (b) a penellipse surrounding a transverse band - family Gracillariidae; (c) two transverse bands - family Sesiidae; (d) a uniordinal circle surrounding a penellipse of larger crochets - subfamily Plutellinae; (e) a simple penellipse - family Gelechiidae; (f) a mesoseries - subfamily Arctiinae.

Larvae usually with several pairs of crochet-bearing abdominal prolegs but sometimes apodous. Pupae obtect, with rudimentary mandibles.

Fig. **116** Head of a nepticulid moth - family Nepticulidae.

Superfamily HEPIALOIDEA

3. Family HEPIALIDAE (swift moths)
(p. 202 *et seq.)*

A small group of primitive, medium-sized to large moths with forewing and hindwing venation similar; forewings with a jugum; antennae very short; females with two genital openings. Larvae elongate, with five pairs of crochet-bearing abdominal prolegs; crochets of different sizes (multiordinal), arranged in a multiserial circle **(Fig. 115a).** Larvae subterranean, feeding mainly on plant roots and pupating in earthen cells. Pupae spinose; although without free appendages (i.e. obtect), able to wriggle to the soil surface prior to emergence of the adult.

EXAMPLE: *Hepialus hamuli* (ghost swift moth).

Superfamily NEPTICULOIDEA

4. Family NEPTICULIDAE (p. 203)

Minute to small moths with a metallic sheen and distinctive 'eye-caps' formed by the basal segment of each antenna **(Fig. 116);** wing venation reduced, especially on hindwings; wings with long hair fringes; female ovipositor short and fleshy. Larvae wedge-shaped and virtually apodous (vestigial legs present on meso- and metathorax, abdominal prolegs small and without crochets); usually leaf miners, pupating externally in small, parchment-like cocoons.

EXAMPLE: *Stigmella malella* (apple pygmy moth).

5. Family TISCHERIIDAE

A small group of very small moths with narrow, pointed wings. Larvae flat-bodied with reduced thoracic legs and vestigial abdominal prolegs. Individuals feed in blotch-like, silk-lined leaf mines; pupation occurs within the mine, from which the pupa protrudes following emergence of the adult.

EXAMPLE: *Tischeria margined* (a leaf miner on raspberry).

Superfamily INCURVARIOIDEA

6. Family INCURVARIIDAE (p. 203)

A diverse group of often day-flying, metallic-looking moths, including several with particularly well-developed (often very long) antennae, especially in males. Larvae, when young, are often leaf miners; later, those of many species inhabit portable cases made of leaf fragments; crochets rudimentary and arranged in a single transverse band.

EXAMPLE: *Lampronia rubiella* (raspberry moth).

Suborder DITRYSIA

Adults without functional mandibles; venation of forewings and hindwings different; forewings without a fibula or a jugum; hindwings usually with a frenulum; females with one genital opening on the eighth and one on the ninth abdominal segments. Larval form extremely variable, usually with up to five pairs of crochet-bearing abdominal prolegs. Pupae obtect, without functional mandibles.

Superfamily COSSOIDEA

7. Family COSSIDAE (p. 203 *et seq.)*

A relatively primitive group of large moths. Adults with no proboscis; frenulum usually well developed. Larvae stout-bodied, with large mandibles and a well-developed prothoracic plate; crochets biordinal or triordinal, arranged in a complete circle. Larvae are wood-borers in tree trunks, stems or branches.

EXAMPLES: Cossinae - *Cossus cossus* (goat moth); Zeuzerinae - *Zeuzera pyrina* (leopard moth).

Superfamily TINEOIDEA

An extremely large and varied group of small to medium-sized moths, including clothes moths (family Tineidae), various leaf miners and stem miners; wings typically elongate, with long hair fringes.

8. Family TINEIDAE

A large group of small moths, associated mainly with dried animal or plant material. Proboscis of adult short or absent; head rough-haired; maxillary palps often very long.

EXAMPLES: *Tineola bisselliella* (common clothes moth), *Nemapogon granella* (corn moth).

9. Family LYONETIIDAE (p. 204)

A small group of leaf miners; adults usually with mainly white forewings, the wings with long hair fringes. Larvae are leaf miners and more or less moniliform, with a complete circle of crochets on each abdominal proleg.

EXAMPLES: Cemiostominae - *Leucoptera malifoliella* (pear leaf blister moth);

Lyonetiinae - *Lyonetia clerkella {larva* = apple leaf miner).

10. Family GRACILLARIIDAE
(p. •• *et seq.)*

A large group of minute to small moths with long, narrow wings; wings with long hair fringes; antennae without an 'eye-cap'. Larvae are leaf miners, with four pairs of abdominal prolegs (prolegs absent from the sixth abdominal segment); crochets scattered but sometimes forming a lateral penellipse surrounding several larger crochets **(Fig. 115b);** first-instar larva apodous and very flat, with blade-like mandibles. Pupation occurs in a cocoon within the larval habitation or mine, from which the pupa protrudes following adult emergence.

EXAMPLES: Gracillariinae - *Caloptilia syringella (larva* = lilac leaf miner); Lithocolletinae - *Phyllonorycter blancardella* (apple leaf blister moth).

11. Family PHYLLOCNISTIDAE

A group of very small moths with an 'eye-cap' (see Fig. f 16). Larvae apodous and sap-feeding throughout their leaf-mining life.

EXAMPLE: *Phyllocnistis unipunctella {larva* - poplar leaf miner).

Superfamily YPONOMEUTOIDEA
12. Family SESIIDAE (clearwing moths)
(p. •• *et seq.)*

Wasp-like, day-flying moths with scales absent over much of the wing area; forewings very narrow (Fig. **117);** antennae frequently expanded at apex; abdomen terminating in a fan-like tuft of scales. Larvae feed and pupate within the wood or pith of host plants; crochets uniordinal, arranged in two transverse bands **(Fig. 115c),** but in a single row on the anal prolegs. Pupae capable of cutting their way out of the larval gallery, using the heavily sclerotized head.

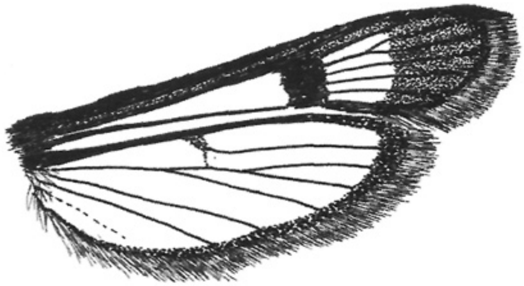


Fig. 117 Right forewing and hindwing of a clearwing moth - family Sesiidae.

EXAMPLE: *Synanthedon myopaeformis* (apple clearwing moth).

13. Family CHOREUTIDAE (p. 206 *et seq.)*

A distinctive group of small moths, formerly included within the family Glyphipterigidae. Adults broad-winged, the wings held flat over the body when in repose. Larvae usually web-forming on dicotyledonous plants; abdominal prolegs pencil-like.

EXAMPLE: *Choreutis pariana (larva* = apple leaf skeletonizer).

14. Family GLYPHIPTERIGIDAE
(p. 206)

A large family of small or very small moths, established mainly in the southern hemisphere and poorly represented in Europe. Adults have prominent ocelli. Larvae with prothoracic spiracle surrounded by a sclerotized plate, and three or fewer crochets on each abdominal proleg. Larvae usually feed on grasses and sedges.

EXAMPLE: *Glyphipterix simpliciella* (cocksfoot moth).

15. Family YPONOMEUTIDAE
(e.g. small ermine moths) (p. 206 *et seq.)*

A variable and diverse family of small to medium-sized moths with well-developed, pro-

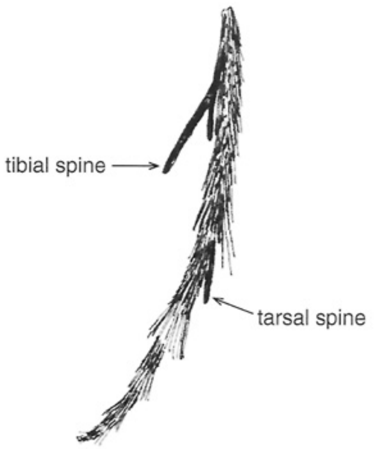


Fig. 118 Hind tibia and tarsus of an epermenid moth - family Epermeniidae.

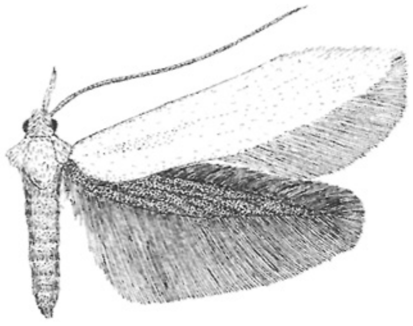
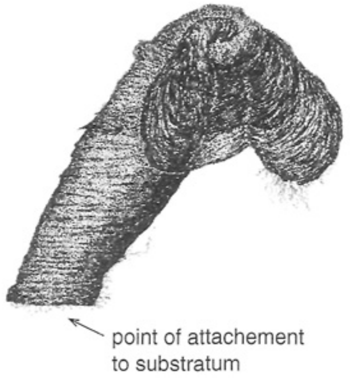


Fig. 119 Body and right-hand wings of a casebearer moth, *Coleophora anatipennella* ~ family Coleophoridae (x7).



point of attachement
to substratum

Fig. 120 Pistol-shaped habitation (case) of a casebearer larva. *Coleophora anatipennella* - family Coleophoridae (x6).

jecting maxillary palps. Larvae of various forms: prothoracic plate sometimes ill-defined (subfamily Argyresthiinae); abdominal prolegs with crochets often arranged in several concentric circles (i.e. multiserial) (e.g. subfamily Yponomeutinae) (see later in Fig. 276) or with a circle of small crochets surrounding a penellipse of larger crochets (e.g. subfamily Plutellinae) **(Fig. 115d).** Larvae of many species feed within plant buds, fruits or shoots; some are gregarious and web-inhabiting.

EXAMPLES: Acrolepiinae - *Acrolepiopsis assectella* (leek moth); Argyresthiinae - *Argyresthia pruniella* (cherry fruit moth); Plutellinae - *Plutella xylostella* (diamond-back moth); Yponomeutinae - *Yponomeuta* spp. (small ermine moths).

16. Family EPERMENIIDAE (p. 208 *et seq.)*

A small group of moths, structurally similar to members of the family Yponomeutidae but with stiff bristles on the hind tibiae and hind tarsi **(Fig. 118).** The larvae feed mainly on Umbelliferae, at first mining the leaves but later inhabiting webs.

EXAMPLE: *Epermenia aequidentellus* (a leaf miner on carrot).

Superfamily GELECHIOIDEA
17. Family COLEOPHORIDAE (casebearer moths) (p. 209)

Small moths with narrow, pointed wings **(Fig. 119);** antennae directed forwards when in repose. Young larvae are leaf miners but later instars inhabit portable cases, formed from silk and leaf fragments; cases often cigar-shaped or pistol-shaped **(Fig. 120);** crochets on the abdominal prolegs often scattered and much reduced in number but, typically, at least those on each anal clasper arranged in a uniserial transverse band.

EXAMPLES: *Coleophora anatipennella* (cherry pistol casebearer moth), *Coleophora laricella*

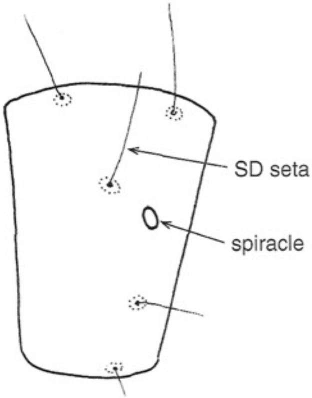


Fig. 121 Eighth abdominal segment of an oecophorid larva - family Oecophoridae.

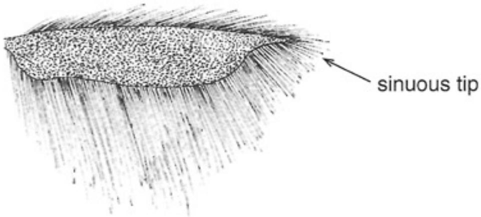


Fig. **122** Hindwing of a gelechiid moth - family Gelechiidae.

Fig. **123** Adult of a blastobasid moth, *Blastobasis decolorella* - family Blastobasidae (x4).

(larch casebearer moth), *Coleophora spinella* (apple & plum casebearer moth).

18. Family OECOPHORIDAE
(p. 210)

A group of moderately small moths with prominent labial palps and broadly elongate forewings; base of antennae usually with a pronounced tuft of hair (the pecten). Larvae with a well-developed prothoracic plate and tortrix-like (see family Tortricidae) but the anal prolegs with the semicircle of crochets often broken into two bands and the long subdorsal (SD) seta on the eighth abdominal segment often placed more dorsally than the spiracle **(Fig. 121).** The larvae often feed within spun leaves, shoots or flower heads.

EXAMPLES: Depressariinae - *Agonopterix nervosa* (carrot & parsnip flat-body moth), *Depressaria pastinacella* (parsnip moth); Oecophorinae - *Endrosis sarcitrella* (white-shouldered house moth).

19. Family GELECHIIDAE (p. 210 *et seq.)*

Small moths with palps curved upwards; margin of hindwing usually sinuous **(Fig. 122);** antennae usually without a basal pecten. Larvae tortrix-like (see family Tortricidae) but with relatively narrow abdominal prolegs and small abdominal spiracles; abdominal prolegs with relatively few crochets (sometimes fewer than three), forming a mesal penellipse **(Fig. 115e).** Larvae usually feed within spun leaves or shoots.

EXAMPLES: *Anarsia lineatella {larva* = peach twig borer), *Dichomeris marginella* (juniper webber moth), *Phthorimaea operculella* (potato moth), *Sitotroga cerealella* (Angoumais grain moth).

20. Family BLASTOBASIDAE

A small group of small moths with elongate wings **(Fig. 123).** Larvae **(Fig. 124)** tortrix-like (see family Tortricidae) but with relatively small abdominal spiracles; lateral (L) pinaculum on prothorax placed below the spiracle **(Fig. 125);** subdorsal 1 (SDl) pinaculum on abdominal segments 1-7 crescent-shaped **(Fig. 126).** Larvae usually feed amongst debris and other dry material.

Fig. 124 Dorsal view of a blastobasid larva, *Blastobasis decolorella* - family Blastobasidae (x4).

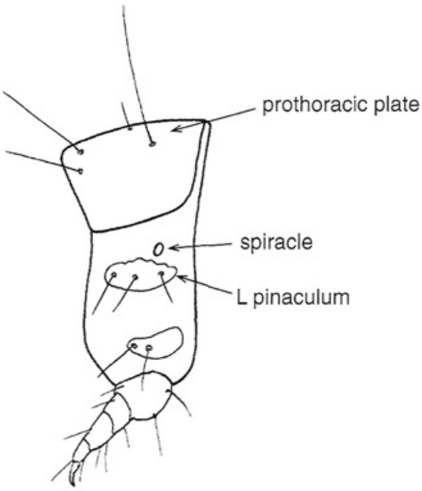


Fig. 125 Prothoracic segment of a blastobasid larva - family Blastobasidae.

EXAMPLE: *Blastobasis decolorella* (straw-coloured apple moth).

21. Family MOMPHIDAE (p. 211 *et seq.)*

A small group of small moths with narrow, strongly fringed wings. Larvae with body covered in small setae; dorsal plates present on the caudal segments **(Fig. 127).** Larvae are often leaf miners, seed- or shoot-borers.

EXAMPLE: *Spuleria atra* (pith moth).

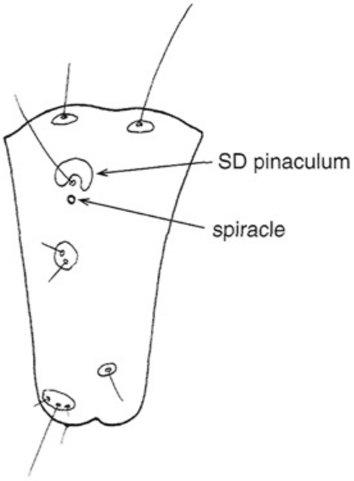


Fig. 126 Second abdominal segment of a blastobasid larva - family Blastobasidae.

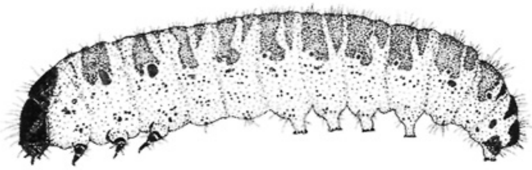


Fig. 127 Larva of a pith moth, *Spuleria atra* - family Momphidae (x8).

Superfamily TORTRICOIDEA

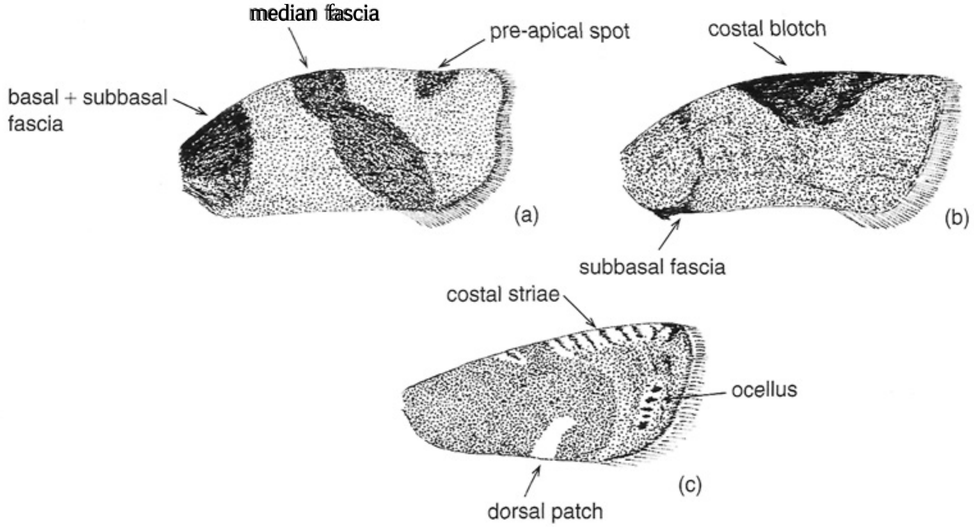
22. Family COCHYLIDAE (p. 211 *et seq.)*

Features for distinguishing between members of this and the following family are slight, adults being most reliably separated by slight differences in wing venation. The forewings of cochylids are often elongate and, when in repose, are held in a steep, roof-like posture. Some authors consider that the Cochylidae deserves only subfamily status, within the family Tortricidae. Larvae usually feed within flowerheads, seedheads, roots or stems of plants.

EXAMPLE: *Eupoecilia ambiguella* (vine moth).

23. Family TORTRICIDAE (tortrix moths) (p. 212 *et seq.)*

Small moths with broad wings, the forewings sometimes falcate apically but typically more or



/ (c)
dorsal patch

Fig. 128 The main wing patterns of tortricid moths: (a) and (b) subfamily Tortricinae; (c) subfamily Olethreutinae.

less bluntly rounded and rectangular; hair fringes short; forewings of male often with a costal fold; labial palps short; maxillary palps absent; tympanal organs absent. *Subfamily Tortricinae:* forewings often with basal, subbasal and median fasciae, a pre-apical spot or a costal patch **(Figs 128a, b);** *subfamily Olethreutinae:* forewings often with distinctive costal striae, an ocellus and a dorsal patch **(Fig. 128c).** Larvae usually with distinct pro thoracic and anal plates **(Fig. 129);** crochets on the abdominal prolegs biordinal or triordinal, arranged in a complete circle (Fig. 129a), those on the anal prolegs forming a semicircle (cf. family Oecophoridae); an anal comb often present (Fig. 129b); prespiracular plate on prothorax with three lateral (L) setae **(Fig. 130)** (cf. family Pyralidae); abdominal segments 1-7 usually with one short and one long subdorsal (SD) seta, the long SD seta on the eighth abdominal segment usually immediately anterior to the spiracle **(Fig. 131)** (cf. family Oecophoridae). Larvae usually inhabit spun leaves or shoots, and pupation usually occurs in the larval habitation, amongst spun leaves or in a folded leaf; typically, the pupa protrudes from the cocoon following emergence of the adult.

EXAMPLES: Olethreutinae - *Cydia nigricana* (pea moth), *Pammene rhediella* (fruitlet mining tortrix moth); Tortricinae - *Acleris comariana* (strawberry tortrix moth), *Adoxophyes orana* (summer fruit tortrix moth), *Archips podana* (fruit tree tortrix moth), *Cacoecimorpha pronubana* (carnation tortrix moth), *Cnephasia asseclana* (flax tortrix moth).

Superfamily PYRALOIDEA

A large and varied group of small to medium-sized, often narrow-bodied, delicate-looking moths; labial palps often very long and porrect; forewings usually elongate and hindwings broad, both with short hair fringes; legs usually long and slender.

24. Family PYRALIDAE (p. 223 *et seq.)*

Adults with tympanal organs present at base of abdomen. Larvae with crochets on abdominal prolegs biordinal or triordinal, forming a complete circle or a mesal penellipse; pre-

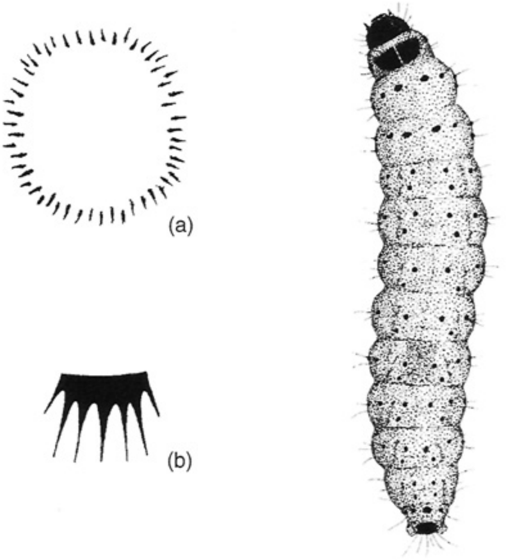


Fig. 129 A tortricid larva - family Tortricidae:
(a) arrangement of crochets on an abdominal proleg;
(b) anal comb.

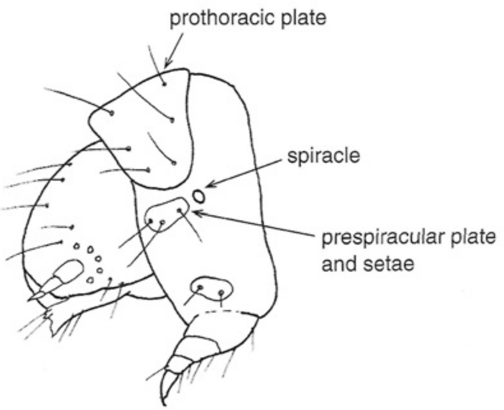


Fig. 130 Head and prothorax of a tortricid larva - family Tortricidae.

spiracular plate on prothorax with two setae **(Fig. 132)** (three in most other Lepidoptera).

EXAMPLES: Crambinae - *Chrysoteuchia culmella* (garden grass veneer moth); Evergestiinae - *Evergestis forficalis* (garden pebble moth); Galleriinae - *Galleria mellonella*

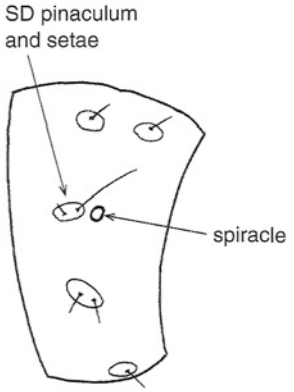


Fig. 131 Eighth abdominal segment of a tortricid larva - family Tortricidae.

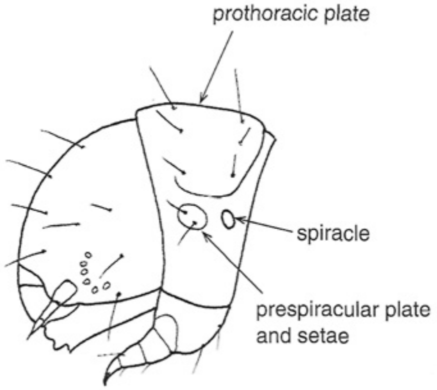


Fig. 132 Head and first thoracic segment of a pyralid larva - family Pyralidae.

(honeycomb moth); Phycitinae - *Ephestia elutella* (warehouse moth), *Plodia interpunctella* (Indian meal moth); Pyralinae - *Pyrolls farinalis* (meal moth); Pyraustinae - *Margaritia sticticalis (larva* = beet webworm), *Ostrinia nubilalis (larva* = European corn borer).

Superfamily PAPILIONOIDEA (butterflies)

Typically day-flying, colourful, broad-winged insects with slender antennae which, unlike those of other Lepidoptera, terminate in a distinct club **(Fig. 133);** labial palps long and often prominent;

Fig. 133 Antenna of a butterfly - family Pieridae.

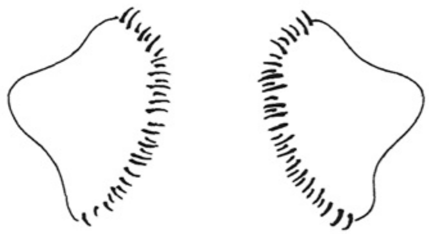


Fig. **134** Arrangement of crochets on a pair of abdominal prolegs of a pierid larva - family Pieridae.

frenulum absent; forelegs often reduced or otherwise modified.

25. Family PIERIDAE (p. 226 *et seq.)*

Usually mainly white-scaled butterflies, marked with black, yellow or orange; forelegs unmodified. Larvae elongate, the body bearing short setae; crochets on the abdominal prolegs biordinal or triordinal, arranged in a mesoseries **(Fig. 134);** setae on the head arising from raised tubercles (cf. family Lasiocampidae).

EXAMPLE: *Pieris brassicae* (large white butterfly).

Superfamily BOMBYCOIDEA

Tympanal organs absent; frenulum usually vestigial; antennae pectinate (in male, often strongly bipectinate); proboscis atrophied.

26. Family LASIOCAMPIDAE (p. 228)

Medium-sized to large, stout-bodied moths with bipectinate antennae in both sexes; frenulum vestigial. Larval body hairs mainly scattered but some may arise from verrucae; crochets on abdominal prolegs biordinal, arranged in a mesoseries; setae on the head not arising from raised tubercles (cf. family Pieridae).

EXAMPLE: *Malacosoma neustria* (lackey moth).

Superfamily GEOMETROIDEA

Mainly small or medium-sized moths, most often with narrow bodies and relatively large wings. Tympanal organs present in the abdomen.

27. Family GEOMETRIDAE (geometer moths) (p. 228 *et seq.)*

A very large family of mainly weak-flying moths, usually with both a frenulum and a proboscis; tympanal organs located at base of abdomen; relative to body, wings often large and, sometimes, butterfly-like but antennae either thread-like **(Fig. 135a)** or feathery **(Fig. 135b),** never clubbed; females sometimes wingless or with vestigial wings. Larvae typically long, thin and often twig-like **(Fig. 136),** progressing with a looping gait; most have just two pairs of functional abdominal prolegs (located on the sixth and tenth abdominal segments) **(Fig. 137a)** but rudimentary prolegs are sometimes present on the third, fourth and/or fifth abdominal segments (e.g. **Fig. 137b).**

EXAMPLES: Ennominae - *Abraxas grossulariata* (magpie moth), *Biston betularia* (peppered moth); Larentiinae - *Chloroclystis rectangulata* (green pug moth), *Operophtera brumata* (winter moth); Oenochrominae - *Alsophila aescularia* (March moth).

Superfamily SPHINGOIDEA

28. Family SPHINGIDAE (hawk moths) (p. 232)

Large, stout-bodied moths with long, narrow forewings and a well-developed, often very long, proboscis; antennae noticeably thickened towards or beyond the middle, with the apex pointed and often hooked **(Fig. 138);** frenulum well-developed; tympanal organs absent. Larvae stout-bodied and usually with a prominent dorsal

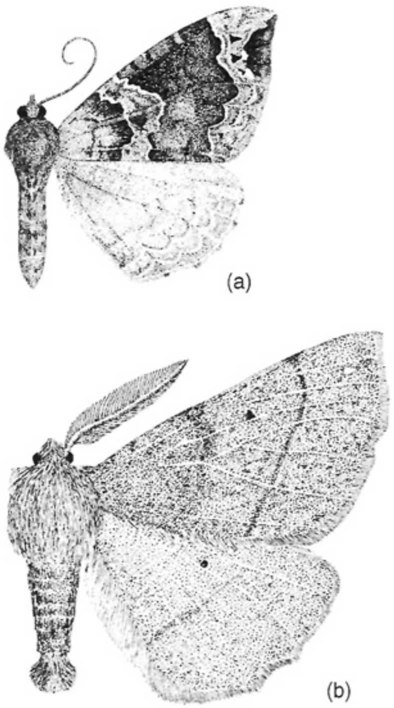


Fig. 135 Body and right-hand wings of geometrid moths - family Geometridae: (a) *Eulithis prunata:* (b) *Colotois pennaria* (x2).

horn on the eighth abdominal segment; skin often rough and finely warted; body hairs minute.

EXAMPLES: *Acherontia atropos* (death's head hawk moth), *Deilephila elpenor* (elephant hawk moth), *Smerinthus ocellata* (eyed hawk moth).

Superfamily NOTODONTOIDEA

29. Family NOTODONTIDAE

(p. 232 *et seq.)*

Medium-sized to large, stout-bodied moths with relatively long forewings; tympanal organs located in the metathorax. Larvae with crochets on abdominal prolegs uniordinal, forming a mesoseries; body hairs never arising in tufts; secondary setae present; anal claspers sometimes modified into filamentous processes; body form extremely variable.

EXAMPLES: *Cerura vinula* (puss moth), *Phalera bucephala* (buff-tip moth).

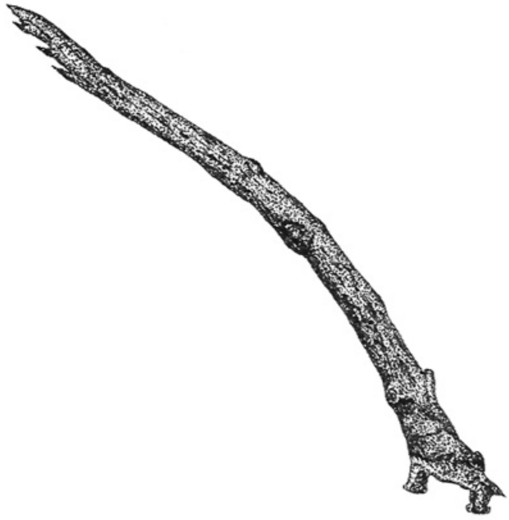


Fig. 136 Twig-like larva of a geometrid moth, *Ourapteryx sambucaria* - family Geometridae (x3).

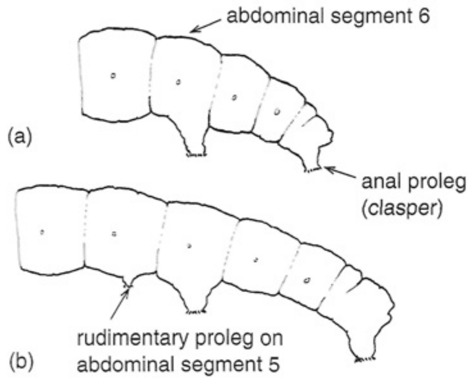


Fig. 137 The hind end of geometrid larvae - family Geometridae: (a) normal complement of prolegs; (b) larva with additional prolegs.

Superfamily NOCTUOIDEA

Medium-sized, stout-bodied moths; tympanal organs located in the metathorax.

30. Family LYMANTRIIDAE (p. 233 *et seq.)*

Medium-sized moths, often with a hairy appearance; females often with a distinct tuft of anal hairs used to cover their egg batches; proboscis absent. Larvae very hairy, either with distinct

Fig. **138** Antenna of a hawk moth - family Sphingidae.

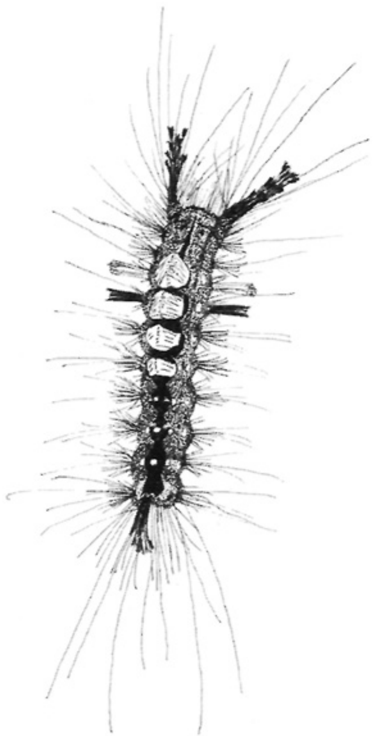


Fig. **139** A lymantriid larva with hair 'pencils'. *Orgyia antiqua* - family Lymantriidae (x2).

hair 'pencils' arising from the first to fourth abdominal segments **(Fig. 139)** or with eversible glands dorsally on the sixth and seventh abdominal segments; head often glabrous; body hairs often urticating.

EXAMPLES: *Euproctis chrysorrhoea* (brown-tail moth), *Lymantria dispar* (gypsy moth), *Orgyia antiqua* (vapourer moth).

Fig. **140** An ermine moth, *Spilosoma lutea* - family Arctiidae: subfamily Arctiinae (x2).

31. Family ARCTIIDAE (subfamily ARCTIINAE)

Medium to relatively large, stout-bodied, broad-winged moths, often conspicuously marked and brightly coloured; includes the ermine moth **(Fig. 140)** and tiger moths (Fig. **141);** proboscis present. Larvae very hairy, the hairs arising in tufts from verrucae, but with a glabrous, shiny head; crochets form a mesoseries on each abdominal proleg, with those at each end much reduced in size **(Fig. 115f).** Pupation occurs in a flimsy, silken cocoon incorporating the larval body hairs.

EXAMPLES: *Arctia caja* (garden tiger moth), *Spilosoma lutea* (buff ermine moth).

32. Family NOCTUIDAE (p. 234 *et seq.)*

The dominant family of Lepidoptera. Adults usually stout-bodied and powerful flyers, with a well-developed proboscis; most species are of drab appearance but some are brightly coloured; forewings often with a characteristic reniform stigma **(Fig. 142);** frenulum present. Larvae rarely hairy *(exception:* subfamily Acronictinae - hairs arising in tufts and body with distinct dorsal humps) and most possess five pairs of functional abdominal prolegs **(Fig. 143)** *(exception:* subfamily Plusiinae - larvae with just three pairs,

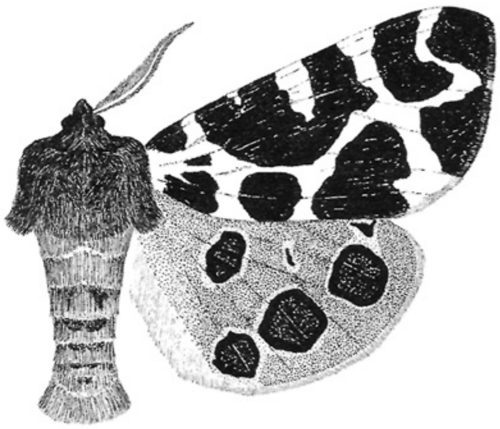


Fig. 141 A tiger moth, *Arctia caja* - family Arctiidae: subfamily Arctiinae (x2).

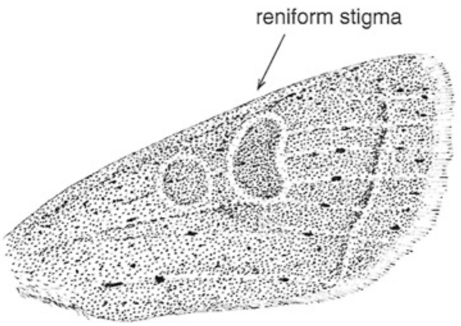


Fig. 142 Typical forewing pattern of a noctuid moth - family Noctuidae.

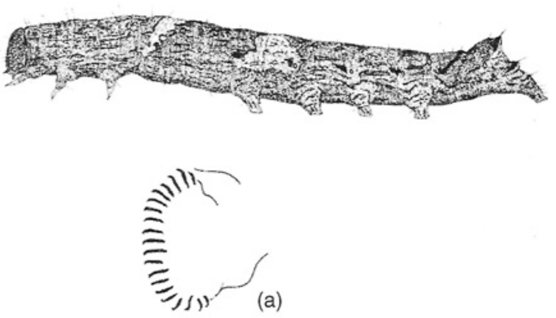


Fig. 143 A noctuid larva - family Noctuidae: (a) arrangement of crochets on an abdominal proleg.

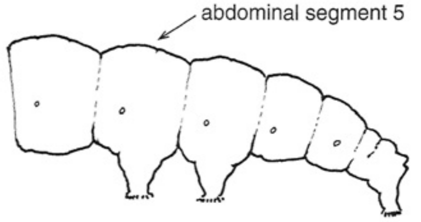


Fig. 144 Hind end of a noctuid larva - subfamily Plusiinae.

Fig. 144); crochets uniordinal, arranged in a mesoseries **(Fig. 143a);** spiracle on the eighth abdominal segment more than twice the size of that on the seventh; eighth abdominal segment sometimes elevated (e.g. Fig. 143) but not forming a horn (cf. family Sphingidae). Pupation usually occurs in the soil in an earthen cell, with or without forming a cocoon.

EXAMPLES: Acronictinae - *Hydraecia micacea* (rosy rustic moth); Amphipyrinae *Phlogophora meticulosa* (angle-shades moth); Hadeninae - *Lacanobia oleracea* (tomato moth), *Mamestra brassicae* (cabbage moth), *Orthosia incerta* (clouded drab moth); Heliothidinae - *Helicoverpa armigera (larva* = Old World bollworm); Noctuinae - *Agrotis segetum* (turnip moth); Plusiinae - *Autographa gamma* (silver y moth).

ORDER TRICHOPTERA (CADDIS FLIES)

Small to large insects, the wings covered with minute hairs; wings with few cross-veins and, in repose, held in a sloping roof-like posture; antennae long, thin and many-segmented; compound eyes small; ocelli present or absent; mouthparts often vestigial; maxillary palps long. Metamorphosis complete. Immature stages aquatic, the larvae usually inhabiting protective cases constructed from particles of sand or grit, pieces of vegetation or other debris; larvae campodeiform or eruciform; abdominal prolegs absent.

1. Family LIMNEPHILIDAE (p. 94 *et seq.)*

Associated mainly with slow-moving water; antennae about as long as forewings, each with a bulbous basal segment; ocelli present; fore tibiae each with one or no spurs. Larvae of various habits; larval cases made of sand grains, shells or pieces of plant tissue, and often very large.

EXAMPLES: *Halesus radiatus* (a pest of water-lilies and other aquatic ornamentals), *Limnephilus lunatus* (a pest of watercress).

ORDER HYMENOPTERA (ANTS, BEES, SAWFLIES, WASPS, ETC.)

Minute to large insects, usually with two pairs of membranous wings; wings usually transparent, with relatively few veins; hindwings the smaller pair and interlocked with the forewings by small hooks; mouthparts adapted for biting but often also for lapping and sucking; females with ovipositor modified for sawing, piercing or stinging. Metamorphosis complete. Eggs usually sausage-shaped and whitish in colour. Larvae usually apodous or eruciform, and usually with a well-developed head. Pupae exarate, rarely obtect, and usually formed in a cocoon.

Suborder SYMPHYTA

Abdomen attached broadly to the thorax, with no marked constriction between the first and second abdominal segments; fore tibiae nearly always with two apical spurs; ovipositor adapted for sawing or boring. Larvae with a well-developed, strongly chitinized head and thirteen body segments; usually with three pairs of thoracic and six or more pairs of abdominal prolegs (unlike lepidopterous larvae, the latter lack crochets); one pair of ocelli; spiracles present on the prothorax (rarely on the metathorax) and on the first eight abdominal segments; faeces are excreted throughout larval life.

Superfamily MEGALODONTOIDEA

Fore tibiae with two apical spurs.

1. Family PAMPHILIDAE (p. 245 *et seq.)*

Robust-bodied sawflies with a short ovipositor and long, filiform antennae; abdomen dorso-ventrally flattened. Larvae without abdominal prolegs but with prominent anal cerci **(Fig. 145);** leaf-rolling or web-forming and often gregarious.

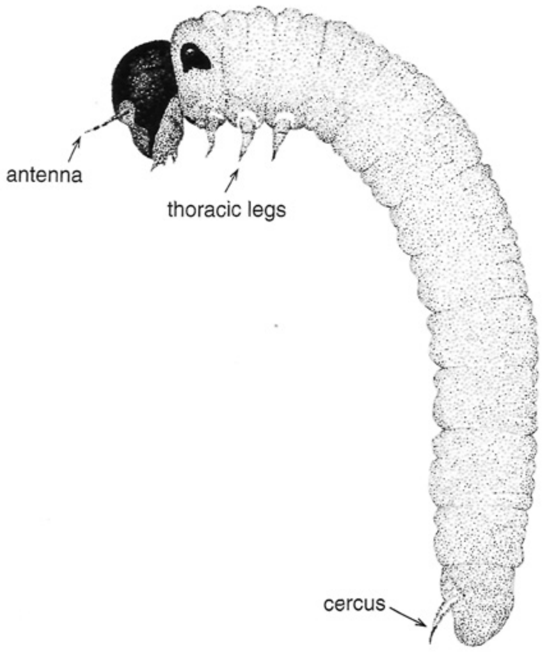


Fig. 145 Larva of a social pear sawfly, *Neurotoma saltuum* - family Pamphilidae (x5).

Fig. 146 Forewing of a wood-wasp - family Siricidae.

EXAMPLE: *Neurotoma saltuum* (social pear sawfly).

Superfamily SIRICOIDEA

Fore tibiae with either just one apical spur or with the second very small.

2. Family SIRICIDAE (wood-wasps)

Large, often conspicuously coloured insects; ovipositor very strong, projecting back horizontally in repose, as if a formidable sting; Rs vein of forewing recurved **(Fig. 146).** Larvae are wood-borers. This family includes various species of economic importance to the timber trade, including *Urocerus gigas* (giant wood-wasp), but none of agricultural significance.

Superfamily CEPHOIDEA

Fore tibiae with one apical spur; cenchri absent; abdomen constricted between the first and second segments.

3. Family CEPHIDAE (stem sawflies)
(p. 246 *et seq.)*

A small group of relatively small, mainly black, yellow-banded, slender-bodied sawflies with long, thread-like (filiform) antennae. Larvae apodous but with three pairs of small, leg-like thoracic tubercles; ocelli vestigial; metathoracic spiracles well developed; subanal appendages present but vestigial; abdomen terminating in a fleshy protuberance above the anus **(Fig. 147).** Larvae bore within shoots or stems, pupation

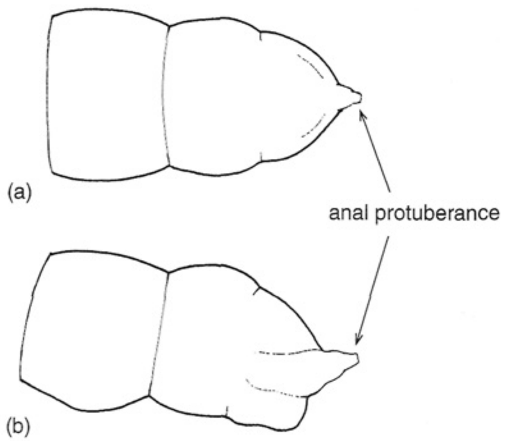


Fig. 147 Hind end of a sawfly larva - family Cephidae: (a) dorsal view; (b) left lateral view.

usually occurring in a transparent cocoon within the larval gallery.

EXAMPLE: *Cephus pygmeus* (wheat stem sawfly).

Superfamily TENTHREDINOIDEA

Fore tibiae with two apical spurs; cenchri present; ovipositor saw-like. Larvae usually with three pairs of thoracic legs and six to eight pairs of abdominal prolegs; prolegs without crochets (cf. Lepidoptera). Larvae entirely phytophagous, including many free-living species and leaf miners, usually pupating in silken cocoons.

4. Family ARGIDAE (p. 247)

Medium-sized, stout-bodied, slow-moving sawflies; antennae with three segments **(Fig. 148a),** the third long and often bifid; forewings without cross-vein 2r (cf. Fig. 149); cenchri particularly large. Larvae with six to eight pairs of abdominal prolegs.

EXAMPLE: *Arge ochropus* (large rose sawfly).

5. Family CIMBICIDAE

Relatively small to large, stout-bodied, fast-flying sawflies; antennae strongly clubbed

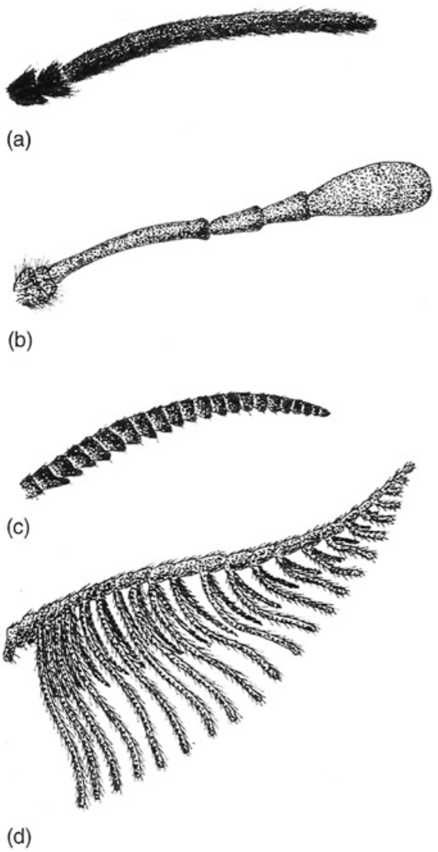


Fig. 148 Antennae of sawflies: (a) family Argidae (3-segmented); (b) family Cimbicidae (clavate); (c) family Diprionidae - female (serrate); (d) family Diprionidae - male (bipectinate).

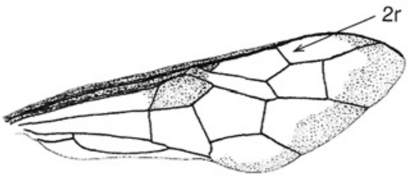


Fig. 149 Forewing of a cimbicid sawfly - family Cimbicidae.

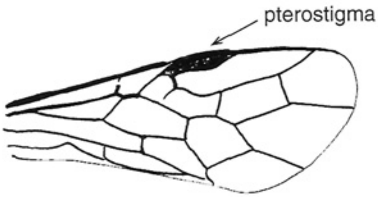


Fig. 150 Forewing of a pine sawfly - family Diprionidae.

Fig. 151 Antenna of an antler sawfly - family Tenthredinidae.

(Fig. 148b); cross-vein 2r of forewing present **(Fig. 149).** Larvae fleshy and usually remaining curled up when in repose; body often dusted with whitish wax.

EXAMPLE: *Cimbex femoratus* (large birch sawfly).

6. Family DIPRIONIDAE

Medium-sized, stout-bodied, slow-flying sawflies; antennae with more than nine segments, and more or less serrate (in females) **(Fig. 148c)** or bipectinate (in males) **(Fig. 148d);** forewings without cross-vein 2r, therefore, with an open cell below the pterostigma **(Fig. 150).** Larvae associated with conifers and typically gregarious; those of several species are destructive forestry pests and some are also associated with ornamental conifers.

EXAMPLES: *Diprion pini* (pine sawfly), *Neodiprion sertifer* (fox-coloured sawfly).

7. Family TENTHREDINIDAE
(p. 247 *et seq.*)

Small to medium-sized sawflies up to 20 mm long; antennae usually with nine segments; antennae simple, but projections present on basalmost segments in the genus *Cladius* **(Fig. 151);** thorax with a distinct postscutellum. A very diverse group, including many parthenogenetic species; eggs are usually laid in plant tissue, the female using her saw-like ovipositor **(Fig. 152)** to

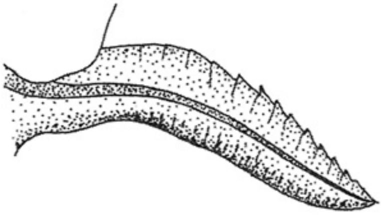


Fig. 152 Tip of ovipositor of a sawfly - family Tenthredinidae.

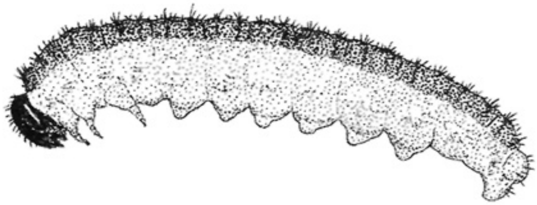


Fig. 153 A sawfly larva, *Priophorus morio* - family Tenthredinidae (x6).

cut small incisions in leaves, shoots, etc. Larvae eruciform, with three pairs of thoracic legs and, usually, six to eight pairs of abdominal prolegs **(Fig. 153);** extremely variable in appearance, ranging from cryptically coloured and brightly coloured, caterpillar-like types (sometimes armed with distinct spines or coated with waxen powder), to slug-like, slime-covered forms; entirely phytophagous, solitary or gregarious; usually free-living but some species are gall-inhabiting, leaf-mining or stem-boring.

EXAMPLES: Blennocampinae - *Athalia rosae* (turnip sawfly), *Blennocampa pusilla* (leaf-rolling rose sawfly), *Caliroa cerasi* (pear slug sawfly); Nematinae - *Cladius difformis* and *C. pectinicornis* (antler sawflies), *Croesus septentrionalis* (hazel sawfly), *Hoplocampa testudinea* (apple sawfly), *Nematus ribesii* (common gooseberry sawfly); Selandriinae - *Dolerus* spp. (pests of cereals and grasses).

Suborder APOCRITA

Abdomen typically with a deep constriction between the first (propodeum) and second abdominal segments (the part of the abdomen behind

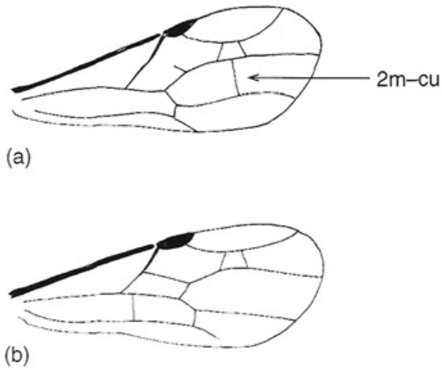


Fig. 154 Venation of the forewings of parasitoid wasps: (a) family Ichneumonidae; (b) family Braconidae.

this constriction being termed the 'gaster'); cenchri absent; fore tibiae usually with one spur. Larvae apodous; head often well developed but greatly reduced in some parasitic forms. Larvae of many species are carnivorous, being either ectoparasitoids or endoparasitoids; others are predacious and some feed on nectar and pollen; faeces are usually retained throughout larval development and ejected just before pupation (as the larval meconium).

This suborder divides into the PARASITICA (ovipositor modified for piercing or boring) and the ACULEATA (ovipositor modified for stinging) but this is not particularly satisfactory and use of superfamilies is more appropriate.

Superfamily ICHNEUMONOIDEA

The largest superfamily, members characterized by the presence of a pterostigma on each forewing; antennae long, filiform and usually with more than 16 segments; gaster attached at or near bottom of propodeum. All members have parasitic larvae.

8. Family ICHNEUMONIDAE (ichneumons)

Adults up to 37 mm long and distinguished by presence of forewing cross-vein 2m-cu **(Fig. 154a).** Larvae with 13-segmented body and, often, a caudal appendage (which may function as an egg-tooth, helping the first-instar larva to break out of the egg); early and later instars often very different in form; pupation usually occurs in a silken, often iridescent, cocoon. Most species are parasitoids of Lepidoptera but some attack Coleoptera.

EXAMPLES: *Diadegma fenestralis, Glypta* spp., *Ichneumon* spp., *Itoplectis* spp., *Lissonota* spp., *Ophion luteus* (yellow ophion), *Pimpla hypochondriaca* (red-legged ichneumon), *Scambus pomorum* (apple blossom weevil parasitoid).

9. Family BRACONIDAE (braconids)

Adults up to 15 mm long and forewing cross-vein 2m-cu absent **(Fig. 154b).** Larvae similar to those of ichneumonids, pupating within the host or externally in silken cocoons; they attack mainly Lepidoptera but also many other insects, including dipterous leaf miners.

EXAMPLES: *Apanteles* spp., *Bracon* spp., *Dacnusa* spp., *Macrocentrus* spp., *Meteorus* spp., *Microctonus* spp., *Microgaster* spp., *Perilitus* spp.

10. Family APHIDIIDAE

Parasitoids of aphids (often included within the family Braconidae).

EXAMPLES: *Aphidius* spp., *Diaeretiella rapae* (cabbage aphid parasitoid), *Ephedras* spp., *Praon* spp.

Superfamily CHALCIDOIDEA (chalcids)

Antennae geniculate, with one to three annuli (cf. superfamily Proctotrupoidea) and fewer than 14 segments; wings, when present, without a pterostigma and the venation much reduced; pronotum not extending back to the tegulae (cf. superfamily Proctotrupoidea). This superfamily contains the largest number of species, most of small size, and includes the smallest of all insects; most are parasitoids or hyperparasitoids, the former attacking mainly Hemiptera (notably scale insects), Diptera and Lepidoptera, especially lepidopterous eggs and larvae.

The main families of economic importance are as follows.

11. Family TORYMIDAE

Often brilliantly metallic-green, elongate-bodied chalcids with a very long ovipositor; hind coxae enlarged; hind femora sometimes toothed; tarsi 5-segmented. Mainly parasitoids of gall-forming insects, but family also includes some phytophagous species.

EXAMPLES: *Megastigmus* spp. (seed wasps), *Torymus bedeguaris* (a parasitoid in bedeguar galls on rose).

12. Family EURYTOMIDAE

Pronotum broad and quadrate; hind coxae not enlarged; hind femora untoothed. An exceedingly variable family, including parasitic and phytophagous species.

EXAMPLE: *Eurytoma orchidearum* (orchid wasp).

13. Family PTEROMALIDAE

Extremely variable chalcids, often metallic-coloured with the gaster often more or less triangular in profile (Fig. **155);** pronotum narrow; hind coxae not enlarged; hind femora untoothed; tarsi 5-segmented; wings without hair fringes, the venation characteristic **(Fig. 156a).** Includes parasitoids of many insect groups, including various crop pests.

EXAMPLES: *Pteromalus puparum* (large white butterfly parasitoid), *Trichomalus perfectus* (cabbage seed weevil parasitoid).

14. Family ENCYRTIDAE

A distinct group of chalcids, characterized by the much enlarged spur on each mid tibia (Fig. **157);** forewing venation entirely separated from the wing margin **(Fig. 156b).** Most are parasitoids of insects, especially Hemiptera and Lepidoptera; some species exhibit polyembryony.

EXAMPLES: *Copidosoma flavomaculatum* (pith moth parasitoid), *Litomastix aretas* (strawberry tortrix moth parasitoid).

15. Family APHELINIDAE

Mainly black-bodied chalcids with venation of the forewing lying mainly along the front margin **(Fig. 156c);** tarsi 5-segmented.

EXAMPLES: *Aphelinus mali* (woolly aphid parasitoid), *Aphytis mytilaspidis* (mussel scale parasitoid), *Encarsia formosa* (glasshouse whiteny parasitoid).

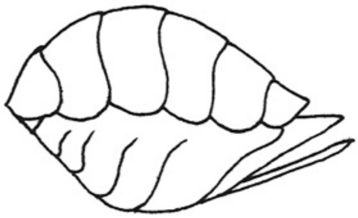


Fig. 155 Left lateral view of the abdomen of a pteromalid wasp - family Pteromalidae.

16. Family EULOPHIDAE

Tarsi 4-segmented; wing pubescence irregular. Most species are 1-3 mm long and parasitoids of leaf-mining insects, including many crop pests.

EXAMPLES: *Chrysocharis prodice* (apple pygmy moth parasitoid), *Diglyphus* spp., *Eulophus pennicornis* (brassy tombstone chalcid), *Tetrastichus asparagi* (asparagus beetle parasitoid).

17. Family TRICHOGRAMMATIDAE

Tarsi 3-segmented; forewings broad, the venation S-shaped **(Fig. 156d);** wing pubescence arranged in distinct lines; hindwings very narrow; hair fringes short; constriction between propodeum and gaster secondary. All species are minute (0.3-1.0 mm long) and parasitoids of insect eggs.

EXAMPLE: *Trichogramma evanescens* (a parasitoid of many lepidopterous pests).

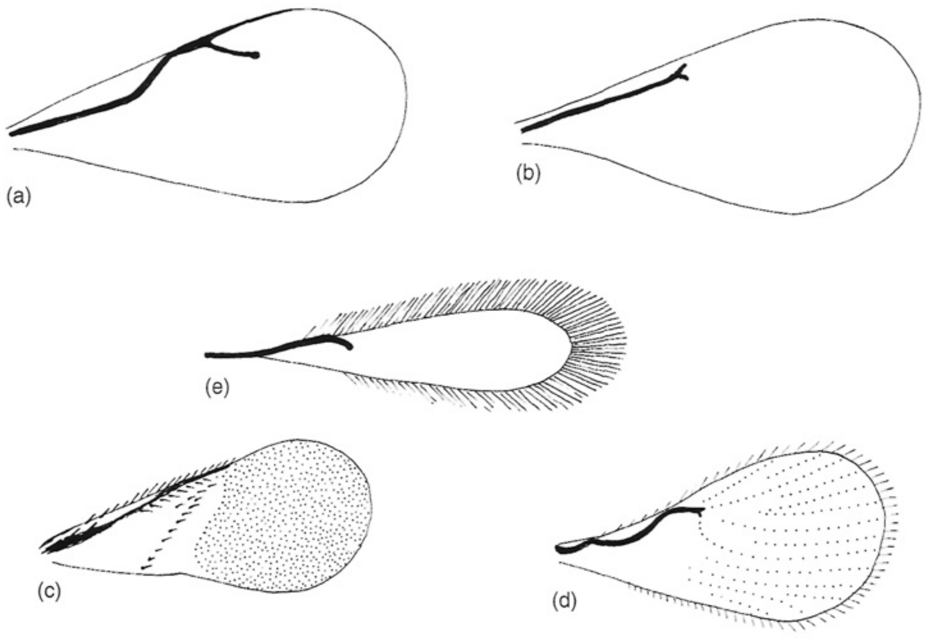


Fig. 156 Venation of the forewings of chalcid wasps: (a) family Pteromalidae; (b) family Encyrtidae; (c) family Aphelinidae; (d) family Trichogrammatidae; (e) family Mymaridae.

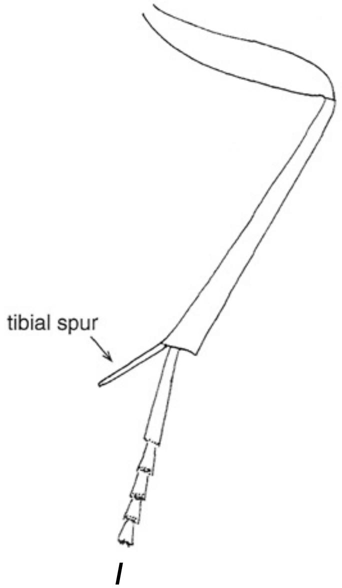


Fig. 157 Mid-leg of an encyrtid wasp - family Encyrtidae.

Fig. **158** Venation of the forewing of a cynipid wasp - superfamily Cynipoidea.

18. Family MYMARIDAE (fairy flies)

Minute chalcids (many less than 0.25 mm long) with linear, stalked wings **(Fig. 156e);** mainly black or yellow and non-metallic; scape of antenna short; ovipositor arising near tip of gaster. All species are egg parasitoids.

EXAMPLE: *Anagrus atomus* (glasshouse leafhopper parasitoid).

Superfamily PROCTOTRUPOIDEA

A very large group of minute or small, black and slender-bodied parasitoids, with a much reduced wing venation; a pterostigma sometimes present; apterous forms common; antennae without annuli (cf. superfamily Chalcidoidea), usually 10- to 12-segmented, the apical four or five segments often forming a slight club; pronotum reaching back to the tegulae (cf. superfamily Chalcidoidea) and the ovipositor arising from the extreme tip of the gaster, features shared by certain members of the Aculeata (e.g. superfamily Vespoidea); front tibiae each with one spur (cf. superfamily Ceraphronoidea).

19. Family PLATYGASTERIDAE

Antennae usually 10-segmented. Primarily parasitoids of gall midges (family Cecidomyiidae).

EXAMPLES: *Platygaster oebalus* (brassica pod midge parasitoid), *Platygaster zosine* (hessian fly parasitoid).

Superfamily CYNIPOIDEA (cynipids)

Minute or small, mainly black insects; antennae not geniculate, those of females usually 13-segmented (males 14- or 15-segmented); wings, when present, without a pterostigma; venation often reduced and rather characteristic **(Fig. 158);** gaster compressed laterally. Larvae apodous and maggot-like, pupating without forming a cocoon. Includes parasitic and gall-forming species, and also many gall-inhabiting inquilines.

20. Family CYNIPIDAE

Mainly gall-forming cynipids, often with very complex life-cycles; gastral tergites 2 and 3 form the bulk of the gaster. Many species are associated with forest and ornamental trees and shrubs.

EXAMPLES: *Andricus kollari* (marble gall wasp), *Diplolepis rosae* (bedeguar gall wasp), *Neuroterus quercusbaccarum* (oak leaf spangle-gall cynipid).

Superfamily SCOLIOIDEA

Includes various parasitic species with formidable stings.

Fig. 159 Thorax and part of gaster of an ant - family Formicidae (petiole shaded).

21. Family MUTILLIDAE (velvet ants)

Parasitic insects with a hard, black and red body shell; body partly clothed in a silvery, velvet-like pubescence; females apterous and superficially ant-like; males usually winged.

EXAMPLE: *Mutilla europaea,* a parasitoid of bumblebees.

Superfamily FORMICOIDEA

Includes a single family, nowadays often included in the superfamily Scolioidea.

22. Family FORMICIDAE (ants)
(p. 253 *et seq.)*

Antennae geniculate and usually 4- to 13-segmented; first or first and second gastral segments small but often with distinctive outgrowths **(Fig. 159).** Ants are colony-inhabiting, social insects with a caste system including males, females (queens) and workers.

EXAMPLE: *Easius flavus* (yellow meadow ant).

Superfamily VESPOIDEA (wasps)
23. Family VESPIDAE (wasps)
(p. 253 *et seq.)*

Eyes deeply notched **(Fig. 160);** wings folded longitudinally when in repose; antennae usually 12- or 13-segmented; pronotum extending back to tegulae. Wasp larvae are carnivorous, but adults feed on nectar and other sugary substances. The family includes solitary and social species. Social wasps of the genus *Vespula* are of particular economic significance (primarily as important predators but also as minor pests).

EXAMPLES: *Vespa crabro* (hornet), *Vespula vulgaris* (common wasp).

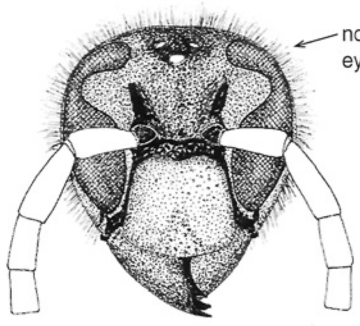


Fig. 160 Head of a wasp - family Vespidae.

Superfamily APOIDEA (bees)

Medium-sized to large, usually distinctly hairy solitary or social insects. Body hairs typically branched or plumose; hind tarsi usually broad and often densely hairy; antennae 10-, 12- or 13-segmented. Adults and larvae feed on nectar (some also on honey) and pollen. Most bees, whether solitary or social, are useful pollinators of flowering plants and several species are used commercially. The following families are of greatest economic importance.

24. Family ANDRENIDAE

Females with densely hairy femora and tibiae; tongue usually short and ovate.

EXAMPLE: *Andrena fulva* (tawny burrowing bee) - although a useful pollinator, this species can be a nuisance when its nesting burrows are formed in lawns and bowling greens or in sandy banks in public places.

25. Family ANTHOPHORIDAE
(flower bees)

Densely hairy, bumblebee-like species but compound eyes extending down sides of head to the mandibles **(Fig. 161)** and hind femur

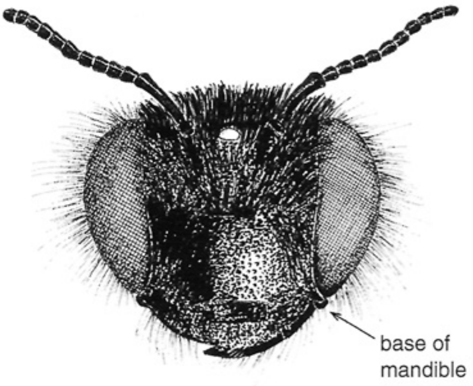


Fig. 161 Head of a flower bee - family Anthophoridae.

of female not forming a corbiculum (cf. Fig. 162).

EXAMPLE: *Anthophora retusa* (a flower bee).

26. Family MEGACHILIDAE

Females (apart from parasitic species) with pollen-collecting hairs located on the gastral sternites to form a ventral scopa.

EXAMPLES: *Megachile centuncularis* (common leaf cutter bee), *Osmia rufa* (mason bee); the former species often damages rose bushes, and certain other ornamental plants, by cutting out leaf segments for use in its brood chambers.

27. Family APIDAE

Pollen-collecting apparatus (corbiculum) of female located on the hindleg **(Fig. 162);** tongue long to very long; compound eyes separated from the mandibles by distinct cheeks (genae) **(Fig. 163).** Members of this family are typically social, colony-inhabiting species with a worker caste.

EXAMPLES: Apinae - *Apis mellifera* (honey bee); Bombinae - *Bombus* spp. (bumblebees), *Psithyrus* spp. (cuckoo bumblebees).

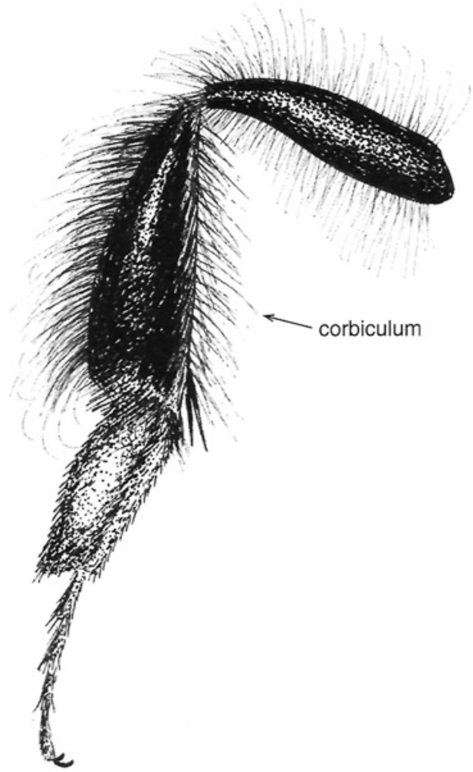


Fig. 162 Left hindleg of a worker bumblebee family Apidae.

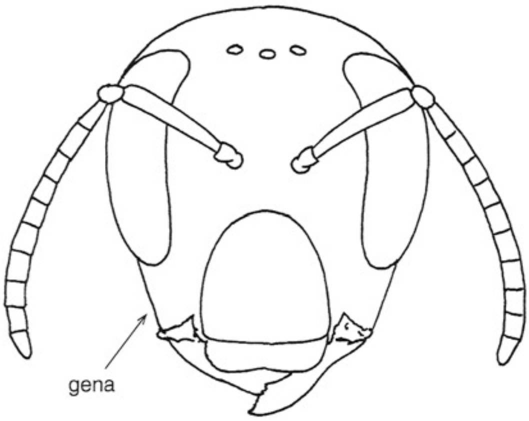


Fig. 163 Head of a bumblebee - family Apidae.

Mites

Mites form a subclass, known as the Acari, within the class Arachnida (phylum Arthropoda). The Arachnida also includes, for example, harvestmen (subclass Opiliones), spiders (subclass Araneida) and scorpions (subclass Scorpionida).

EXTERNAL FEATURES

Members of the Acari are minute or small arachnids and, although sharing many features of insects, usually lack obvious body segmentation. Unlike insects, mites have no antennae, compound eyes or wings; also, the body of a mite is composed of just two main sections: a gnathosoma (which bears a pair of segmented pedipalps and the mouthparts - including, ventrally, a beak-like hypostome) and a sac-like idiosoma (which bears the legs).

The pedipalps have up to five main segments: trochanter, femur, genu, tibia, tarsus, the tarsal segment often bearing at its basal inner angle an articulating, two-, three- or four-pronged sixth segment called the apotele **(Fig. 164).** The mouthparts of mites are adapted for biting or piercing and usually include a pair of, often chelate (for grasping) or needle-like (for piercing), chelicerae; the chelicerae often terminate in one fixed and one moveable, thumb-like digit, and often coalesce to form a needle-like stylophore.

Adult mites, unlike insects, are usually 8-legged, and each leg has up to six segments: coxa, trochanter, femur, genu, tibia and tarsus **(Fig. 165);** also, the legs often end in a soft ambulacrum (which may comprise a pretarsus and a pad-like pulvillus), at the tip of which may

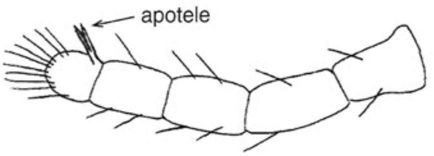


Fig. 164 Segmentation of the pedipalp of a mite.

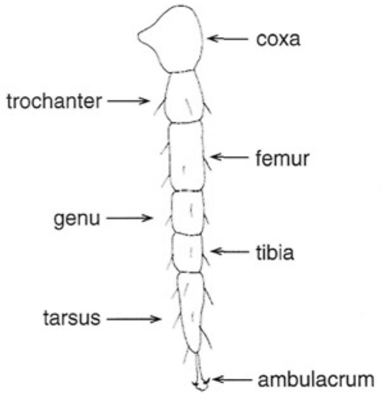


Fig. 165 Segmentation of the leg of a mite.

be inserted one or more claws; the ambulacrum on leg I may be small or absent. In some groups of mites, the idiosoma is subdivided by a sejugal furrow into an anterior propodosoma and a posterior hysterosoma **(Fig. 166),** each bearing two pairs of legs. Mites within the superfamily Eriophyoidea (order Prostigmata) possess just two pairs of legs, both of which arise from the propodosoma. Ocelli, when present, are located on the propodosoma.

The body of a mite often bears more or less sclerotized plates (shields) and these are useful for distinguishing between various groups. Identification of mites, however, usually requires high-powered microscopical examination; detailed examination of setae on the body and appendages (chaetotaxy) is of particular importance but is a specialist task and beyond the scope of the present work. Features of the shield which overlies the propodosoma of eriophyid mites (in the present work termed the prodorsal shield - also widely known as the cephalothoracic shield, the dorsal shield and the propodosomal shield), and the number and orientation of the setae arising from it, are of considerable taxonomic significance; although brief mention of the more gross features is made in the specific descriptions (see Part II, p. 255 *et seq.)*, their full appreciation requires the use of a scanning electron microscope.

INTERNAL FEATURES

Apart from bearing the pedipalps and the mouthparts, the gnathosoma is little more than a tube through which the foregut passes into the idiosoma. It does not contain a brain, the nervous system of a mite being located within the propodosoma and, typically, forming a ring of nervous tissue (the central nerve mass) around the pharynx. The alimentary canal includes a pharynx, an elongated oesophagus, a mid-gut (ventriculus) and a hindgut, the anterior part of which may include several Malpighian-like tubules.

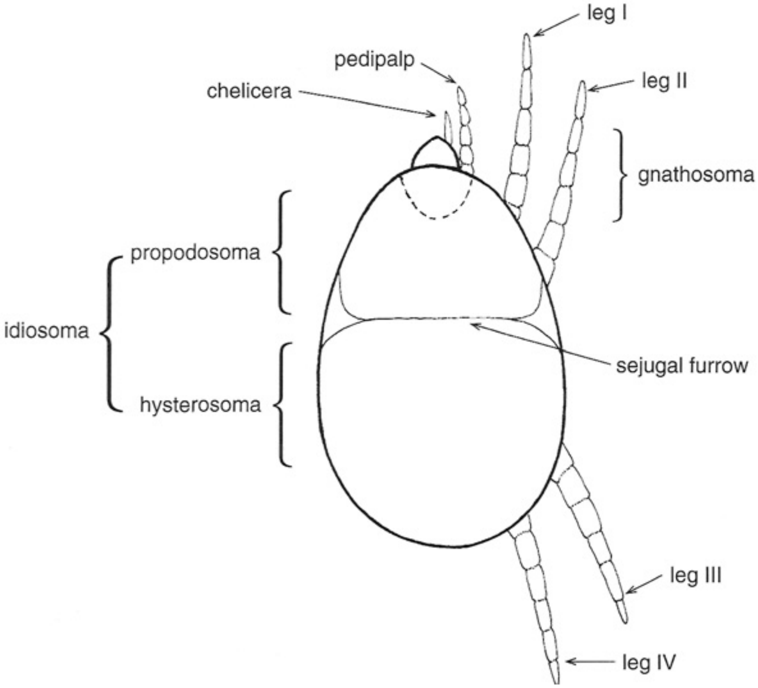


Fig. 166 General structure of a mite.

The respiratory system varies considerably. Mites with a tracheal system have spiracular openings (stigmata) whose number and position on the body may vary from order to order. Mites that lack a tracheal system effect gaseous exchange thorough their integument.

The reproductive organs are located midventrally within the idiosoma, their exact position varying considerably. In some mites they lie close to the tip of the hysterosoma (i.e. they occur distally); in others they may occur immediately just behind the gnathosoma at the anterior part of the propodosoma (i.e. they occur proximally). In eriophyid mites, they are located at the anterior part of the hysterosoma, just behind the coxae and, in females, are concealed by a distinctive flap (genital flap), the features of which (microscopically) are often of taxonomic value.

DEVELOPMENT AND GROWTH

Most mites develop through an egg stage, a 6-legged so-called 'larval' stage and one, two or three 8-legged nymphal stages: protonymphs, deutonymphs and tritonymphs, respectively. There are notable exceptions, for example: (a) in the superfamily Eriophyoidea there is no larval stage; also, the adults and nymphs have just two pairs of legs; (b) in the family Tarsonemidae (order Prostigmata) the 6-legged larva, when fully fed, typically develops to adulthood through a sedentary and non-feeding, pupa-like (quiescent nymphal) stage that is retained within the bloated, cast-off skin of the larva - this is reminiscent of the puparium found in certain Diptera.

CLASSIFICATION OF THE SUBCLASS ACARI

Several classifications, often based partly on the location on the body of a pair of breathing pores (the stigmata), have been proposed for mites; these include various combinations of superorders, orders and suborders. Mites (often cited as the Acarina) have also been regarded merely as an order within the Arachnida.

Table 2 shows a relatively simple classification which maintains names familiar to many agricultural zoologists (for clarification, frequently used alternative names are indicated). Features of the main groups of mites of agricultural or horticultural significance in northern Europe are summarized below.

ORDER MESOSTIGMATA

A large, diverse group of mites, including many predacious species, most inhabiting soil or decaying organic material; a single pair of stigmata sited laterally or dorsolaterally, close to coxae II-IV; pedipalps 5-segmented; hypostome without teeth; ocelli absent. Most species are free-living but some are adapted for life as parasites of animals. Adults 0.2-2.0 mm long.

1. Family DERMANYSSIDAE

Oval or egg-shaped mites with, in females, either a divided or an undivided dorsal shield; if divided then the posterior section minute; dorsal shield with more than 30 pairs of setae; chelicerae often very long and needle-like. Obligate parasites of vertebrates, especially birds.

Table 2 Classification of the subclass Acari.

Superorder ANACTINOTRICHIDA (= PARASITIFORMES)

Small to large, usually heavily sclerotized mites with body setae and leg setae non-birefringent under polarized light; idiosoma with a suture (i.e. no sejugal furrow) between legs II and III; coxae of legs not fused to the idiosoma.

- **Order NOTOSTIGMATA** (= Opilioacarida) - *a small group of uncertain relationship, not found in northern Europe.*
- **Order HOLOTHYRIDA** (= Holothyroidea; = Tetrastigmata) - *a small group of possibly predatory mites, not found in Europe.*
- **Order MESOSTIGMATA** (= Gamasida) (p. 77 *et seq.)*
- **Order IXODIDA** (= Ixodides; = Metastigmata) (p. 79)

Superorder ACTINOTRICHIDA (= ACARIFORMES)

Mites with body setae and leg setae birefringent under polarized light; idiosoma usually with a sejugal furrow between legs II and III, separating the propodosoma from the hysterosoma; coxae of legs fused to the idiosoma. Usually weakly sclerotized mites (except for most oribatids).

- **Order PROSTIGMATA** (= Actinedida + Tarsonemida; = Trombidiformes) (p. 79 *et seq.;* p. 225 *et seq.)*
- **Order ASTIGMATA** (= Acarida; = Sarcoptiformes *in part)* (p. 83 *et seq.;* p. 269 *et seq.)*
- **Order CRYPTOSTIGMATA** (= Oribatida; = Sarcoptiformes *in part)* (p. 84; p. 270 *et seq.)*

EXAMPLES: *Dermanyssus gallinae* (chicken mite), *Ornithonyssus sylviarum* (northern fowl mite).

2. Family PHYTOSEIIDAE

Oval to elongate-oval, plant-dwelling mites with fewer than 20 pairs of dorsal-shield setae **(Fig. 167);** dorsal shield weakly sclerotized but covering the idiosoma and undivided; pedipalpal tarsus with a specialized two-pronged apotele. Phytoseiids are of considerable economic importance; several species are of significance as predators of small invertebrate pests, especially gall mites and spider mites.

EXAMPLES: *Amblyseius* spp., *Typhlodromus* spp., *Phytoseiulus persimilis* (two-spotted spider mite predator).

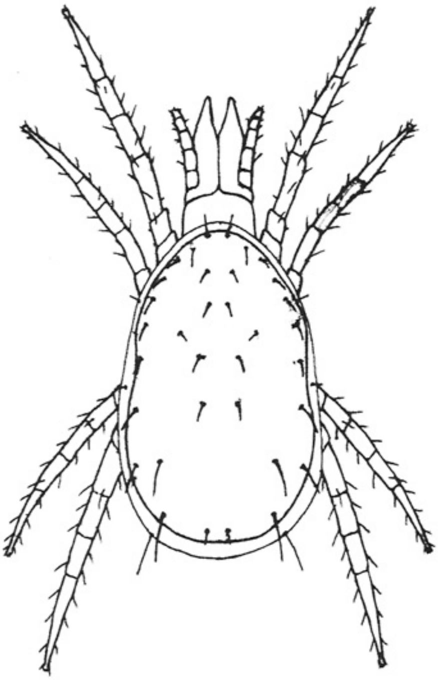


Fig. 167 A phytoseiid mite, *Typhlodromus pyri* - family Phytoseiidae (xl50).

3. Family LAELAPTIDAE

A group of free-living (often predatory) or parasitic, usually brownish mites, many of the parasitic forms being highly specialized. Dorsal shield undivided and usually with more than 30 pairs of setae; pedipalpal tarsus with a specialized two-pronged apotele.

EXAMPLES: *Androlaelaps casalis* (poultry litter mite); *Varroa jacobsoni*, a parasite of honey bees.

4. Family PARASITIDAE

Oval (although sometimes somewhat pointed anteriorly), usually heavily sclerotized, reddish-brown or yellowish-brown mites; dorsal shield covering the idiosoma, and either undivided or subdivided transversely into two; females with a large metasternal shield; pedipalpal tarsus with a specialized three-pronged apotele. Parasitid mites are especially numerous in the soil leaf-litter layer, the family including both detritus-feeding and predatory species.

EXAMPLES: *Parasitus* spp., including some that are abundant in mushroom beds.

ORDER IXODIDA (TICKS)

A major group of blood-sucking external parasites, associated with vertebrates (but not fish) and known collectively as ticks; includes the largest of all mites (adults of some species are up to 30 mm or more in length when fully engorged with blood from the host). Gnathosoma with a well-developed hypostome, armed with numerous barb-like teeth; ocelli present or absent.

1. Family IXODIDAE (hard ticks)

Idiosoma partly (in males almost entirely) covered dorsally by a sclerotized, leathery scutum; gnathosoma clearly visible from above (unless tick fully engorged); body oval or pyriform. Several species are of considerable economic importance, some being vectors of the organisms that cause, for example, the arboviral disease Lyme disease and the rickettsial diseases louping ill and Q fever.

EXAMPLE: *Ixodes ricinus* (sheep tick).

2. Family ARGASIDAE (soft ticks)

Ticks usually without a distinct scutum; gnathosoma placed ventrally and visible from above only during the larval stage; coxae without spurs; body oval or rounded. Soft ticks are parasites of bats and birds, and are of considerable economic importance.

EXAMPLE: *Argas persicus* (fowl tick).

ORDER PROSTIGMATA

Adults usually weakly sclerotized and most ranging from 0.1 to 1.0 mm in length, although some species are considerably larger; stigmata, when present, located between the chelicerae or dorsally on the propodosoma; chelicerae either chelate or needle-like but sometimes reduced; pedipalps usually 3- to 5-segmented, the tibia and tarsus often forming a distinct 'thumb-claw'; ocelli present or absent. This is the main group of phytophagous mites and includes many important pests, some of which are vectors of plant virus diseases; superfamilies are indicated below but not defined.

Superfamily ERIOPHYOIDEA (gall mites)

1. Family PHYTOPTIDAE (p. 255)

Minute, vermiform (worm-like) mites up to 0.2mm long; two pairs of legs, located anteriorly; propodosoma forming a shield-like structure (the prodorsal shield) which bears three or four setae **(Fig. 168a);** hysterosoma elongated and annulated; feather-claws (see Fig. 169a) simple. Includes gall-forming and free-living species.

EXAMPLE: *Phytoptus avellanae* (filbert bud mite).

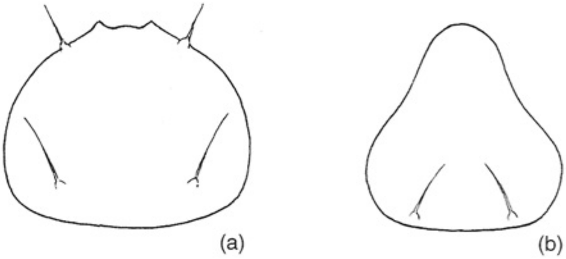


Fig. 168 Prodorsal shield of eriophyid mites: (a) family Phytoptidae; (b) family Eriophyidae.

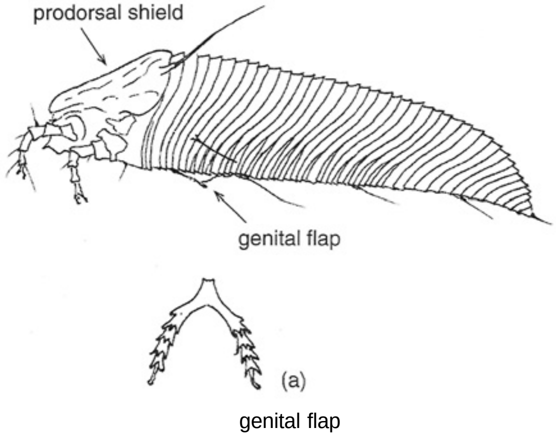


Fig. 169 A female gall mite - family Eriophyidae: (a) feather claw.

2. Family ERIOPHYIDAE (gall mites) (p. 255 *et seq.)*

Minute, fusiform, pyriform or vermiform mites up to 0.2mm long; two pairs of legs, located anteriorly; propodosoma forming a shield-like structure (the prodorsal shield) which bears two or no setae **(Fig. 168b)** and is often characteristically shaped or sculptured; hysterosoma elongated and annulated, with numerous tergites and sternites, the latter frequently occurring in greater numbers **(Fig. 169)** (in the subfamily Phyllocoptinae - hysterosoma often with relatively few, very broad tergites); feather-claws either simple or divided **(Fig. 169a).** Includes free-living and gall-forming species, and gall-inhabiting inquilines.

EXAMPLES: Cecidophyinae - *Cecidophyopsis ribis* (black currant gall mite), *Colomerus vitis* (vine leaf blister mite); Eriophyinae - *Acalitus essigi* (blackberry mite), *Aceria lycopersici* (tomato erineum mite), *Eriophyes pyri* (pear leaf blister mite); Phyllocoptinae - *Abacarus hystrix* (cereal rust mite), *A cuius schlechtendali* (apple rust mite), *Phyllocoptes gracilis* (raspberry leaf & bud mite).

Superfamily TARSONEMOIDEA

3. Family SCUTACARIDAE

Minute mites with an anterior dorsal plate forming a roof-like shield (scutum) over the gnathosoma; hindlegs of female elongated and each bearing several whip-like setae. Includes some highly specialized insect-parasitic species.

EXAMPLE: *Acarapis woodi* (acarine disease mite), a well-known parasite of honey bees.

4. Family TROMBICULIDAE

Small (up to I mm long), oval to broadly dumb-bell-shaped, superficially spider-like mites with a dorsal scutum. Adults and nymphs are free-living but larvae are parasitic on warm-blooded vertebrates, including farm animals and man.

EXAMPLE: *Neotrombicula autumnalis* (harvest mite).

5. Family TARSONEMIDAE (tarsonemid mites) (p. 260 *et seq.)*

Small, often transparent, brownish to whitish, barrel-shaped mites; chelicerae short and needle-like; hindlegs of female reduced and without claws **(Fig. 170);** hindlegs of male 3-segmented, robust and often clasper-like, each terminating in a stout claw and often bearing a distinctive inwardly directed flange **(Fig. 171).**

EXAMPLES: *Phytonemus pallidus* (cyclamen mite); *Polyphagotarsonemus latus* (broad mite).

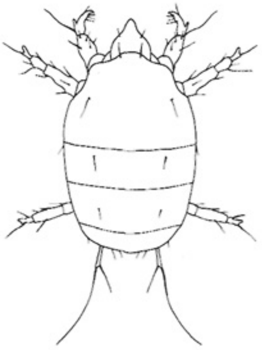


Fig. 170 A female tarsonemid mite - family Tarsonemidae (xlOO).

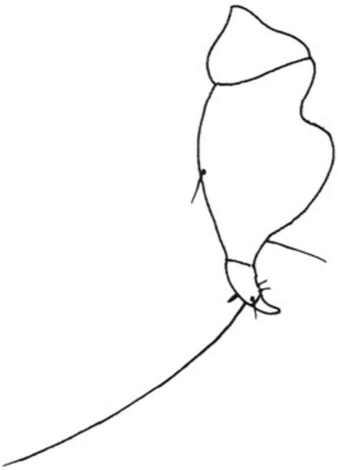


Fig. **171** Hindleg of a male tarsonemid mite - family Tarsonemidae.

6. Family PYGMEPHORIDAE (red pepper mites) (p. 264)

Small, tarsonemid-like mites but hindlegs well developed in both sexes, in the male 5-segmented; gnathosoma of male reduced and apparently non-functional.

EXAMPLE: *Pygmephorus mesembrinae.*

Superfamily EUPODOIDEA
7. Family EUPODIDAE (p. 264 *et seq.)*

Small (0.2-1.0mm long), greenish or yellowish, very active mites with reddish, or red and black-flecked, legs; body pyriform (and pointed posteriorly), soft and striated; propodosoma with a pair of lateral eye spots; chelicerae with a styliform moveable digit, the fixed digit terminating in several finger-like processes; legs each with two claws; setae short and serrated.

EXAMPLE: *Penthaleus major* (red-legged earth mite).

Superfamily TYDEOIDEA
8. Family TYDEIDAE

Small (0.2-0.3 mm long), very active, short-legged, often diamond-shaped or egg-shaped mites; pedipalps 4-segmented, without a distinct claw; chelicerae each with a styliform moveable digit. Body yellowish, pale brown, pale red or whitish but only weakly coloured. Of various habits and often predacious on other mites and small insects.

EXAMPLE: *Tydeus interruptus.*

Superfamily RAPHIGNATHOIDEA
9. Family STIGMAEIDAE

Small (0.5mm long), rather sedentary, relatively short-legged, diamond-shaped mites; pedipalps with a tibial claw. Minor predators of other mites, including gall mites, rust mites and spider mites.

EXAMPLE: *Zetzellia mail*

Superfamily TETRANYCHOIDEA
10. Family TETRANYCHIDAE (spider mites) (p. 265 *et seq.)*

Spider-like **(Fig. 172),** often reddish or greenish mites; pedipalps robust, 5-segmented and with both a tibial claw and a spinneret (therefore, capable of producing silken webbing); chelicerae

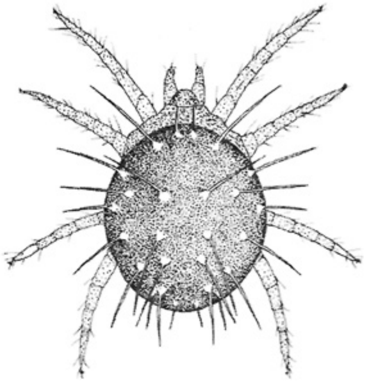


Fig. 172 A spider mite, *Panonychiis ulmi* - family Tetranychidae (x75).

Fig. 174 A whirligig mite, *Anystis agilis* - family Anystidae (x20).

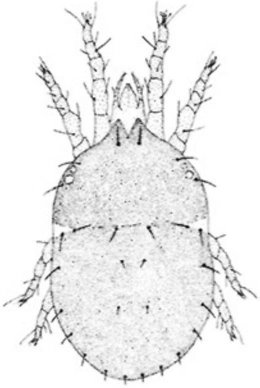


Fig. 173 A false spider mite, *Cenopalpus pulcher* - family Tenuipalpidae (xlOO).

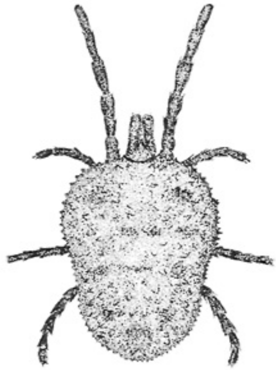


Fig. 175 A red velvet mite, *Allothrombium fuliginosum* - family Trombidiidae (xlO).

fused, each with the moveable digit forming a long, piercing stylophore.

EXAMPLES: Bryobiinae - *Bryobia praetiosa* (clover bryobia mite), *Petrobia latens* (stone mite); Tetranychinae - *Eotetranychus tiliarium* (lime mite), *Oligonychus ununguis* (conifer spinning mite), *Panonychiis ulmi* (fruit tree red spider mite), *Tetranychus urticae* (two-spotted spider mite).

11. Family TENUIPALPIDAE
(false spider mites) (p. 268 *et seq.)*

Small (0.2-0.3 mm long), reddish, polyphagous mites **(Fig. 173);** similar to tetranychids but pedipalps slender, 1- to 5-segmented, and lacking both a tibial claw and a spinneret.

EXAMPLES: *Brevipalpus* spp.; *Cenopalpus pulcher* (flat scarlet mite).

Superfamily ANYSTOIDEA
12. Family ANYSTIDAE

Very active, dark red mites (0.5-1.3 mm long), with long legs radiating from a hub-like body **(Fig. 174);** legs with numerous setae. Predacious on other mites and small insects.

EXAMPLE: *Anystis agilis* (whirligig mite).

Superfamily DEMODICOIDEA
13. Family DEMODICIDAE

Minute (0.1-0.4mm long), vermiform, distinctly annulated, almost colourless mites; legs very short and stumpy, located anteriorly; chelicerae stylet-like. The mites inhabit the hair follicles of mammals, including those of man.

EXAMPLES: *Demodex bovis* (cattle follicle mite), *Dermodex equi* (horse follicle mite).

Superfamily TROMBIDIOIDEA
14. Family TROMBIDIIDAE

Relatively large (2-3 mm long), plump, spider-like mites with a velvet-like appearance, owing to the dense coat of setae on the body and legs **(Fig. 175).** Predacious on various insects.

EXAMPLE: *Allothrombium fuliginosum* (red velvet mite).

ORDER ASTIGMATA

Weakly sclerotized, whitish or pale brown mites without stigmata or tracheae; pedipalps small, 2-segmented and inconspicuous; chelicerae distinctly chelate; idiosoma usually oval and with no obvious segmentation, although sometimes with a slight groove between the propodosoma and hysterosoma; ocelli usually absent. Terrestrial mites, including parasitic, predatory and phytophagous species. Adults 0.2-1.5 mm long.

1. Family ACARIDAE (p. 269 *et seq.)*

Pearly-white or translucent, smooth-bodied mites; some body setae often very long; propodosoma and hysterosoma separated by a sejugal furrow **(Fig. 176).** Often associated with damp, mouldy or rotting plant tissue and breeding amongst stored farm products.

EXAMPLES: *Acarus siro* (flour mite), *Gohieria fusca* (brown flour mite), *Rhizoglyphus callae* and *R. robini* (bulb mites), *Tyrophagus neiswanderi* (cucumber mite).

2. Family HEMISARCOPTIDAE

Small (0.2-0.3mm long), smooth, shiny, egg-shaped mites, with a propodosomal shield and short, robust legs; propodosoma and hysterosoma clearly demarcated by a sejugal furrow; each leg terminates in a trumpet-like pulvillus but there is no tarsal or ambulacral claw. The only known species is predacious on scale insects.

EXAMPLE: *Hemisarcoptes malus* (mussel scale predatory mite).

3. Family SARCOPTIDAE

Small, globular mites with very short, stumpy legs; body distinctly striated transversely but

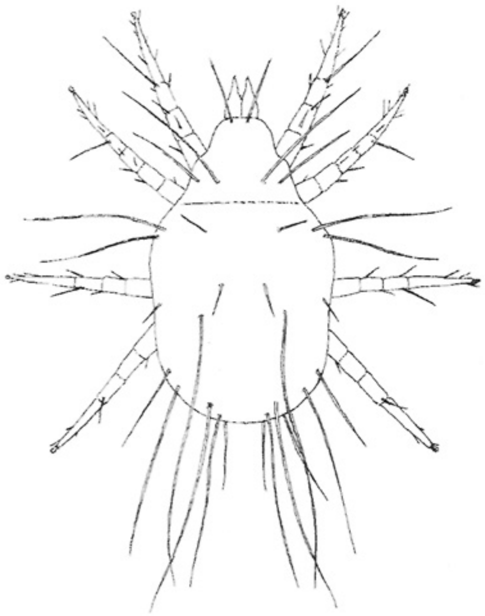


Fig. **176** A fungal mite, *Tyrophagus* sp.- family Acaridae (xlOO).

propodosoma and hysterosoma not separated by a sejugal furrow. Notorious skin parasites of birds and mammals.

EXAMPLE: *Sarcoptes scabiei* (itch mite), the cause of scabies in man and sarcoptic mange in various domestic and farm animals.

4. Family PSOROPTIDAE

Small, oval mites with distinctive bell-shaped ambulacra, often borne on long stalks; males with a pair of anal suckers. Primarily skin parasites of mammals.

EXAMPLE: *Psoroptes equi* (psoroptic mange mite), the cause of cattle scab and sheep scab.

ORDER CRYPTOSTIGMATA (BEETLE MITES)

Adults usually heavily sclerotized and darkly coloured, the idiosoma with wing-like or ridge-like expansions (the pteromorphs) **(Fig. 177);** chelicerae typically chelate and prominent, sometimes with a long shaft; ocelli absent. Most species are vegetarian and ground-dwelling, inhabiting the leaf-litter layer; a few species occur above ground on plants. Adults 0.2-1.5 mm long.

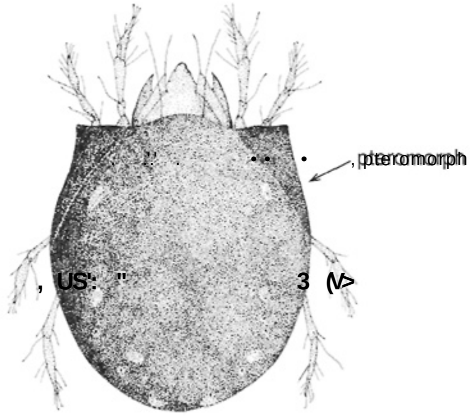


Fig. 177 A cherry beetle mite, *Humerobates rostrolamellatus* - family Mycobatidae (x40).

1. Family MYCOBATIDAE (p. 270 *et seq.)*

A group of 'higher' cryptostigmatids in which, during ecdysis, the cuticle splits along a line of weakness around the sides of the hysterosoma; idiosoma smooth; pteromorphs hinged; chelicerae relatively short.

EXAMPLE: *Humerobates rostrolamellatus* (cherry beetle mite).

PART II

Pests of Agricultural and Horticultural Crops

Small Insect Orders

ORDER COLLEMBOLA (SPRINGTAILS)

Family HYPOGASTRURIDAE

***Hypogastrura* spp.**
Gunpowder-mites

The so-called gunpowder-mites, which occasionally cause damage in mushroom beds, are actually springtails. They breed continuously under favourable conditions and vast numbers sometimes aggregate on the compost in mushroom houses. The insects will then cause significant damage by feeding on the fungal mycelium and thus retarding growth. They may also attack the sporopores, to form characteristically *dry* pits which lead to internal channels in the stipe and cap (cf. damage caused by mould mite, *Tyrophagus putrescentiae,* p. 270); the pests are especially destructive to button mushrooms and often cause them to split open. Adults **(Fig. 178)** are minute (1.0-1.5mm long), bluish-black, purplish or greenish-black, with a pale underside, short, 4-segmented antennae and a short, 2-segmented saltatory appendage.

Family ONYCHIURIDAE

***Onychiurus* spp.**
White blind springtails

Several species of *Onychiurus* are damaging to cultivated plants. They attack the roots and cause seedlings to collapse and die. In glasshouses, significant damage is sometimes noted on cucumber, lettuce, tomato and various ornamentals. Damage also occurs on outdoor crops such as bean, carrot, celery, pea, potato and sugar beet. The springtails form minute pits in the roots, and damaged tissue soon turns black; they may also attack the cotyledons and hypocotyl, and sever the fine roots and root hairs (see also damage caused by pygmy mangold beetle, *Atomaria linearis,* p. 135). On older plants, leaves in contact with the soil surface may be pitted or skeletonized; such damage is often noticed on lettuce and potato. Springtail damage to the roots will also allow pathogenic fungi to gain entry, increasing the significance of attacks.

BIOLOGY
These springtails, which lack a saltatory appendage and are unable to jump (cf. family Sminthuridae, below), are often abundant in wet, organic soils or compost. Development from egg to adult extends over several months but breeding is continuous, so long as conditions remain favourable.

DESCRIPTION
Adult up to 3 mm long, white, stout-bodied with six abdominal segments; *head* large; *antennae and legs* short; *saltatory appendage* absent. **Nymph** similar to adult but smaller.

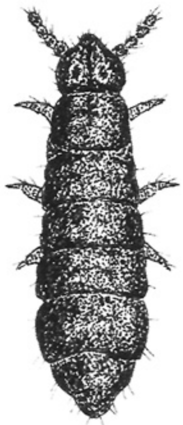


Fig. 178 A gunpowder-mite, *Hypogastrura* sp. (x35).

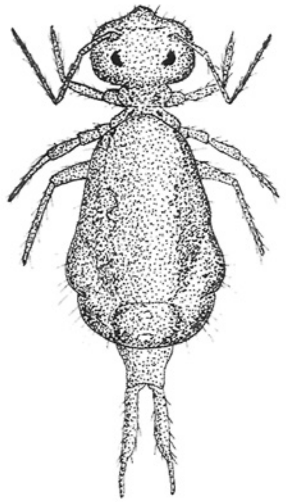


Fig. 179 Lucerne-flea, *Sminthurus viridis* (x20).

Family SMINTHURIDAE

Bourletiella hortensis **(Fitch)**
Garden springtail

Infestations of this generally common springtail occur mainly on wet, acid soils. The insects make small pits in the cotyledons and hypocotyl of seedlings of various plants; feeding damage may also occur on young leaves. Attacks, which are usually of greatest significance before July, occur both in the open and in glasshouses. Outdoor crops affected include beet, mangold, potato and radish; this springtail is also a serious seedling pest in conifer nurseries.

BIOLOGY
This species inhabits the soil surface and, although breeding throughout the year, is usually most numerous from late April to the end of June. Eggs are deposited in small groups in the soil, up to 100 eggs being laid by each female. The rate of nymphal development varies according to conditions and may be protracted but, under favourable conditions, the adult stage is usually attained within 2-3 months.

DESCRIPTION
Adult 1.5 mm long, mainly black to dark green but often spotted with white; *head* large, with black, yellowish-bordered eyes; *antennae* long and geniculate; *abdomen* globular, with a small, tube-like ventral sucker and a forked saltatory appendage.

Sminthurus viridis **(L.)**
Lucerne-flea

Although associated mainly with clover and lucerne, this widely distributed springtail also occurs on various other crops, including cereals, cucumber, grasses and lettuce. Damage is usually limited to the production of small holes in the cotyledons of seedlings but is sometimes more extensive; leaves of young plants may then become skeletonized. Although reported as an important pest in Australia, the lucerne-flea is usually of little or no economic significance in Europe.

BIOLOGY
This species breeds continuously whilst conditions are favourable, eggs being deposited in the soil in batches of up to 60. The eggs hatch within a few days but hatching may be delayed in dry conditions. The nymphs feed for 1-3 months before becoming adults.

DESCRIPTION
Adult 2-3 mm long; *body* greenish and globular; *saltatory appendage* forked and well developed; *antennae* long and geniculate **(Fig. 179).** **Egg** 0.3 mm in diameter, globular, whitish-yellow. **Nymph** similar to adult but smaller.

ORDER DERMAPTERA (EARWIGS)

Family FORFICULIDAE

***Forficula auricularia* L.**
Common earwig

Earwigs are polyphagous insects, and often cause damage to chrysanthemum, clematis, dahlia and other herbaceous plants, including potato. Damaged petals become ragged, spoiling the appearance of ornamentals. Attacks on leaves are unimportant but chewed buds may die, resulting in blind shoots; most damage occurs from June to September. Earwigs sometimes attack celery plants, to form brownish, longitudinal grooves in the petioles; such damage is distinguished from similar symptoms of physiological disorders by the presence of masses of black frass **(Plate la)** and tends to occur most frequently on plants suffering from boron deficiency. Earwigs may also shelter beneath the sheaths of developing maize (and sweet corn) cobs and then damage the kernels, particularly at the tips of the cobs **(Plate lb).** In orchards, earwigs often feed on ripening fruits already damaged by mechanical or other means; also, in black currant plantations, earwigs (which often rest in the bushes) are frequent contaminants in trays of mechanically harvested fruit. Although of some pest status, both outdoors and in glasshouses, earwigs are also beneficial and will destroy large numbers of aphids and other pests.

BIOLOGY
Adult earwigs, reared during the summer or autumn, overwinter in the soil and mate in the early winter. In December or January, each mated female lays a batch of up to 100 eggs in an earthen cell (brood chamber); the maternal female then guards over the eggs and, later, the first-instar nymphs before eventually emerging. Nymphs developing from 'winter' eggs usually reach the adult stage by the early summer, individuals passing through four nymphal instars. The maternal females often deposit smaller batches of eggs in May or June, and nymphs arising from these eggs usually complete their development by the end of September. In parts of continental Europe, there may be three egg-laying periods annually. Earwigs are nocturnal insects, and usually hide during the daytime amongst curled leaves, under loose bark and in other sheltered situations.

DESCRIPTION
Adult female 12-14 mm long, chestnut-brown; *posterior pincers* slightly curved (see Fig. 18a). **Adult male** similar in appearance to female but larger; *posterior pincers* strongly curved (see Fig. 18b). **Egg** 1.3 x 0.8mm, oval, pale yellow. **Nymph** whitish or greyish to brown.

ORDER THYSANOPTERA (THRIPS)

Family AEOLOTHRIPIDAE (banded thrips)

***Aeolothrips intermedins* Bagnall**

This generally common species is associated with various members of the Asteraceae, Brassicaceae, Fabaceae and Linaceae, including crops such as field bean, linseed and oilseed rape, but is of little or no pest status. Second-instar nymphs are at least partly predacious.

BIOLOGY
Adults occur from May to August, and nymphs develop from July onwards. Fully grown nymphs

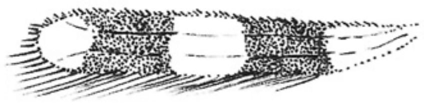


Fig. 180 Forewing of *Aeolothrips intermedius* (x50).

spin cocoons in the soil or amongst leaf litter (in which they then spend the winter), adults emerging in the spring. There is just one generation annually.

DESCRIPTION
Adult 2mm long, black-bodied; *forewings* white, banded with black (imparting a striking banded appearance to the insect) **(Fig. 180)** and with the vein around the tip pale (cf. *Aeolothrips tenuicornis,* below). **Nymph** white to creamish-white.

***Aeolothrips tenuicornis* Bagnall**
Banded-wing flower thrips

This common species is also associated with Asteraceae, Brassicaceae, Fabaceae and Linaceae, and has a similar life-cycle to that of the previous species. Adults are distinguished from those of *Aeolothrips intermedius* (above) by the dark colour of the marginal vein at the tip of the forewing.

Family THRIPIDAE

***Aptinothrips rufus* (Haliday)**
Grass thrips

This widely distributed and often abundant thrips is associated mainly with grasses. It will also breed on cereals, such as barley, oats and wheat, but is not an important pest of these crops.

BIOLOGY
Adults of this mainly parthenogenetic species overwinter in tufts of dead grass, amongst turf and in other sheltered situations. They become active in the spring and eventually deposit eggs. Populations of adults and nymphs are at their

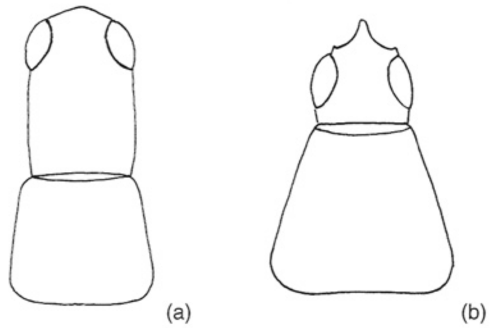


Fig. 181 Outline of the head and pronotum: (a) *Aptinothrips;* (b) *Chirothrips.*

greatest from July to September, and there are up to three overlapping generations annually. The egg stage is moderately protracted and lasts for almost 3 weeks. Nymphs feed for about 2 weeks and adults appear just over a week later, after very brief propupal and pupal stages.

DESCRIPTION
Adult 0.8-1.Omm long, yellowish-brown, narrow-bodied, apterous; *head* longer than wide **(Fig. 181a);** *pronotum* more or less quadrate; *antennae* 6-segmented. **Nymph** pale yellowish-orange.
NOTE Other species are also of significance on cultivated grasses, at least in continental Europe. These include *Anaphothrips obscurus* Miiller and *Aptinothrips stylifer* Trybom.

***Chirothrips* spp.**

Members of the genus *Chirothrips* breed on wild and cultivated grasses and, in continental Europe, sometimes reach pest status. The thrips are readily distinguished from members of other grass-infesting genera (e.g. *Aptinothrips,* above), as the head is distinctly smaller than the pronotum **(Fig. 181b).** Also (but not in the meadow foxtail thrips, *Chirothrips hamatus* Trybom). the second antennal segment is asymmetrical, usually having an outwardly directed apical projection. The grass flower thrips *{Chirothrips manicatus* Haliday) is a very polyphagous species and that most frequently encountered.

Frankliniella occidentalis **(Pergande)**
Western flower thrips

In the 1980s, this polyphagous non-indigenous thrips appeared in considerable numbers on glasshouse plants in England and various other parts of Europe, including France, Germany, the Netherlands and Scandinavia, having been introduced accidentally from abroad, mainly on chrysanthemum cuttings. Significant infestations have occurred on aubergine, cucumber, tomato and various other plants (including many ornamentals) and attempts to eradicate the pest have not proved successful. In warmer parts of Europe, this pest is also now established on various outdoor hosts, including fruit trees and vines. Adults and nymphs cause distortion, silvering and speckling of leaves and flowers **(Plates lc and Id),** and damage from even a relatively small number of individuals is often extensive. The thrips are also implicated in the transmission of important plant viruses, such as tomato spotted-wilt virus.

BIOLOGY
This species breeds continuously under suitable conditions, and the life-cycle is completed in 2-3 weeks at normal glasshouse temperatures. There are two nymphal instars, after which individuals drop to the ground to complete their development in the soil. Although adults and nymphs are sometimes observed on the exposed surfaces of leaves and flower petals, they are of secretive habit and occur more frequently on the underside of leaves, or hidden within the shelter of flowers and beneath bud scales.

DESCRIPTION
Adult 1-2mm long, pale yellow to brownish-yellow; *antennae* 8-segmented; *forewings* with a complete row of setae along veins I and II (cf. onion thrips, *Thrips tabaci,* p. 93). **Egg** 0.2mm long, pearly-white. **Nymph** golden-yellow; *eyes* reddish.

Frankliniella intonsa **(Trybom)**
Flower thrips

This generally common, polyphagous species is sometimes damaging to outdoor broad-leaved plants. Damage is usually restricted to the leaves and is of only minor significance. However, on strawberry (in common with certain species of thrips that may feed within the flowers at blossom time) this pest has been implicated in the development of distorted fruitlets, especially on late-season cultivars. Individuals are distinguishable from *Frankliniella occidentalis* (above) on the basis of microscopical features.

Kakothrips pisivorus **(Westwood)**
Pea thrips

This widely distributed thrips is a generally common pest of legumes, especially pea and broad bean crops growing in allotments and private gardens. The surface of infested tissue becomes silvery and flowers sometimes fail to develop; plants and pods are also malformed. Heavily infested plants are severely stunted and crop yields may be reduced. Most damage tends to occur under dry conditions during June and July; late-sown or late-maturing crops are particularly susceptible. In the British Isles, attacks are often especially common in the south and east of England.

BIOLOGY
Adults occur from May to July, when they infest the flowers, foliage and pods of pea and bean crops. Eggs are inserted in rows along the stamen sheaths or in other floral tissue; they hatch in about 10 days. Nymphs are very active and are usually most numerous in June or July. Individuals feed for up to 3 weeks before becoming fully grown. They then enter the soil, where they overwinter. The new adults appear after nymphs have passed through brief propupal and pupal stages. There is a single generation each year.

DESCRIPTION
Adult female 1.5-2.0 mm long, blackish-brown to black, and somewhat flattened; *antennae* 8-segmented, the third segment yellow; *legs* mainly brown, with yellow tarsi; *forewings* dark brown but clear basally; *abdomen* distinctly pointed

posteriorly. **Nymph** yellow when young, later becoming orange; *abdomen* with a dark brown tip in the second instar.

Limothrips cerealium Haliday
Grain thrips

This thrips is generally abundant on cereals (especially wheat and oats) and grasses, and often causes concern. Developing grains of heavily infested florets become shrivelled and discoloured; infested florets may also become blind. Germination of seed is affected adversely and, on barley, attacks can result in poor malting quality of the grain. Damage caused to crops, however, is rarely extensive and the pest is usually of only minor significance. Mass nights of adult females in summer (these are the familiar 'thunderflies') often constitute a nuisance, especially when the insects invade glasshouses, homes, gardens and amenity areas. The thrips readily gain entry through seemingly impenetrable joints or cracks, and are often then implicated in the triggering of burglar-, fire- and smoke-alarms. In continental Europe, infestations of *Limothrips* on cereal crops often occur in association with *Haplothrips aculeatus* (p. 94), an uncommon species in the British Isles.

BIOLOGY
Adult females overwinter away from host plants, often sheltering beneath the bark of conifer trees. They become active from late May onwards and migrate to host plants where eggs are laid, each placed in a small slit cut into the plant tissue. The eggs hatch within 2 weeks. The nymphs then feed within the shelter of leaf folds, beneath leaf sheath, or in the developing flowers, and pass through two instars. They are fully grown in about 2 weeks and then enter brief propupal and pupal stages (within the ear or a leaf sheath) before the appearance of the new adults. Mating takes place before the short-lived males die. The females then migrate in vast masses, at about harvest time, before taking up their winter quarters. There is typically one generation annually.

DESCRIPTION
Adult female 1.6-1.8mm long, black to brownish-black, with fully developed wings; *head* as large as pronotum (prothorax); *antennae* 8-segmented; *pronotum* transversely rectangular; *legs* yellowish. **Adult male** similar to female but smaller and apterous. **Egg** 0.3 mm long, whitish-yellow. **Nymph** whitish or yellowish. **Pupa** whitish to pale yellow; *eyes* reddish.

Limothrips denticornis Haliday
Barley thrips

This often common and widely distributed species is also associated with various species of Poaceae, especially barley and oats. Adults are most readily distinguished from those of *Limothrips cerealium* (above) by the asymmetrical third antennal segment, which is drawn outwards into a distinct, thumb-like prominence.

Taeniothrips inconsequens (Uzel)
Pear thrips

Infestations of this often common thrips occur on various deciduous trees, especially pear but also apple and plum. The thrips feed within the flower buds; sap often seeps from the damaged tissue. Later, they attack the petals, stamens and styles of open flowers, to produce brownish patches and distortion; young leaves are also attacked. Heavy infestations lead to reduced fruit set and to russeting of fruitlets.

BIOLOGY
Adults of this mainly parthenogenetic, univoltine thrips appear from January or February onwards. They then feed in the swelling and opening buds of host trees. Eggs are laid during May, either in leaf veins or in the blossom stalks (pedicels), and they hatch about 10 days later. The nymphs feed for several weeks and eventually, when fully grown, enter the soil. Each forms a small earthen cell within which the propupal and pupal stages occur. Individuals

eventually moult into new adults and these emerge in the following spring.

DESCRIPTION
Adult 1.2-1.7 mm long, dark brown; *legs* pale; *wings* greyish; *antennae* 8-segmented. **Nymph** whitish to yellowish-white; *eyes* dark red.

Thrips angusticeps Uzel
Field thrips

The field thrips is a widespread and locally common pest of various agricultural and horticultural crops, including field bean, linseed, pea, red beet and sunflower. Infested leaves are often discoloured and distorted. On pea crops, which are particularly susceptible, most damage occurs in April or May before seedlings are 5-10 cm high; plants then become stunted and the leaves puckered and blotched with yellow (cf. damage caused by pea thrips, *Kakothrips pisivorus*, p. 91). Infestations are especially common following brassica seed crops that have been infested during the previous season.

BIOLOGY
Adult thrips with reduced wings (i.e. brachypterous adults) overwinter in the soil. They emerge in the early spring and then invade various hosts. A generation of nymphs develops on the young leaves and within the growing points of the plants, which eventually gives rise to fully winged (macropterous) adults; these migrate in late May or early June to summer hosts, including various brassicaceous plants (Brassicaceae). Nymphs produced on these hosts develop into the overwintering generation of brachypterous adults.

DESCRIPTION
Adult 1.0-1.3 mm long, mainly brown or dark brown; *antennae* 7-segmented, with a pale third segment; *legs* mainly brown with yellow tarsi; *forewings* with a complete row of setae along vein II and an incomplete row of setae along vein I. **Nymph** translucent-whitish.

Thrips tabaci **Lindeman**
Onion thrips

This often abundant pest occurs on many cultivated plants, including leek, onion and various glasshouse-grown vegetables and ornamentals; the thrips are directly harmful and often cause extensive silvering of affected tissue. Outdoor attacks are especially severe in hot, dry weather. Although formerly considered an important vector of plant viruses, this no longer appears to be so. **Cucumber and tomato:** infested foliage and fruits become mottled, and young cucumber leaves may develop noticeable window-like patches; the thrips can also transmit spotted-wilt virus. **Leek and onion:** infested foliage turns silvery, and leaves may subsequently twist and curl.

BIOLOGY
This thrips is parthenogenetic. Eggs, usually about 30 per female, are laid in plant tissue and hatch within 1-2 weeks. Nymphs feed on host plants for up to 2 weeks and then enter the soil to complete their development. New adults appear about a week later. Large populations may develop on glasshouse-grown plants, and breeding is continuous so long as conditions remain favourable. Outdoors, females usually overwinter in the soil and two or more generations of adult females and nymphs occur from May onwards.

DESCRIPTION
Adult female 1.0-1.3 mm long, greyish-yellow to brown; *forewings* pale brownish-yellow, with line of setae along vein I incomplete; *antennae* 7-segmented, yellowish-brown (cf. western flower thrips, *Frankliniella occidentalis*, p. 91). **Egg** whitish and elliptical. **Nymph** whitish to pale yellowish-orange; *eyes* red.

Thrips simplex **(Morison)**
Gladiolus thrips

This species, which was introduced into Europe from Southern Africa, is an important pest of glasshouse-grown gladioli. The thrips infest the corms and, later, cause a streaking of the developing leaves and flower stems. Direct damage to flowers results in silver flecking; affected tissue eventually turns brown. Breeding is continuous under suitable conditions (temperatures above 10°C) and, on outdoor-planted hosts, is favoured by hot, dry conditions. Adult thrips are 1.5 mm long and dark brown, with 8-segmented antennae; the nymphs are yellowish or orange.

Family PHLAEOTHRIPIDAE

Haplothrips tritici **(Kurdjumov)**
Wheat thrips

This thrips is associated with grasses and cereals, especially wheat. On bread-making wheats, direct feeding on the ovaries leads to considerable distortion of developing grain, some of which may abort; infestations may have an adverse effect on yield and can also lower the baking quality of the harvested grain. On hard wheats, infestations often lead to considerable discoloration of the grain. Although an important pest in continental Europe, this thrips is not found in the British Isles.

BIOLOGY
Adults appear in the early spring and later fly into wheat fields. Females eventually crawl into the sheaths of wheat plants to deposit eggs in the developing ears. The eggs hatch about 10 days later. Nymphs then feed for 3-4 weeks, each passing through two instars. At first, the nymphs feed within the developing flowers but, later, they attack the outer surface of the developing grain. When fully grown, usually in early July, the nymphs emerge from the ears and drop to the ground. They then burrow into the soil to aestivate, typically at a depth of about 30cm. In early October, the nymphs reappear and then overwinter under dry grass and straw. Pupation occurs from mid-March onwards. There is just one generation annually.

DESCRIPTION
Adult 1.5 mm long and mainly black; *antennae* black and 8-segmented; *abdomen* with last segment tube-like (see Fig. 47b). **Egg** 0.3mm long, elliptical and translucent. **Nymph** mainly bright red; *head, antennae, legs and tip of abdomen* black.

Haplothrips aculeatus **(F.)**

This widely distributed thrips occurs on various kinds of Poaceae and related families (e.g. Juncaceae). In continental Europe (but not in the British Isles, where it is uncommon), it is a potentially important pest of grasses and occurs in considerable numbers on all the main cultivated species.

ORDER TRICHOPTERA (CADDIS FLIES)

Family LIMNEPHILIDAE

Limnephilus lunatus **Curtis**

This caddis fly is a frequent pest of watercress. The larvae feed on the leaves, roots and stems, and often cause considerable damage. Infestations in watercress beds are especially harmful during the winter months, when pieces of plant severed by the larvae float away and are lost.

BIOLOGY
Adults appear from late May or June onwards, with some individuals surviving well into November. Jelly-like batches of eggs are laid in the autumn on the leaves and stems of watercress plants, each placed a few centimetres above the surface of the water. The newly laid egg batch soon swells, following the absorption of water, to become a colourless, gelatinous mass up to 10 mm in diameter, in which the individual eggs (of which there may be several hundred) are arranged in distinct rows. The eggs hatch in about 3 weeks; however, development of the embryos may be delayed if the water temperature drops below 10°C. The case-inhabiting larvae feed for several months and pass through five

instars. The cases of first-instar larvae are usually formed from sand grains; those of subsequent instars are constructed from pieces of watercress leaves and petioles, but fourth- and fifth-instar larvae usually revert to using sand grains. Most larvae are fully grown by the following May or June. Each then pupates within its case. There is just one generation annually.

DESCRIPTION

Adult 28 mm wingspan; *forewings* angular, yellowish-brown, suffused with brown and partly transparent centrally; *hindwings* mainly transparent; *fore tibiae* each with a single spur; *abdomen* often appears green (in male) or yellow (in female), owing to the underlying fat-body tissue. Egg 0.4 x 0.3 mm, elliptical, translucent-yellow. **Larva** up to 17 mm long; *head* yellowish-brown with darker markings; *thorax* pale chestnut-brown to yellowish-brown, with darker markings; *abdomen* white. **Case** up to 23 mm long; composed either of sand grains or of cut-out pieces of watercress, cemented together.

Main Insect Orders

ORDER HEMIPTERA (TRUE BUGS)

Family PIESMATIDAE

***Piesma quadratum* (Fieber)**
Beet leaf bug

This locally distributed species is a potentially important pest of sugar beet in parts of continental Europe where, in addition to causing a pale mottling of infested foliage, it is also a vector of beet leaf crinkle virus (a disease not found in the British Isles). In the British Isles, this insect is associated mainly with wild Chenopodiaceae, e.g. *Atrlplex littoralis, Beta vulgaris* and *Halimione portulacoides,* growing along the coast of East Anglia.

BIOLOGY
Adults overwinter in sheltered field margins, hedgerows and other similar situations. They reappear in the spring and then migrate to host plants where, eventually, eggs are laid. The eggs hatch about 2 weeks later. Nymphs then feed on the leaves for about 6 weeks before moulting into adults, usually from July onwards. In favourable situations there may be at least a partial second generation.

DESCRIPTION
Adult 2.5-3.5 mm long, grey to brownish or greenish; *body* flattened and with distinctive lace-like punctures dorsally; *jorewings* with a lace-like, punctate pattern (see Fig. 23); *head* with a pair of horn-like projections between the antennae (see Fig. 22); *eyes* red and prominent; *pronotum* with three longitudinal ridges anteriorly (cf. *Piesma maculatum,* below). **Egg** elongate-oval, yellowish-brown. **Nymph** yellow when freshly emerged, gradually becoming greener or browner.

***Piesma maculatum* (Laporte de Castelnau)**
Spinach beet bug

This bug is distinguished from the previous species by the presence of just two longitudinal ridges on the pronotum; adults are also slightly smaller (up to 2.8mm long). Eggs are laid in the spring on both sides of expanded leaves and also on the petioles. The nymphs develop rapidly, producing pale feeding marks on infested tissue and causing noticeable leaf curling. There is one main generation each year but, in favourable areas, at least a partial second. Although associated with beet crops in various parts of Europe, including East Anglia and other parts of the British Isles, this species is not a vector of beet leaf crinkle virus.

Family MIRIDAE (capsid bugs)

***Calocoris norvegicus* (Gmelin)**
Potato capsid

Infestations of this widely distributed and often abundant capsid occur on various herbaceous plants, including chrysanthemum, and on field crops such as carrot, linseed and potato. The adults and nymphs produce distinctive reddish spots on the foliage; these feeding punctures gradually enlarge and turn brown, eventually developing into holes. The insects damage buds, flowers, leaves and shoots, and infested plants may become distorted; also, attacked tissue often withers and dies. Heaviest attacks tend to occur in weedy sites and are often restricted to the headlands of fields.

BIOLOGY

Eggs laid in summer overwinter in the woody or succulent shoots of host plants. They hatch in late May or early June, and nymphs feed for up to 6 weeks before moulting into adults. There is just one generation annually.

DESCRIPTION

Adult 6-8 mm long, mainly green to yellowish-green, with black body hairs; *elytra* often tinged with reddish-brown; *pronotum* straight-sided, often with a pair of black spots; *forewings* with the membrane often matt black. **Nymph** similar in appearance to adult but wingless, although later instars with obvious wing buds.

Dicyphus errans (Wolff)
Slender grey capsid

This polyphagous capsid occasionally causes minor damage to potato, puncturing and distorting the foliage. Numbers present, however, are usually small. The adults are slender-bodied, 4.5-5.0mm long, with the head, thorax and first two antennal segments mainly brown or black; the elytra are mainly grey or yellowish-white and narrow. Nymphs are mainly green but reddish anteriorly. Adults are most numerous in June and **July** on weeds such as *Epilobium* and *Stachys sylvatica;* infestations on potato are most likely to occur on headlands alongside weedy sites.

Lygocoris pabulinus (L.)
Common green capsid

This capsid is a widespread and often abundant pest of trees, shrubs and herbaceous plants, including field crops (e.g. beet, broad bean, French bean, runner bean, potato and swede), fruit crops (e.g. apple, blackberry, currant, gooseberry, raspberry, strawberry) and various ornamentals. Adults and nymphs cause considerable damage to buds, flowers, fruits, leaves and shoots. Symptoms vary from host to host, attacked tissue becoming discoloured, distorted and, often, ragged, tattered or peppered with holes. Although most often encountered on outdoor plants, infestations are sometimes noted during the summer in glasshouses, especially on chrysanthemum plants.

BIOLOGY

This capsid overwinters as eggs in the bark on shoots of apple, currant and other woody hosts, the eggs hatching in April and early May. Nymphs attack the young foliage of their woody hosts, before eventually departing for herbaceous plants where they complete their development. Adults of the first generation occur in June and July. They deposit eggs in the tissue of herbaceous hosts (including crops and various weeds). Second-generation nymphs complete their development by the autumn. Second-generation adults then migrate to woody hosts, in which winter eggs will be laid.

DESCRIPTION

Adult 5.0-6.5 mm long, bright green with a dusky-yellow pubescence; *antennae* moderately long; *pronotum* with paired, relatively inconspicuous, callosities **(Fig. 182)** (cf. apple capsid, *Plesiocoris rugicollis,* p. 98). **Egg** 1.3mm long, creamish in colour, banana-shaped. **Nymph** pale green to bright green; *antennae* orange-red apically.

Lygus rugulipennis Poppius
Tarnished plant bug

Although associated mainly with weeds, especially Chenopodiaceae, this generally common bug also occurs on various crops, including brassicas, celery, legumes, potato, strawberry, sugar beet and glasshouse-grown cucumber.

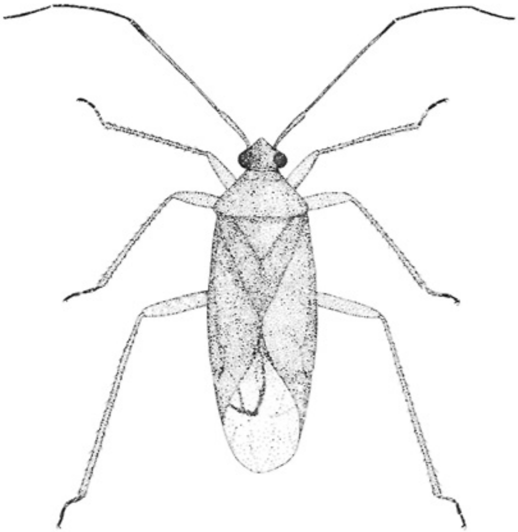


Fig. 182 Common green capsid, *Lygocoris pabulinus* **(x8).**

Most damage is caused to seedlings and to the growing points or young leaves of older hosts. Infestations are especially important on sugar beet and often result in the development of multiheaded plants. Damage may also occur on strawberry, attacked fruits becoming malformed and, hence, unmarketable.

BIOLOGY
This species overwinters in the adult stage, amongst debris or under leaf litter in hedgerows, dykes and other situations. The bugs appear in the early spring and immediately begin to feed; they often then invade field crops. The adults are very active and scurry or fly away when disturbed. Eggs are laid in the stems or other parts of host plants, usually in May. Nymphs appear from late May or early June onwards. They pass through five instars and take up to 2 months to mature. In most regions there are two generations annually, and second-generation nymphs reach adulthood in September or October.

DESCRIPTION
Adult up to 6 mm long, extremely variable in appearance but usually dark brown to reddish-brown. **Egg** 1mm long, creamish-white, flask-shaped. **Nymph** pale yellowish-green to brownish, with a distinct orange mark on the abdomen and a pair of black spots on each thoracic segment.

Plesiocoris rugicollis **(Fallen)**
Apple capsid

Nowadays, this locally distributed capsid is a relatively minor pest of apple. Leaves and shoots are punctured, and tissue becomes distorted and marked with necrotic spots. Attacked fruitlets develop corky scars and may drop prematurely. Apple capsid will also damage the foliage of currant and gooseberry bushes.

BIOLOGY
Adults are active in late June and July, when eggs are laid in the bark of apple trees. The eggs hatch in the following spring. The very active nymphs then attack the foliage and blossom trusses. Developing fruitlets are also attacked. Maturity is reached after five nymphal stages, there being just one generation annually.

DESCRIPTION
Adult 5.5-6.8 mm long, mainly green; *legs* yellow; *elytra* often with a yellow margin; *pronotum* with distinct callosities (cf. common green capsid, *Lygocoris pabulinus*, p. 97). **Nymph** yellowish-green; *antennae* tipped with reddish-brown.

Family CERCOPIDAE (froghoppers)

Cercopis vulnerata **Illiger in Rossi**
Red & black froghopper

This widely distributed and generally common univoltine insect is a minor pest in orchards and hop gardens. The adults pierce the upper surface of the foliage to form small greenish-yellow marks that eventually turn brown. This symptom, which was once thought to be due to a fungal pathogen, is often known as 'angular leaf spot'. On pear, damage is restricted to the fruitlets and fruit stalks, these becoming marked

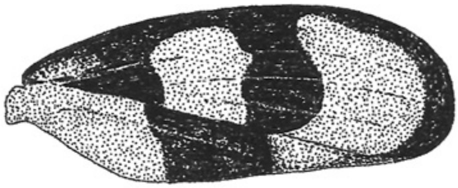


Fig. 183 Forewing of *Cercopis vulnerata* (x7).

with corky blemishes. Nymphs, each sheltered by a mass of 'spittle', develop mainly on the roots of *Rumex* and various other herbaceous plants. The adults (10-11 mm long), which have distinctive black and red forewings **(Fig. 183)** occur from May or June onwards.

***Philaenus spumarius* (L.)**
Common froghopper

This insect is a generally common but minor pest of cultivated plants, most notably fruit crops (especially loganberry, raspberry and strawberry) and ornamentals; attacks also occur on sugar beet and other field crops. Infested foliage is contaminated by 'cuckoo-spit' (this is often an inconvenience to strawberry pickers), and young infested tissue may become distorted; direct damage to host plants, however, is of no economic importance.

BIOLOGY
Adults are active from June onwards. They rarely fly but spring into the air when disturbed. Eggs are laid in September, typically in batches of up to 30. The eggs hatch in the following spring and sedentary nymphs then feed on host plants, each individual imbibing sap and surrounding itself with protective, spittle-like froth which forms the familiar 'cuckoo-spit'. Nymphs develop through five instars before moulting into adults.

DESCRIPTION
Adult 5-7 mm long, stout-bodied, frog-like, pale whitish-yellow to black; *elytra* often noticeably patterned. **Nymph** plump, pale and shiny; *eyes* purplish.

Family CICADELLIDAE (leafhoppers)

***Edwardsiana rosae* (L.)**
Rose leafhopper

This widely distributed leafhopper is a common pest of rose; infestations also occur on fruit trees and ornamentals (Rosaceae), and on various other hosts. Infested foliage becomes speckled and bleached, owing to the removal of chlorophyll from the cells; heavy attacks affect growth and often result in premature leaf-fall. The cast-off nymphal skins often remain attached to the leaves and, in the absence of live insects, are a clear indication of the cause of the damage.

BIOLOGY
This species overwinters in the egg stage. Nymphs occur on the underside of leaves of host plants from spring onwards. They develop through five instars and eventually attain the adult stage in June. The adults are more active than the nymphs and readily fly from the foodplant when disturbed. After mating, eggs are laid and the next brood of nymphs feeds during the summer months. Second-generation adults are active from August to October.

DESCRIPTION
Adult 3.4-4.0mm long, mainly pale yellow, and usually unmarked. **Nymph** whitish to creamish.
NOTE Various other species of *Edwardsiana* are associated with cultivated plants (especially fruit trees and ornamentals); one species, *E. flavescens* (F.) is found, occasionally, on potato.

***Empoasca decipiens* Paoli**
A green leafhopper

Infestations of this generally common leafhopper occur on fruit trees and many other hosts, including potato; the insects cause the foliage to become speckled or more generally discoloured. Heavily infested leaves on fruit trees often become silvery and such foliage is sometimes thought to be suffering from silver-leaf disease. Unlike many other genera, species of *Empoasca* overwinter in the adult stage, individuals typically sheltering on conifers or on other evergreen plants such as *Hedera helix.* Adults of *E. decipiens* are about 3 mm long and mainly green, with whitish markings on the head and thorax.

Eupterycyba jucunda (Herrich-Schaeffer)
Potato leafhopper

Although associated mainly with *Alnus*, infestations of this generally common species often occur during the summer on potato. Infested leaves become speckled and, sometimes, yellowish or brown, but damage is usually unimportant. There are two generations annually. Adults are 4.0-4.5 mm long and mainly greenish or greenish-yellow, spotted with black, and with a mainly black abdomen; there are three distinctive black spots on the pronotum and a pair of black triangles anteriorly on the scutellum.

NOTE Although leafhoppers of various genera are associated with fruit crops and a wide range of ornamental plants, few species are of significance on arable crops. Various species, however, feed on crops such as potato and sugar beet; they cause minor foliage damage but do not transmit viruses.

Eupteryx aurata (L.)
A potato leafhopper

This generally common leafhopper is associated mainly with *Urtica* but, during the summer, it also occurs on various other plants, including potato and various members of the family Labiatae. The adults and nymphs cause a yellowing of the foliage; heavy infestations of this and certain other species of leafhopper (e.g. *Eupterycyba jucunda*, above) may also cause leaves of potato to wilt, turn brown and die, a condition known as 'hopper burn'.

BIOLOGY
This species overwinters in the egg stage on urtica. In summer, eggs are laid in the leaves and stems of potato, and in those of various other underside of the leaves. They pass through five instars before attaining the adult stage.

DESCRIPTION
Adult 3.5-4.3 mm long, mainly yellowish-orange, marked extensively with black; *elytra* yellowish-orange with black markings and, usually, a large, irregular, brown, longitudinal streak. **Nymph** mainly whitish.

Eupteryx melissae Curtis
Chrysanthemum leafhopper

Infestations of this locally abundant leafhopper occur on various cultivated plants, including chrysanthemum, garden mint and sage, individuals often inhabiting the upper surface of the leaves. Infested plants frequently become contaminated by cast-off nymphal skins; leaves also become extensively speckled and such damage is often of considerable significance. Adults are c. 3 mm long and pale-coloured, with a black abdomen and the elytra extensively marked with greyish- or orange-brown **(Fig. 184).**

Hauptidia maroccana (Melichar)
Glasshouse leafhopper

This polyphagous leafhopper is well established in glasshouses in northern Europe. It feeds on the underside of the leaves of cucumber, melon, tomato and various ornamentals, especially chrysanthemum and primrose; if conditions are favourable, infestations may also occur on outdoor plants, including various weeds. The insects cause a pale speckling or mottling of infested leaves **(Plate le).** Attacked plants may be weakened, and seedlings can be killed, but infestations are rarely of significance.

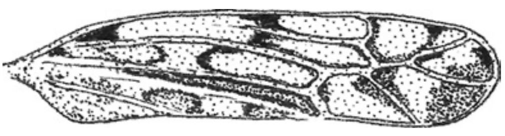


Fig. 184 Forewing of chrysanthemum leafhopper, *Eupteryx melissae* (x25).

BIOLOGY

This species breeds continuously, there being five or more overlapping generations annually. Eggs are inserted singly into the leaf veins and, at normal glasshouse temperatures, each hatches in about a week. The active nymphs then feed for about a month before becoming adults, each passing through five instars. Under colder conditions, however, development from egg to adult is greatly protracted and, in winter, may take several months. Adults are relatively long-lived and many survive for up to 3 months, each female depositing about 50 eggs.

DESCRIPTION

Adult 3.1-3.7mm long, mainly pale yellow, marked with grey or brown; *elytra* each with a pair of brownish-grey bands **(Fig. 185)** which, in repose, form two chevron-like markings over the back.

Family DELPHACIDAE (planthoppers)

Javesella pellucida **(F.)**
Cereal leafhopper

This often abundant leafhopper is associated with wild and cultivated grasses and also infests cereal crops. Although direct feeding by adults and nymphs is usually of little or no significance, the insects are capable of transmitting virus-like (mycoplasmic) diseases, including wheat striate mosaic; this disease can cause stunting of cereals, including barley, oats, rye and wheat.

BIOLOGY

Adults occur in the summer. Eggs are then deposited in the leaf sheaths and hollow stems of cereals and grasses. The eggs hatch in the autumn and the nymphs feed briefly before overwintering. Activity is resumed in the spring, and nymphal development is completed in the early summer. In Britain, this species is single-brooded. Female leafhoppers carrying cereal or grass mycoplasmic diseases are capable of transferring the causal organisms to their offspring via the eggs.

DESCRIPTION

Adult female (macropterous form) 4.0-4.5 mm long, pale brownish-yellow with black markings; *elytra* yellowish, semi-transparent; *hind tibia* with a large, moveable apical spur (typical of family) **(Fig. 186). Adult male (macropterous form)** mainly black, marked with white and yellow; *elytra* hyaline-whitish. **Brachypterous forms** in both sexes vary from pale yellowish to black and are 3 mm long.

Family PSYLLIDAE (psyllids)

Psylla mali **(Schmidberger)**
Apple sucker

This insect is a potentially damaging pest of apple but rarely occurs on regularly sprayed

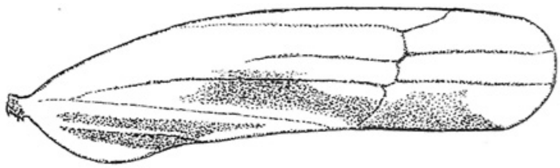


Fig. 185 Forewing of glasshouse leafhopper. *Hauptidia maroccana* (x25).

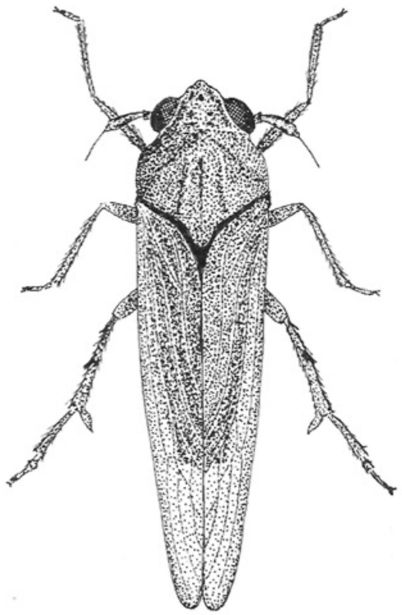


Fig. 186 Cereal leafhopper, *Javesella pellucida* (x15).

trees. Heavy infestations are particularly damaging at the pre-blossom stage, when the nymphs cause the petals of the opening buds to turn brown; this often leads to the death of blossom trusses. These symptoms are often mistaken for frost damage. Nymphal attacks on foliage are of little significance; feeding by adults also appears to be of no economic importance.

BIOLOGY

This pest overwinters as eggs on the fruit spurs of host plants, laid usually along the leaf scars; they may also occur on the shoots and around the base of leaf buds. The eggs hatch in the spring, usually during April. The nymphs soon gain access to the buds, as these begin to open. The nymphs develop through five instars and, although attacking leaves, are most numerous in blossom trusses. They excrete globules of honeydew and also produce white, waxen threads, which often highlight the presence of the pest. Nymphs are fully fed in late May or early June. The new adults remain active on host trees throughout the summer, and fly readily when disturbed; mating, followed by egg laying, occurs in August and September, and may also extend into the autumn. There is just one generation annually.

DESCRIPTION

Adult 2.5-3.0mm long, mainly apple green, yellowish-green or brownish-yellow; *wings* transparent. **Egg** 0.4 mm long, elongate-oval, pale yellow. **Nymph** flat, oval-bodied, yellowish or pale brown (when young) to bright green; *eyes* red and conspicuous; *wing buds* very noticeable in older individuals.

Psylla pyricola **Forster**
Pear sucker

This psyllid is an important pest of pear, and heavy infestations often result in fruit distortion and premature leaf-fall; summer infestations may have a deleterious effect on fruit-bud development and can check tree growth. Nymphs of the first generation can also cause direct damage to blossoms, the petals turning brown. Foliage and fruits are contaminated by honeydew, excreted in profusion by the nymphs, and by sooty moulds that subsequently develop on the honeydew; affected fruits may be unmarketable unless washed or wiped clean.

BIOLOGY

Unlike apple sucker, this species is multivoltine and overwinters in the adult stage. The adults are active in sunny weather, even in mid-winter. They invade pear orchards from February onwards, eggs then being deposited on shoots and spurs. The eggs hatch in late March and April. First-instar nymphs invade the opening buds and blossom trusses; they then begin to feed. There are usually three generations each year and pest numbers typically increase at each generation and reach a peak in the late summer. Summer eggs are usually deposited on the underside of fully expanded leaves, often clustered in large numbers along the mid-rib. In autumn, adults of the final generation fly away from pear trees to seek overwintering sites in nearby hedges and other shelter.

DESCRIPTION

Adult 1.5-2.0mm long, brownish-black to reddish-brown; *wings* transparent **(Fig. 187);** *winter form* darker, with cloudy patches on the wings. **Egg** 0.3 mm long, elongate-oval and lemon-yellow to orange; *pedicel* moderately long. **Nymph** pinkish to orange, with dark brown to blackish markings; older individuals, and nymphs of the first generation, tend to be darkest.

NOTE In parts of continental Europe, *Psylla pyri* (L.) is the main psyllid pest of pear; its biology is similar to that of *P. pyricola,* with adults overwintering, but

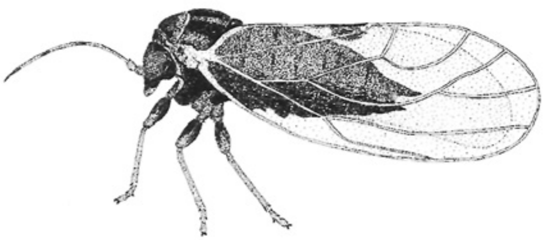


Fig. 187 Pear sucker, *Psylla pyricola* (x25).

there are up to six generations annually. *Psylla pyri* is of no pest status in the British Isles.

Family TRIOZIDAE

***Trioza apicalis* Forster**
Carrot sucker

This psyllid is widely distributed in central and northern Europe, where it is a local and usually minor pest of carrot. Heavy infestations cause distortion of the foliage. The insect is also associated with other umbelliferous plants, including *Anthriscus sylvestris, Heradeum sphondylium* and *Pastinaca sativa.* In the British Isles, carrot sucker is restricted mainly to wild hosts in southern England and is of no pest status.

BIOLOGY
Adults overwinter in the shelter of spruce trees and other conifers. In the spring, they migrate to umbelliferous hosts where eggs are eventually laid. The eggs hatch about 10 days later. Nymphs feed on the leaves during the summer and pass through five instars before attaining the adult stage, usually in September. There is just one generation annually.

DESCRIPTION
Adult 3 mm long, mainly green or yellowish-green, the body of older individuals is sometimes marked with pale brown; *antennae* black-tipped; *forewings* 2.0-2.4 mm long, hyaline.

Family ALEYRODIDAE (whiteflies)

***Aleyrodes proletella* (L.)**
Cabbage whitefly

Cabbage whitefly is a widespread and locally abundant pest, especially in southern areas. Infestations occur mainly on cultivated brassicas, including Brussels sprout, cabbage (especially savoy cabbage) and cauliflower, but are usually of only minor importance. The underside of infested leaves becomes marked by patches of white, mealy wax **(Plate If);** plants are also contaminated by honeydew and sooty moulds, a particular problem on Brussels sprout. Under dry conditions, heavy infestations reduce the vigour of young plants and may cause plants to wilt. Infestations are often first noticed when, on disturbing the plants during the spring, summer or autumn, clouds of adults rise into the air; the adults may even become active, and attract attention, on sunny yet frosty days in mid-winter.

BIOLOGY
Breeding commences in the spring, and females then deposit small semicircular groups of eggs on the underside of leaves of host plants. The eggs hatch in 1-2 weeks. At first, the young nymphs wander over the leaf surface but they soon settle down to feed. Individuals are fully grown in about 10 days. They then pupate and adults appear a few days later. There are four or more overlapping generations annually, with adults and some pseudo-pupae overwintering.

DESCRIPTION
Adult 1.4-1.6 mm long, mainly yellow, coated with white, mealy wax; *head and thorax* marked with brown; *forewings* white, each with two grey spots. **Egg** 0.25 mm long, whitish, oval. **Nymph** flat, scale-like; mainly white, with a pair of yellow spots; *eyes* red. **Pseudo-pupae** pale yellow, flat and scale-like, with a waxen fringe; *eyes* red.

***Bemisia tabad* (Gennadius)**
Tobacco whitefly

In recent years, this tropical pest has occurred in glasshouses in both England and continental Europe, usually having been introduced on imported poinsettia plants or cuttings. In Northern Europe, it is most likely to occur on glasshouse ornamentals and on protected vegetable crops such as sweet pepper and tomato. Infested tissue becomes slightly spotted. Host plants are also contaminated by masses of sticky honeydew and sooty moulds.

BIOLOGY
Under favourable glasshouse conditions this polyphagous whitefly is capable of breeding

continuously, but development from egg to adult tends to be slower than that of the glasshouse whitefly, *Trialeurodes vaporariorum* (below). Eggs are deposited singly, usually low down on the underside of the young leaves. On hatching, the first-instar nymphs wander for a short distance before becoming sedentary and beginning to feed; they pass through three instars before moulting to a non-feeding pseudo-pupal stage. Unlike *T. vaporariorum*, the eggs and scales are scattered on the leaves, rather than clumped together.

DESCRIPTION
Adult 1mm long, mainly white; when at rest, wings held in a relatively steep, roof-like posture (cf. *Trialeurodes vaporariorum*, below). **Egg** 0.2 mm long, pear-shaped, whitish when newly laid but later becoming brownish. **Nymph** flat, scale-like, mainly yellowish. **Pseudo-pupa** 0.7 mm long, slightly pointed posteriorly; unlike that of *T. vaporariorum* lacking waxen processes.

Trialeurodes vaporariorum (Westwood)
Glasshouse whitefly

The glasshouse whitefly is a major pest of protected crops, occurring on aubergine, cucumber, climbing French bean, melon, sweet pepper, tomato and various ornamentals. Whilst conditions remain favourable, the insects may also survive on various weeds out of doors. Infested plants show poor growth and the foliage may become discoloured; when attacks are heavy, leaves wilt and die, and crop yields will be depressed. Attacked plants become coated in honeydew, upon which sooty moulds soon develop; vegetables such as cucumbers and tomatoes often need to be washed before they can be marketed.

BIOLOGY
Whitefly infestations occur mainly on the underside of leaves, eggs being typically deposited in circular groups on smooth leaves but more scattered on hairy ones. Adults are particularly abundant on the uppermost parts of plants, and readily take to the wing when disturbed. They breed continuously whilst conditions remain favourable, each female being capable of depositing 200 or more eggs over a 6-week period; reproduction is normally parthenogenetic. At normal glasshouse temperatures, eggs hatch in about a week to 9 days. The nymphs (the so-called 'scales') at first wander over the foliage but soon become sedentary on the underside of the leaves, where they continue their development. They pass through three instars before entering a brief, non-feeding, pseudo-pupal stage. Development from egg to adult usually takes less than a month and populations in glasshouses can build up very rapidly, with a succession of overlapping generations occurring throughout the summer.

DESCRIPTION
Adult 1mm long, pale yellow to whitish; *wings* white, and held relatively flat when in repose (cf. tobacco whitefly, *Bemisia tabaci*, above). **Egg** 0.2mm long, yellowish, broadly conical, becoming blackish after a few days. **Nymph** translucent to pale green, oval, flat, scale-like. **Pseudo-pupa** oval, whitish,[7] with relatively short marginal waxen processes and several pairs of long waxen tubes dorsally.

Family APHIDIDAE (aphids)

Acyrthosiphon pisum (Harris)
Pea aphid

This species is a widespread and common pest of culinary pea **(Plate 2a)** and certain other cultivated legumes, including field bean and sweet pea; the aphid is also a virus vector. Most damage is caused to the growing points during June and July, with leaves and pods becoming distorted and turning yellow; heavy infestations on culinary peas will reduce yields significantly. Pea enation mosaic virus, pea leaf roll virus and pea mosaic virus are introduced and spread by this insect.

BIOLOGY
Adults and eggs overwinter on perennial legumes such as clover, lucerne and trefoils. Colo-

[7] Pseudo-pupae parasitized by the glasshouse whitefly parasitoid *(Encarsia formosa* Gahan) are black.

nies develop on these plants in the spring; winged forms are produced relatively early in the season, and these migrate to peas and beans from May onwards. These immigrants infest the growing points, and infestations are often overlooked until colonies build-up on the foliage or developing pods. The aphids, which drop readily to the ground when disturbed, often form significant infestations in June and July; colonies on summer hosts usually persist until the autumn.

DESCRIPTION

Aptera 2.5-4.0mm long; *body* elongate, pale green to yellowish or pinkish; *antennae, legs and cauda* long, slender; *siphunculi* very long, slender and dark tipped **(Fig. 188a);** *head* deeply indented **(Fig. 189a). Nymph** similar to adult but with a slight waxy coating.

Amphorophora idaei (Borner)
Large raspberry aphid

Although commonly associated with wild and cultivated raspberry, and closely related plants (but not blackberry), this aphid is rarely numerous and is of significance mainly as a vector of raspberry leaf spot and raspberry mosaic viruses.

BIOLOGY

This species overwinters in the egg stage. Nymphs appear from early March onwards and then feed on the tips of the developing buds. Later, they invade the underside of expanded leaves. The aphids are usually present in relatively small numbers and do not form dense colonies (cf. small raspberry aphid, *Aphis idaei*, p. 108). In June and July, after two generations of wingless forms, winged aphids are produced, and these are responsible for spreading infestations. Sexual forms, including alate males, occur in the autumn. Winter eggs are deposited on the canes by oviparae from October onwards.

DESCRIPTION

Aptera 2.6-4.1 mm long, shiny, pale yellowish-green to green; *antennae and legs* long and slender; *siphunculi* pale, elongate and slightly swollen on the apical half, with the tip flanged; *cauda* finger-shaped.

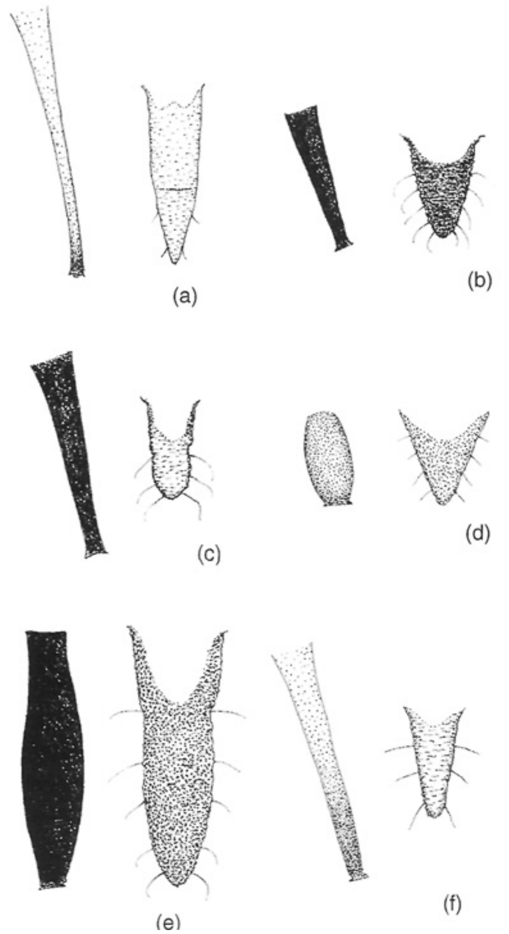


Fig. 188 Siphunculi and caudas of some aphids associated with salad or vegetable crops: (a) pea aphid. *Acyrthosiphon pisum;* (b) black bean aphid, *Aphis fabae;* (c) melon & cotton aphid, *Aphis gossypik* (d) cabbage aphid, *Brevicoryne brassicae;* (e) vetch aphid *Megoura viciae;* (f) currant/lettuce aphid, *Nasonovia ribisnigri.*

Amphorophora rubi (Kaltenbach)
Bramble aphid

This medium-sized to large (2.5-4.0 mm long), shiny green to yellowish-green species is generally common on *Rubus fruticosus,* including cultivated blackberry. It is very similar in appearance to *Amphorophora idaei* (above), with which it was once confused, but does not infest raspberry and is not an important pest. This species sometimes overwinters anholocyclically.

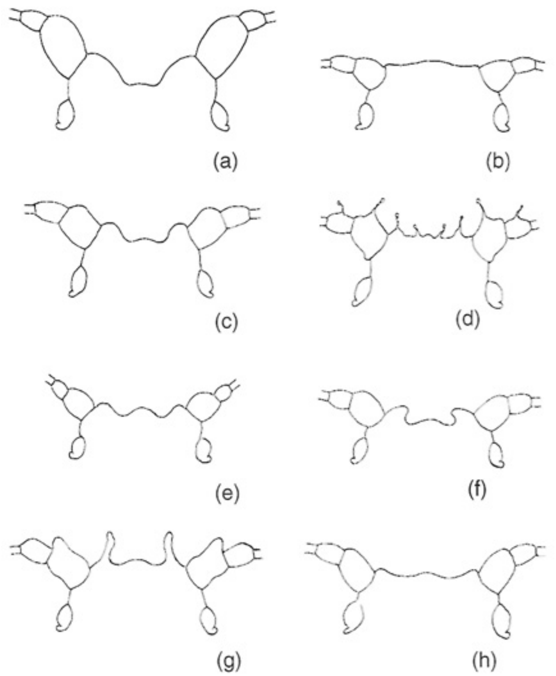


Fig. 189 Outline of front of head of various species of aphid: (a) pea aphid, *Acyrthosiphon pisum;* (b) black bean aphid, *Aphis fabae:* (c) glasshouse & potato aphid, *Aulacorthum solani;* (d) strawberrv aphid, *Chaetosiphon fragaefolii:* (e) rose/grain aphid. *Metopolophium dirhodum;* (f) peach/potato aphid. *Myzus persicae;* (g) damson/hop aphid, *Phorodon humuli;* (h) bird-cherry aphid, *Rhopalosiphum padi.*

Aphis fabae **Scopoli**
Black bean aphid

This well-known aphid is a major pest of field bean, sugar beet and various other plants, including vegetable crops such as broad bean, French bean, red beet, runner bean and spinach; infestations also occur on minor field crops (including quinoa) and on ornamental plants, some of which are primary and others secondary hosts. Heavy infestations on field and vegetable crops can reduce yields significantly; leaves and shoots may become malformed and plants noticeably stunted. The aphids also contaminate host plants with honeydew, upon which sooty moulds develop; on field bean, chocolate spot disease can also develop on excreted honeydew. The aphid is a vector of persistent and non-persistent viruses, including bean yellow mosaic, bean leaf roll, beet yellow net, pea enation mosaic and potato leaf roll.

BIOLOGY

The winter is usually passed in the egg stage on *Euonymus europaeus* although, in favourable situations, colonies may also survive the winter on herbaceous hosts. Eggs hatch in the early spring and colonies of aphids soon develop on the young leaves and shoots. Winged forms appear in May or June and these disperse to various herbaceous plants, colonies on the primary host then dying out. Breeding on herbaceous plants continues throughout the summer, with the frequent production of winged forms and further spread to other secondary hosts. Colonies are often ant-attended, and are most populous in July and August. There is a return migration to primary hosts in the autumn where winter eggs are laid.

DESCRIPTION

Aptera 1.5-3.0 mm long; *body* oval, usually dull black (in older colonies, with conspicuous patches of white wax on the abdomen); *antennae* much shorter than the body; *siphunculi* black and tapered, and distinctly longer than the cauda; *cauda* bluntly finger-shaped **(Fig. 188b);** *head* with lateral tubercles no higher than the median bulge **(Fig. 189b).**

Aphis gossypii **Glover**
Melon & cotton aphid

This aphid is a major glasshouse pest, attacking both ornamental and vegetable crops, especially cucumber, melon and chrysanthemum. This species is a complex of different races; specimens associated with cucurbits, for example, do not breed on chrysanthemum, and vice versa. Foliage of attacked plants turns yellow and may also wilt and die. On cucumber and melon, infested flowers may fail to open and fruitlets can be distorted; crop yields and quality are also reduced by the accumulation of honeydew and development of sooty moulds. The aphids are vectors of viruses, including cucumber mosaic.

BIOLOGY
This entirely parthenogenetic (anholocyclic) species breeds continuously under protection, producing both winged and wingless forms. Colonies are frequently ant-attended and often become very populous. In densely populated colonies, if temperatures are high, the adult aphids are often smaller than normal. Infestations may occur on outdoor plants during the summer but, in Northern Europe, the aphids are unlikely to survive the winter out-of-doors.

DESCRIPTION
Aptera 0.9-1.9 mm long; *body* pear-shaped, usually green or yellowish-green to dark green, blue-green or blackish (dwarf specimens, often no longer than 1mm, usually creamish or whitish); *siphunculi* dark, moderately long and tapered; *cauda* narrow and elongate **(Fig. 188c).**

Aphis nasturtii Kaltenbach
Buckthorn/potato aphid

This generally common species is a minor pest of certain vegetable crops, especially potato and watercress. The aphids cause little direct damage and tend to be of greater significance as vectors of viruses, including potato virus A, potato virus Y and turnip mosaic.

BIOLOGY
This aphid overwinters in the egg stage on *Rhamnus.* Colonies develop during the spring from April onwards and, in June, winged forms migrate to a wide variety of summer hosts, including potato, tomato and watercress. Breeding continues on these hosts until a return migration to *Rhamnus* takes place in early September.

DESCRIPTION
Aptera 1.1-2.2 mm long, bright yellow to yellowish-green; *antennae* much shorter than body; *siphunculi* short, pale with dusky tips but often entirely brown; *cauda* short and tapered **(Fig. 190a).**

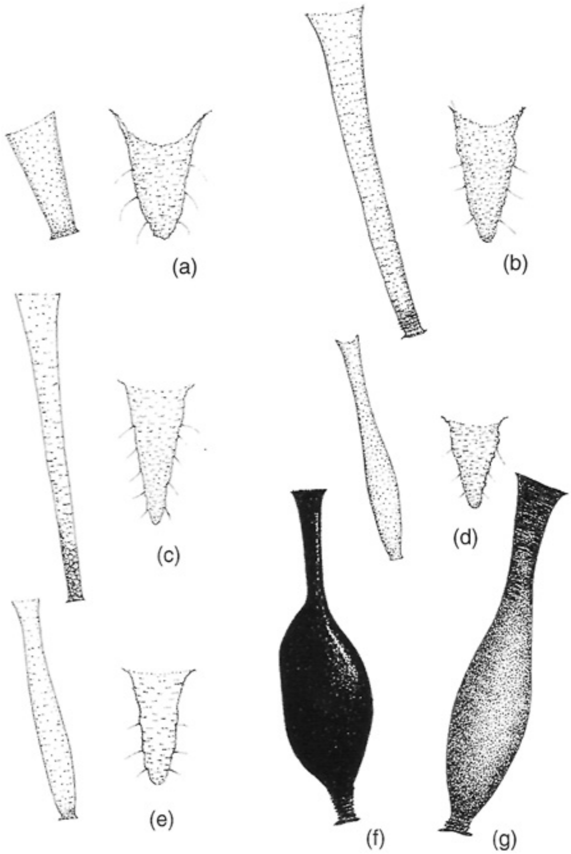


Fig. 190 Siphunculi and caudas of some aphids associated with bulb or potato crops: (a) buckthorn/ potato aphid, *Aphis nasturtii;* (b) glasshouse & potato aphid, *Aulacorthum solani;* (c) potato aphid, *Macrosiphum euphorbiae;* (d) shallot aphid, *Myzus ascalonicus;* (e) peach/potato aphid, *Myzus persicae;* (f) bulb & potato aphid, *Rhopalosiphoninus latysiphon;* (g) mangold aphid, *Rhopalosiphoninus staphyleae tulipaellus.*

Aphis grossulariae Kaltenbach
Gooseberry aphid

This small (1.5-2.2 mm long), greyish-green species overwinters in the egg stage on gooseberry. Colonies develop in the spring at the shoot tips, and attacks often cause significant distortion of the new growth; heavily infested bushes may become stunted. The aphids are also vectors of gooseberry veinbanding virus. Winged aphids migrate in summer to secondary hosts such as

Epilobium, with a return migration to gooseberry in the autumn.

Aphis idaei van der Goot
Small raspberry aphid

This aphid causes leaf curl on loganberry and raspberry, but is of greater importance as a vector of raspberry vein chlorosis virus. Eggs, which overwinter on the canes, hatch in March. Dense colonies then develop on the shoots, buds and flower trusses; such colonies are usually ant-attended. The apterous females within these colonies are 1.5-2.0 mm long and pale green to yellowish-green, with moderately long, outwardly curved siphunculi. Winged forms are reared during the summer and these disperse to the new canes, eventually giving rise to small, pale yellow apterae which develop singly on the underside of expanded leaves. Wingless sexual forms are produced in the autumn.

Aphis pomi Degeer
Green apple aphid

The green apple aphid is associated mainly with apple but will also colonize pear, quince and various other trees and shrubs in the family Rosaceae, including ornamentals. Although often common, and causing slight leaf curl, it is usually of importance only on young host plants. The winter is passed in the egg stage on the bark of the young shoots. The eggs hatch from April onwards and ant-attended colonies develop quickly, the aphids clustering tightly together on the underside of leaves and along the new shoots. Winged migrants produced in June spread infestations. Wingless males and females are produced in the autumn prior to the deposition of winter eggs by oviparae. Apterous females (1.3-2.2 mm long) are bright green to yellowish-green with moderately long, black or dark brown siphunculi and a finger-like, tapered cauda **(Fig. 191a).**

NOTE Several other members of this genus are associated with cultivated plants, including: *Aphis craccivora* Koch (cowpea aphid), a shiny black aphid infesting herbage legumes and ornamental legumes; *A. lambersi* (Borner) (permanent carrot aphid), a black to greenish-black aphid on carrot; *A. schneideri* (Borner) (permanent currant aphid), a dark green, wax-coated aphid on red currant and black currant; and *A. triglochinis* Theobald (red currant/arrowgrass aphid), a brownish-green species overwintering on red currant and, less frequently, black currant.

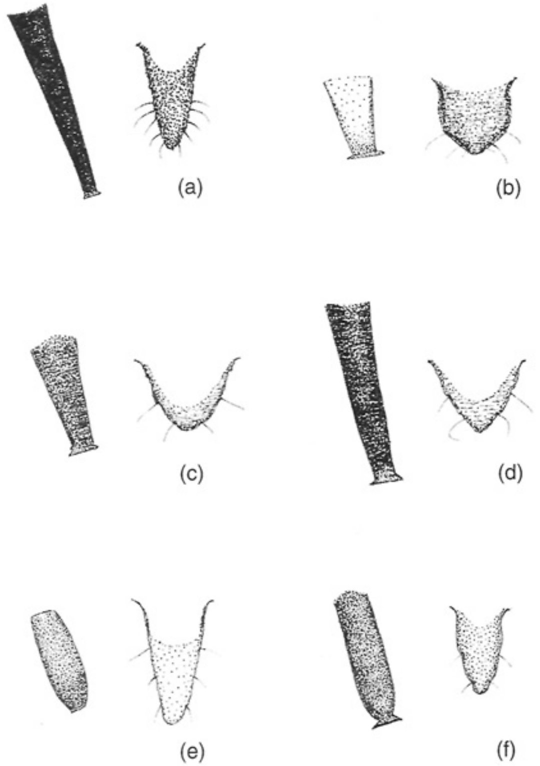


Fig. 191 Siphunculi and caudas of some aphids associated with fruit trees: (a) green apple aphid, *Aphis pomi;* (b) leaf-curling plum aphid, *Brachycaudus helichrysi;* (c) rosy leaf-curling aphid, *Dysaphis devecta;* (d) rosy apple aphid, *Dysaphis plantaginea;* (e) mealy plum aphid, *Hyalopterus pruni;* (f) apple/grass aphid, *Rhopalosiphum insertum.*

Aulacorthum solani (Kaltenbach)
Glasshouse & potato aphid

This extremely polyphagous aphid is a common glasshouse species, where it infests various vegetable and ornamental plants. It is often also present in potato chitting houses and stores. In summer, infestations will occur on various outdoor hosts, including lettuce, potato, tomato and many herbaceous weeds. Infestations on glasshouse lettuce, tomato and ornamentals weaken plants; they also affect quality. Direct damage to potato is usually limited to tubers in store or to those in chitting houses. The aphids are vectors of plant viruses, including potato leaf roll and potato virus Y but, compared with other potato-infesting species, such as potato aphid *(Macrosiphum euphorbiae)* (p. 114) and peach/potato aphid *(Myzus persicae)* (p. 116), they are usually of minor significance.

BIOLOGY

This highly polyphagous species often overwinters in the egg stage. In spring, colonies develop rapidly, producing both wingless and winged forms. Infestations spread to many other hosts, and summer colonies reach their maximum development in July. Sexual forms, when produced, usually include wingless males. Colonies die out before the onset of winter but, if conditions are favourable, the aphids will continue to breed parthenogenetically throughout the year.

DESCRIPTION

Aptera 1.8-3.Omm long; *body* more or less pear-shaped, shiny greenish-yellow, with a darker (often rusty) patch at the base of each siphunculus, to uniformly dull greenish-brown or green; *antennae* relatively long, reaching to the cauda, mainly pale but dark tipped; *siphunculi* long, slender, mainly pale but dark and flanged apically **(Fig. 190b);** *head* with raised lateral tubercles **(Fig. 189c). Nymph** shiny yellowish-green, with darker legs and antennae.

Aulacorthum circumflexum **(Buckton)**
Mottled arum aphid

This polyphagous, probably entirely parthenogenetic species, is often abundant in glasshouses, affecting a wide range of ornamental plants; infestations also occur on stored bulbs. Apterae (1.2-2.6 mm long) are smaller than those of *Aulacorthum solani* (above) and characterized by the black, often horseshoe-shaped pattern on the abdomen. Alatae are similar in appearance to apterae but occur only rarely.

Brachycaudus helichrysi **(Kaltenbach)**
Leaf-curling plum aphid

This aphid is a major pest of damson and plum, distorting foliage and stunting growth; affected leaves often turn yellow and may drop prematurely. Infestations may be extensive and can have a considerable effect on cropping, as fruits on affected branches remain small and are of poor quality. Infestations on summer hosts (e.g. chrysanthemum) cause leaf mottling, stunting and distortion; in continental Europe, this species also damages sunflower crops. Infestations on clover (by the distinct form *Brachycaudus helichrysi warei* Theobald) may result in leaf mottling and reduced seed yield. *Brachycaudus helichrysi* is a vector of plum pox virus ('Sharka disease'), and a potential vector of non-persistent viruses (e.g. potato virus Y) on crops it feeds upon but does not colonize.

BIOLOGY

In most parts of its geographical range, this aphid includes an egg stage in the life-cycle, overwintering on damson and plum. At least in England, the eggs often hatch in mid-winter, usually in November and December. Nymphs of this first generation feed at the base of the buds and eventually mature to produce a second generation that may also have commenced feeding before bud-burst. During the spring, heavy infestations often develop on the flower buds and young foliage. Breeding on primary hosts continues throughout the spring, with winged forms appearing in increasing numbers from late May onwards. Colonies on primary hosts usually die out by late June or early July. Colonies on secondary (summer) hosts include both wingless and winged aphids. Breeding culminates in the production of winged males and winged females that fly to primary hosts. The winged females (gynoparae) then produce a wingless generation of oviparae that, after mating with the winged males, deposit the winter eggs. Under warm conditions (including heated glasshouses in temperate regions) this species breeds parthenogenetically throughout the year and lacks a sexual phase (i.e. is anholocyclic); the clover-inhabiting form *B.h. warei* is also believed to be anholocyclic.

DESCRIPTION
Aptera (on primary host) small (up to 2 mm long), rounded, shiny (with a slight waxy bloom), varying in colour from brownish (= the late winter/early spring form) to yellowish-green; *siphunculi* short, pale; *cauda* short, tongue-like **(Fig. 191b). Aptera (on secondary host)** very small (often <lmm long), pale greenish or whitish-yellow to pale pinkish-white.
NOTE Peach trees are colonized by *Brachycaudus persicae* (Passerini) (black peach aphid) and *B. schwartzi* (Borner) (peach aphid); these two species are distinguished from *B. helichrysi* by their dark siphunculi.

Brevicoryne brassicae (L.)
Cabbage aphid

This notorious aphid is a widespread and generally abundant pest of brassica crops, including broccoli, Brussels sprout, cabbage, cauliflower, oilseed rape and swede. Attacked leaves may become discoloured (often reddish or purplish) and distorted, severely weakening plants and checking growth; heavily infested seedlings or young plants wilt and may die. The presence of the aphids, along with quantities of secreted wax, can also be a problem at harvest, rendering otherwise edible parts of plants useless for human consumption. The aphids may also transmit certain viral diseases, such as cabbage black ring spot, cabbage ring necrosis and cauliflower mosaic. Damaging spring populations on overwintering brassica seed crops, such as winter oilseed rape **(Plate 2b),** occur only following mild winters. Heavy infestations cause distortion and, often, a reddish or purplish discoloration of both leaves and pods; such damage, however, is largely cosmetic and rarely of significance.

BIOLOGY
Although commonly overwintering in the egg stage on old wild and cultivated brassica plants, wingless aphids may also survive the winter if conditions are suitably mild. Overwintered eggs hatch in April, and breeding on the original host plants is then resumed. Winged forms appear in colonies from May onwards. These spread infestations to newly planted brassica plants, where colonies develop on the underside of leaves and on flower heads. Colony development reaches its peak in the autumn, when sexual forms are produced, by which time host plants may be heavily infested and covered in aphids and secreted wax. Winter eggs are laid in the autumn, particularly during October.

DESCRIPTION
Aptera 1.6-2.6 mm long, greyish-green, with small paired black patches on the abdomen and coated with greyish-white, mealy wax; *siphunculi* short, barrel-shaped; *cauda* short, triangular **(Fig. 188d).**

Cavariella aegopodii **(Scopoli)**
Willow/carrot aphid

This aphid is an important pest of carrot; infestations also occur on other umbelliferous crops, including celery, parsley and parsnip. The aphids cause significant damage to early and mid-season crops, infested leaves turning yellow and plants becoming stunted. The aphids are also important vectors of persistent viruses (e.g. carrot motley dwarf, carrot red leaf), semi-persistent viruses (e.g. parsnip yellow fleck) and non-persistent viruses (e.g. celery mosaic), the foliage of affected plants often becoming mottled with yellow.

BIOLOGY
Winter eggs occur on *Salix* (especially *S. alba* and *S. fragilis).* In spring, colonies of aphids develop on the young shoots, culminating in the production of winged forms that migrate in May

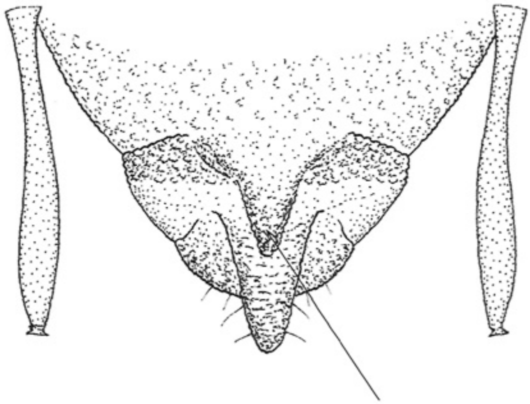


Fig. 192 Tip of abdomen of willow/carrot aphid, *Cavariella aegopodii.*

to umbelliferous summer hosts. Colonies on these secondary hosts occur mainly from late May to early July. There is then a return migration to primary hosts where oviparae are produced and eggs laid. Although usually overwintering on primary hosts in the egg stage, viviparous aphids may survive the winter on overwintering umbelliferous plants or in carrot clamps.

DESCRIPTION

Aptera 1.0-2.6 mm long, mainly green to yellowish-green or reddish, elongate-oval, dorsoventrally flattened; *siphunculi* relatively long and distinctly swollen apically; *body* with an elongated tubercle (the supracaudal process) on the eighth abdominal tergite **(Fig. 192).**

Cavariella theobaldi **(Gillette & Bragg)**
Willow/parsnip aphid

This species, which also overwinters on *Salix,* occurs in summer on various umbelliferous plants, including cultivated parsnip. The aphids cause direct damage and are also capable of spreading viruses such as parsnip yellow fleck. They are distinguishable from *Cavariella aegopodii* (above) by their brighter green body colour and by their unswollen, slightly tapered siphunculi.

Chaetosiphon fragaefolii **(Cockerell)**
Strawberry aphid

This species is a well-known pest of cultivated strawberry. Although causing little direct damage, the aphids contaminate plants with sticky honeydew and are particularly important as potential vectors of persistent and non-persistent viruses.

BIOLOGY

The aphids breed parthenogenetically on strawberry throughout the year, and tend to be most numerous on the underside of young leaves. Colonies are usually most populous in early summer (established plants) or autumn (first-year plantings); although excreting considerable quantities of honeydew, the aphids are not attended by ants. Winged females are produced in May and June, and sometimes also in late autumn or early winter, but there is usually no sexual phase in the life-cycle; males and egg-laying females (oviparae) are, however, reported to occur under artificial conditions.

DESCRIPTION

Aptera 0.9-1.8mm long, elongate-oval, pale greenish-yellow to translucent whitish; *eyes* reddish; *body hairs* capitate; *siphunculi* relatively long, tapered; *head and basal segments of antennae* with prominent, capitate hairs **(Fig. 189d).**

Cryptomyzus ribis (L.)
Red currant blister aphid

This species is a generally common pest of red currant, causing noticeable reddish or purplish-red blisters (pseudo-galls) on the foliage; infested tissue also becomes distorted, and foliage and fruits contaminated by sticky honeydew and sooty moulds. Colonies occur occasionally on other kinds of *Ribes,* causing less obvious, usually yellowish-green, blisters.

BIOLOGY

This species overwinters in the egg stage on the shoots of currant. In spring, colonies develop on the underside of the leaves within the hollows formed beneath the leaf blisters, and eventually produce winged forms. These migrate to summer hosts, especially *Stachys. A* return migration to currant occurs in the autumn.

DESCRIPTION

Aptera 1.2-2.5 mm long, oval-bodied, either shiny white or pale ereamish-white to pale yellowish-green; *body hairs* capitate; *siphunculi* relatively thin, often more than three times as long as the cauda; *cauda* tongue-like.

***Cryptomyzus galeopsidis* (Kaltenbach)**
Black currant aphid

This aphid has two biological races, sometimes afforded subspecific status: one occurs entirely on black currant and red currant; the other alternates between *Ribes* (including gooseberry) and various Labiatae, especially *Galeopsis* and *Lamium* (the labiates are the secondary, summer hosts). The aphids cause no direct damage. However, if populations on *Ribes* are large, honeydew excreted by the aphids will cause noticeable contamination of foliage and fruit. The aphids are similar in appearance to those of *Cryptomyzus ribis* (above) but readily distinguished by the more elongate cauda (usually more than half the length of the siphunculi); they are also often greener in appearance and have a dark dorsal stripe.

***Dysaphis devecta* (Walker)**
Rosy leaf-curling aphid

This aphid is a widespread but local pest of apple. Infested leaves become curled downwards and develop a characteristic bright red coloration. Attacks tend to occur on mature trees with roughened bark and are rarely of major importance.

BIOLOGY

This species is restricted to apple and overwinters as eggs secreted under bark or in deep bark fissures. Colonies develop on the rosette leaves from early spring onwards, and are well established by the green-cluster stage. Later, the aphids also invade the young shoots. Although producing winged forms during the summer, the extent of migration is strictly limited and aphids rarely fly away from the tree upon which they were reared. Winter eggs are deposited from mid-Iune onwards, and most colonies will have completed their development before the end of My.

DESCRIPTION

Aptera 1.8-2.4mm long, mainly bluish-grey, coated with white, waxy powder; *antennae* relatively short; *siphunculi* black, short, tapered, flanged apically; *cauda* black, triangular **(Fig. 191c).**

***Dysaphis plantaginea* (Passerini)**
Rosy apple aphid

This aphid (commonly known as 'blue bug') is a serious pest of apple, causing severe curling and distortion of leaves; affected tissue (pseudo-galls) may also become yellowish or brown but not red (cf. *Dysaphis devecta,* above). Infested shoots also become distorted and stunted and fruits remain small and malformed. Heavy infestations also lead to premature leaf-fall and will reduce cropping potential for the following year.

BIOLOGY

Eggs, overwintering on the bark, hatch in the early spring. Colonies then develop on the rosette leaves and, later, on the young shoots. Winged forms are produced in June or July, when there is a migration to *Plantago,* especially *P. lanceolata.* Colonies, however, often also persist on apple well into the summer. In early autumn a return migration occurs from summer hosts to apple, where winter eggs will be laid.

DESCRIPTION
Aptera 2.1-2.6 mm long, pinkish to dark bluish-grey, coated with white, mealy wax; *siphunculi* black, elongate, tapered, flanged apically; *cauda* dark, triangular **(Fig. 191d).**

***Dysaphis pyri* (Boyer de Fonscolombe)**
Pear/bedstraw aphid

The pear/bedstraw aphid is a potentially important pest of pear. Infestations lead to considerable distortion and yellowing of foliage and have a deleterious effect on shoot growth. The aphids also contaminate host plants with vast quantities of honeydew.

BIOLOGY
This species overwinters as eggs on pear, the primary host. Colonies develop during the spring on the young leaves and shoots, often becoming very populous. Winged forms are usually produced in June, and these migrate to *Galium* the secondary, summer host. Winged migrants from *Galium* eventually return to pear in the autumn.

DESCRIPTION
Aptera 1.7-3.2mm long, distinctly plump, brownish-red to dark brown but coated in whitish wax, which gives the body a pinkish appearance; *siphunculi* black; *cauda* short, tongue-like.

***Dysaphis apiifolia petroselini* (Borner)**
Hawthorn/parsley aphid

This common species forms red pseudo-galls on leaves of *Crataegus* during the spring, and migrates in summer to the base of the stems of celery and parsley. Colonies on these summer hosts are commonly sheltered by ant-constructed earthen canopies. The aphids are similar in appearance to the more widely known *Dysaphis crataegi* (below) but with a distinct rust-coloured patch around the base of each siphunculus. Damage caused to primary and secondary hosts is of little or no importance but, at least under laboratory conditions, the aphids are capable of transmitting various virus diseases, including cauliflower mosaic, celery crinkle leaf and celery mosaic.

***Dysaphis crataegi* (Kaltenbach)**
Hawthorn/carrot aphid

This aphid overwinters in the egg stage on *Crataegus*, where spring colonies of blackish aphids, lightly dusted with wax, form conspicuous, deep-red pseudo-galls on the leaves. Winged aphids later migrate to wild and cultivated carrot, where they initiate dense, ant-attended colonies of wingless aphids on the tap root and leaf bases; aphids also occur in summer on parsnip **(Plate 2c),** as a separate subspecies: *Dysaphis crataegi kunzei* (Borner) = hawthorn/parsnip aphid. In the autumn, winged forms are produced, and these return to *Crataegus* where winter eggs are laid. Apterae on carrot and parsnip are 1.4-2.6mm long, yellowish-grey, greenish-grey or pinkish-grey, and lightly dusted with wax; the siphunculi are relatively short and distinctly tapered.

***Dysaphis tulipae* (Boyer de Fonscolombe)**
Tulip bulb aphid

This virtually cosmopolitan aphid is associated with monocotyledonous plants and is an important pest of various ornamentals, causing both direct damage and also acting as a virus vector. It is often abundant on iris, lily and tulip, and large numbers often cluster on young shoots sprouting from corms or bulbs. Apterae are 1.5-2.5 mm long, grey, pink or whitish-yellow, and covered in a white, powdery wax. This species is anholocyclic, breeding entirely parthenogenetically.

***Hyalopterus pruni* (Geoffroy)**
Mealy plum aphid

This aphid is a generally common pest of damson and plum; infestations also occur on certain wild species of *Prunus*, especially *P. spinosa.* Vast numbers of aphids often coat the underside of the expanded leaves; colonies may also spread along the young shoots. Unlike the leaf-curling plum aphid, *Brachycaudus helichrysi* (p. 109), mealy plum aphid does not cause leaf distortion, but infested foliage often becomes yellow and may drop prematurely; honeydew excreted by the aphids is also a problem, enabling sooty moulds to develop. Attacks sometimes also occur on almond, apricot and peach trees.

BIOLOGY

Overwintering eggs, laid on the young shoots of *Prunus* in the autumn, hatch in the spring. Colonies then develop on the primary hosts, numbers at first remaining relatively low but later increasing rapidly. In June and July, colonies are often extremely populous and they may remain active into August. Winged migrants are produced from late June or early July onwards and these fly to various summer hosts, including *Phragmites communuis.* A return migration to primary hosts occurs in the autumn.

DESCRIPTION

Aptera 1.5-2.6mm long, elongate, mainly pale green but dark-mottled and liberally coated with white, mealy wax; *antennae, legs and siphunculi* dusky-tipped; *siphunculi* short, apically rounded; *cauda* finger-like **(Fig. 191e).**

***Macrosiphum euphorbiae* (Thomas)**
Potato aphid

This polyphagous species, first introduced into Europe from North America in about 1917, is often abundant on edible crops such as lettuce, potato and tomato, and on various other hosts including borage and many ornamentals. The aphids often cause stunting and distortion; they are also vectors of both persistent and non-persistent viruses, including freesia mosaic, pea enation mosaic, pea leaf roll and potato leaf roll; compared with peach/potato aphid *(Myzus persicae*, p. 116), however, their role in spreading potato leaf roll virus is minor. Infestations are especially common in unheated glasshouses, and often develop on potato shoots in chitting houses.

BIOLOGY

In Europe, the potato aphid is mainly anholocychc, breeding parthenogenetically and overwintering in protected situations as either adults or nymphs. Occasionally, however, the aphid overwinters in the egg stage on Rosaceae, including cultivated rose. Aphid numbers are capable of developing rapidly in the spring and, in May and June, when winged forms are produced, infestations soon spread to many kinds of plant.

DESCRIPTION

Aptera 1.7-3.6 mm long; *body* spindle-shaped, shiny, greyish-green to pink; *antennae and legs* long; *siphunculi* very long and slender, with a reticulate pattern apically; *cauda* elongate **(Fig. 190c). Nymph** elongate, pale with a dark central longitudinal stripe and a slight wax coating.

Macrosiphum albifrons **Essig**
Essig's lupin aphid

This North American aphid was first reported in the British Isles in 1981. It has since become a widespread and important pest of lupin, and is now also well established in continental Europe. The aphids are very large (up to 4.5mm long), and greyish-green, dusted with whitish wax. They form dense colonies on the leaves and flower spikes, causing severe damage to lupins in gardens and nurseries, and also transmitting viruses. Infestations also occur on agricultural lupin crops, e.g. white lupin; alkaloid content and composition of the plant is important in determining host suitability. On autumn-sown lupins, infestations often become extensive by mid-April. On spring-sown crops, aphids usually occur from July onwards, with largest populations developing during flowering. In Europe, this species appears to be anholocychc and breeds entirely parthenogenetically.

***Macrosiphum** rosae* **(L.)**
Rose aphid

This aphid is a major pest of rose. Colonies often persist on rose bushes throughout the year, overwintering in the egg stage, but a summer migration to secondary hosts (including Dipsacaceae and Valerianaceae) also occurs. The medium-sized to relatively large aphids (up to 3.6mm long) are broadly spindle-shaped and shiny; they vary in colour from green to pink or reddish-brown, and have long antennae, legs and siphunculi; the siphunculi are characteristically black and shiny.

***Megoura viciae* Buckton**
Vetch aphid

Minor infestations of this aphid occur on various members of the Fabaceae, including broad bean, culinary pea and vetches. Heavily infested parts of plants become discoloured, the affected tissue turning red and eventually black; damage, however, is rarely important. The aphids are also vectors of several viruses, including bean enation mosaic and bean leaf roll.

BIOLOGY
Eggs overwintering on host plants hatch in the spring from early April onwards. After about three generations of wingless forms, winged aphids are produced, and these spread infestations to other locations. Breeding continues until the autumn when populations reach their peak and, eventually, winter eggs are laid.

DESCRIPTION
Aptera 3.0-4.3 mm long, *body* spindle-shaped, mainly green to dark bluish-green; *head, antennae, prothorax and legs* black; *siphunculi* black and distinctly swollen; *cauda* black and finger-shaped **(Fig. 188e).**

***Metopolophium dirhodum* (Walker)**
Rose/grain aphid

This aphid is a potentially harmful pest of cereals, especially winter wheat and barley; infestations also occur on grasses. Damage is rarely important, but 'outbreak' years are known in which very large populations develop and yield reductions occur. On wheat and barley, aphids developing on flag leaves from ear emergence onwards are of greatest significance; on maize and sweet corn, the aphids are of only minor importance unless very numerous. Colonies on rose bushes have little direct effect on plant growth.

BIOLOGY
This species overwinters in the egg stage on wild and cultivated rose bushes where, in spring, colonies develop on the leaves and flower buds. Winged forms are produced from April or early May onwards. These aphids migrate to cereals and grasses, where breeding continues; colonies on rose do not persist beyond June (cf. rose aphid, *Macrosiphum rosae,* above). On cereals, the aphids are restricted mainly to the lower leaves but, especially if numerous, they may invade the upper leaves, including the flag leaves. The aphids feed mainly beneath the leaves and, although dislodged by gusts of wind, usually remain undisturbed by rain (cf. grain aphid, *Sitobion avenae,* p. 120). Colony decline on Poaceae is followed by a return migration to rose, the primary host; winter eggs are laid in October and November. In mild, ideally damp situations, the aphids are capable of surviving the winter pathenogenetically on grasses.

DESCRIPTION
Aptera 1.5-3.0 mm long; *body* broadly spindle-shaped, pale green (rarely pink) with a dark longitudinal stripe dorsally; *siphunculi* long and pale; *cauda* broadly finger-shaped **(Fig. 193a);** *head* with divergent lateral prominences and a distinct median prominence (outline, therefore, W-shaped) **(Fig. 189e).**

Metopolophium festucae **(Theobald)**
Fescue aphid

This species is associated mainly with grasses, but will also occur on cereals, overwintering

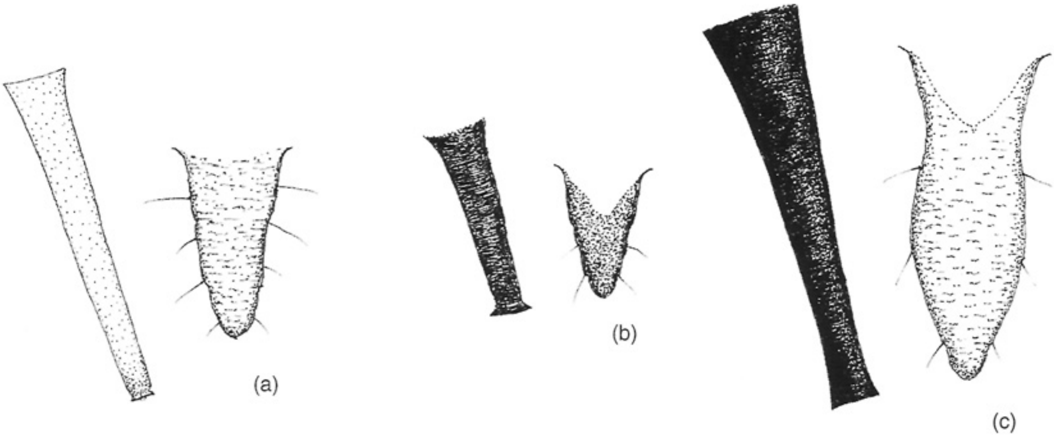


Fig. 193 Siphuculi and caudas of three common species of cereal aphid: (a) rose/grain aphid, *Metopolophium dirhodum;* (b) bird-cherry aphid, *Rhopalosiphum padi;* (c) grain aphid, *Sitobion avenae.*

either in the egg stage or, more frequently, as adults. There are no non-poaceous hosts and, hence, no alternation of generations in the life-cycle. The aphids are similar in appearance to *Metopolophium dirhodum* (p. 115) but slightly smaller (up to 2.2mm long), yellower in colour and without the dark longitudinal dorsal stripe; a reddish form also occurs.

Myzus ascalonicus Doncaster
Shallot aphid

The shallot aphid is an often common pest of herbaceous plants, including beet, lettuce, onion **(Plate 2d),** potato, shallot, strawberry and various ornamentals. Infestations lead to considerable stunting, distortion and malformation of the foliage or flower trusses of host plants; subsequent growth from previously infested bulbs or corms in store may also be affected when these are planted out, the new shoots often being weak and noticeably distorted. Damage to strawberry crops (a winter host) tends to be patchy and sporadic, typically occurring in the early spring but usually only if the late winter has been mild. Shallot aphid is also a virus vector.

BIOLOGY
This species breeds parthenogenetically throughout the year, often surviving the winter on stored bulbs, corms and root vegetables, and on various glasshouse plants. Under mild conditions, colonies can also survive the winter out-of-doors (e.g. on strawberry). Winged migrants appear in the spring, and these spread infestations to various herbaceous plants; colonies on winter hosts often then die out.

DESCRIPTION
Aptera 1.1-2.2 mm long, pale shiny brown, greenish-brown or yellowish-brown, distinctly convex; *siphunculi* pale, moderately long (but shorter than the third antennal segment) and the apical half distinctly swollen; *cauda* triangular, hardly visible from above (at least in live specimens) **(Fig. 190d);** *head* with lateral tubercles slightly convergent.

Myzus persicae **(Sulzer)**
Peach/potato aphid

The peach/potato aphid is a polyphagous pest of herbaceous plants, often attacking beet, cucumber (it is the main aphid pest of glasshouse-grown cucumber in northern areas of Britain), lettuce, mangold, oilseed rape, potato and vegetable brassicas; various ornamentals are also affected. This species is a notorious vector of plant viruses, including beet western yellows, cabbage black ringspot, carnation latent and chrysanthemum virus B, potato leaf roll virus and potato virus Y (the two most important aphid-borne viruses of potato in the UK), tomato yellow top and various mosaic viruses; the aphids also transmit cucumber mosaic from lettuce to cucumber. Direct feeding is rarely significant although, on certain protected crops, the aphids may cause distortion of leaves, buds and flowers, and stunting of terminal shoots.

BIOLOGY
This aphid usually breeds parthenogenetically and occurs throughout the year on a wide range of herbaceous plants. In some areas, however, the winter is passed in the egg stage on primary hosts such as nectarine and peach. Unlike many aphids, this species does not form dense colonies; also, the aphids are rather restless and frequently wander over the foodplant. Aphid numbers are usually greatest in July.

DESCRIPTION
Aptera 1.2-2.5 mm long; *body* oval and light green to yellowish-green or olive-green, occasionally mottled with pink or red; *siphunculi* moderately long (longer than the third antennal segment), pale but dark-tipped, the apical half slightly swollen **(Fig. 190e);** *cauda* bluntly triangular and clearly visible from above (cf. *Myzus ascalonicus*, p. 116); *head* with convergent lateral tubercles **(Fig. 189f).**

Myzus cerasi **(F.)**
Cherry blackfly

This insect is a potentially serious pest of cherry, affecting both fruiting and ornamental species. In spring, the aphids form dense, ant-attended colonies at the tips of the shoots. They cause considerable distortion and interruption of growth; the aphids are also virus vectors. In summer, the aphids occur on various summer hosts, including *Galium* and *Veronica;* a return migration to primary hosts occurs in the autumn. Apterae are 1.5-2.6 mm long and mainly brownish-black to black. Alatae are slightly smaller and paler in colour.

Myzus ***ornatus*** **Laing**
Violet aphid

The violet aphid is an entirely parthenogenetic, polyphagous species, which attacks various herbaceous plants. It is often a persistent pest of house plants and of ornamentals grown in glasshouses but is rarely found on outdoor plants. Apterae are very small (1.0-1.7 mm long) and pale yellow to greenish, with the dorsal surface marked with darker green or brown; the lateral tubercles on the head are well developed and strongly convergent. Although living singly, rather than in compact colonies, host plants become extensively contaminated by sticky honeydew and cast-off nymphal skins. The aphids are also virus vectors.

Nasonovia ribisnigri **(Mosley)**
Currant/lettuce aphid

The currant/lettuce aphid is a widespread and generally common pest of *Ribes*, especially gooseberry; the aphids distort leaves at the tips of the shoots and, if bushes become heavily infested, infestations will also check growth. On lettuce, the pest feeds beneath the outer canopy of leaves and invaded plants quickly become contaminated by the aphids and their cast skins. Attacks on lettuce are of significance, therefore, even when the aphids are present in only small numbers. Direct damage to lettuce is particularly severe on protected crops.

BIOLOGY
This species usually overwinters in the egg stage on gooseberry and currant bushes. Colonies develop on these primary hosts in the spring. In late May or June, winged forms migrate to lettuce and certain other summer hosts, including various wild Asteraceae, e.g. *Crepis, Hieracium* and *Veronica.* Breeding continues on these summer hosts until the autumn, when there is a return migration to gooseberry and currant by winged females (gynoparae) and winged males. The former produce a generation of wingless females (oviparae) which, after mating with the winged

males, deposit the winter eggs. In favourable situations, especially in glasshouses, aphids may survive on lettuce throughout the winter.

DESCRIPTION

Aptera 1.3-2.7 mm long, shiny dark green (summer form: often shiny pale yellow to green or reddish, with dark brown abdominal markings); *antennae and legs* long, with dusky tips; *siphunculi* moderately long, flanged, dark-tipped (in summer form: dark green or blackish); *cauda* elongate **(Fig. 188f).**

Ovatus crataegarius **(Walker)**
Mint aphid

This aphid forms small colonies in spring on young shoots of *Crataegus* and, sometimes, certain other Rosaceae, but does not cause damage. However, in summer, the aphids infest wild and cultivated mint, and may then be troublesome in kitchen gardens. Apterae are small (1.1-1.9mm long), oval and yellowish-green to green, with moderately long, tapered siphunculi and a pair of prominent, convergent antennal tubercles. In favourable situations, the aphids continue to breed parthenogenetically throughout the year. Elsewhere, the winter is passed in the egg stage on *Crataegus.*

Phorodon humuli **(Schrank)**
Damson/hop aphid

On damson and plum, this notorious pest is of little direct importance; however, infestations on hop are of considerable significance, reducing plant vigour and potentially limiting crop production; foliage and developing cones also become contaminated with sticky honeydew, upon which sooty moulds develop. The aphids transmit various plant viruses, including hop mosaic, hop slit-leaf blotch and plum pox ('Sharka disease').

BIOLOGY

Colonies develop in spring on the underside of the leaves of damson, plum and certain wild *Prunus* hosts, such as *P. spinosa.* Winged forms are produced from mid-May onwards, and these aphids then migrate to wild and cultivated hop, the main secondary hosts. This migration usually reaches a peak in mid- to late June and then declines but, exceptionally, may extend into August. Colonies of wingless aphids develop rapidly on the leaves and cones throughout the summer, ending with the production of winged aphids that fly to winter hosts where, eventually, winter eggs are laid.

DESCRIPTION

Aptera 2.0-2.5 mm long, elongate-oval, pale shiny green to yellowish-green with three longitudinal stripes on the abdomen; *head* with long lateral tubercles **(Fig. 189g).**

Rhopalosiphoninus latysiphon **(Davidson)**
Bulb & potato aphid

This aphid is a generally common pest of glasshouse-grown bulbs or corms, and of potatoes in store or in chittting houses; heavy infestations cause discoloration and death of sprouting shoots. The aphids will also damage such crops in the field, infested potato haulm turning yellow and wilting, significantly reducing yields. Heavily infested plants may be killed, especially in hot, dry summers when crops are under particular stress. Although known to transmit viruses, including potato leaf roll, this species is not an important virus vector.

BIOLOGY

Subterranean field infestations occur throughout the summer on potatoes, tulips and other hosts, colonies (which often include winged forms) typically becoming established several centimetres below the soil surface. The aphids are entirely parthenogenetic and breed without a sexual phase. Unlike many other species, their colonies are not attended by ants. The aphids usually survive the winter in store on host bulbs, corms or tubers.

DESCRIPTION

Aptera 1.5-2.5 mm long; *body* plump, shiny dark olive-green, with a distinct shiny blackish shield over the dorsal part of the abdomen; *siphunculi* strongly and abruptly swollen, shiny black **(Fig. 190f);** *cauda* bluntly triangular; *head* smooth (i.e. not spinose: cf. the following species); *antennae* noticeably hairy. **Nymph** green; *siphunculi* black.

***Rhopalosiphoninus staphyleae tulipaellus* (Theobald)**
Mangold aphid

The mangold aphid has a wide host range. It breeds on plant roots during the summer but is of most significance as a pest in mangold clamps. where large populations often develop; the aphids also overwinter on stored bulbs and corms (including crocus, lily and tulip). Direct feeding damage is of minor consequence but the aphids are vectors of viruses, including beet yellows. Apterae are very similar in appearance to those of *Rhopalosiphoninus latysiphon* (above), from which they may be distinguished by the spinose head, the less noticeably hairy antennae, the interrupted dark pattern of plates on the abdomen and the less-abruptly swollen siphunculi; the swollen middle section of each siphunculus is also noticeably paler than either the basal or the apical sections **(Fig. 190g).** This subspecies, which is sometimes treated as a separate species, was restricted to Europe, but appears also now to have been introduced into North America.

***Rhopalosiphum padi* (L.)**
Bird-cherry aphid

The bird-cherry aphid is an often common pest of cereals, including barley, oats and wheat. In mild regions (including southwest England), where populations survive the winter on these secondary hosts, the aphids are particularly important as vectors of barley yellow dwarf virus (BYDV). Early-sown winter cereals are most at risk from aphids migrating into them in September and October from grasses and cereal stubble. Direct damage to crops in summer is rarely of significance, although the aphids may cause stunting and discoloration of foliage. In some years, heavy infestations develop during the late summer on maize and sweet corn. The aphids often then occur beneath leaves shielding the developing cobs, and affected tissue becomes soiled by sticky honeydew and blackened by sooty moulds.

BIOLOGY
This often abundant species occurs on grasses and cereals. Under mild conditions, it overwinters parthenogenetically on these secondary hosts. Overwintering aphids on autumn-sown cereals and grasses usually occur on the shoots, just below the soil surface. Other populations overwinter in the egg stage on *Prunus padus,* the primary host, these eggs being deposited from September to November. Spring colonies on *Prunus* occur from April onwards, and culminate in the production of winged forms which migrate to cereals and grasses in May and early June. Aphids on Poaceae in summer occur mainly on the lower leaves but, if numerous, may become established on other aerial parts of the plants. On oats, and also on maize and sweet corn, the aphids often feed within the shelter of the leaf sheaths.

DESCRIPTION
Aptera 2mm long; *body* rather plump, brownish-green to olive-green, with a conspicuous rusty-red patch around the base of each siphunculus and near the base of the cauda; *antennae* short; *siphunculi* pale, flanged apically and slightly tapered; *cauda* elongate and tapered **(Fig. 193b);** front of head with lateral prominences slightly higher than the median bulge **(Fig. 189h).**

***Rhopalosiphum insertum* (Walker)**
Apple/grass aphid

The apple/grass aphid overwinters as eggs on apple, pear and certain other Rosaceae. During the summer, the aphids occur on cereals and grasses, their secondary hosts. Heavy populations on primary hosts in early spring can be damaging but usually occur only if the previous summer was wet and, therefore, conducive to the growth of grasses. Summer populations on cereals and grasses are of little or no importance, although the aphids are capable of transmitting barley yellow dwarf virus (BYDV). Apterae on cereals are broad-bodied (f.4-2.0 mm long), yellowish-green and somewhat dusky, with short, purplish-brown siphunculi. Those developing on apple and pear in spring are larger (2.f-2.6mm long), shiny yellowish-green to bright green, with a darker dorsal stripe and mainly green siphunculi; the siphunculi are distinctly flanged **(Fig.l91f).**

Rhopalosiphum maidis **(Fitch)**
Cereal-leaf aphid

This entirely viviparous, anholocyclic species occurs only on members of the Poaceae, especially wild grasses. During the summer, it will also infest cereal crops, especially barley, maize and sweet corn. Apterae are c. 1.0-2.5 mm long, and pale bluish-green and velvet-like, with a small purplish patch at the base of each siphunculus; the antennae are short and dusky, and the legs and siphunculi black and relatively short. The abdomen of alatae is uniformly yellowish-green or dark green. Infestations are rarely of significance in the UK, although the aphids are vectors of viruses.

Sitobion avenae **(F.)**
Grain aphid

The grain aphid is an important pest of winter wheat; infestations also occur on other cereals, including barley, oats, rye and sweet corn, and various grasses. Infested young plants may lack vigour. However, more important damage is caused later in host-plant development when aphids feed on the developing grain. Yield losses are especially severe if heavy attacks develop before the milky-ripe stage; the quality of infested grain is also affected. Once the developing grains harden, infestations are of little or no significance. This aphid is the main vector of barley yellow dwarf virus (BYDV) in eastern and northern Britain (cf. bird-cherry aphid, *Rhopalosiphum padi*, p. 119); it is also of significance as a virus vector in continental Europe. Early-sown winter cereals are especially at risk from immigrating aphids that arrive in September and October from grasses and cereal stubble. Aphids on maize and sweet corn are capable of transmitting maize mosaic virus; however, colonies on these crops usually develop relatively late in the season and are rarely populous (cf. bird-cherry aphid, *R. padi*, p. 119).

BIOLOGY
Eggs, which overwinter on cereals or grasses, hatch in March. Colonies of wingless aphids then develop, especially on the uppermost leaves **(Plate 2e)** and on the emerging or emerged ears of winter wheat; usually, they do not become populous until late June. Winged forms occur during the summer and these spread infestations to other cereals and grasses, where further colonies of wingless aphids are initiated. Aphid development during the summer is rapid in hot, dry weather, and the potential for colony growth is especially great on wheat. In the autumn, winged sexual forms are produced and these eventually give rise to a generation of egg-laying oviparae. In mild regions, however, this pest lacks a sexual phase and survives the winter as either winged or wingless viviparous females.

DESCRIPTION
Aptera 1.5-3.Omm long, shiny yellowish-green to dark reddish-brown; *antennae* uniformly dusky; *siphunculi* long, black; *cauda* pale, about three-quarters as long as the siphunculi **(Fig. 193c).**

Sitobion fragariae **(Walker)**
Blackberry/cereal aphid

This species overwinters in the egg stage on blackberry, where heavy infestations in spring cause significant leaf damage and also depress fruit yields. In summer, colonies develop on various cereals and grasses, which act as secondary hosts. Although often invading the ears of wheat and other members of the Poaceae, the aphids are rarely numerous and, although capable of transmitting viruses (e.g. BYDV), are of only minor importance. Apterae on blackberry are broadly spindle-shaped, 2-3 mm long, shiny yellowish-green with dark or mainly dark siphunculi (cf. bramble aphid, *Amphorophora rubi*, p. 105). Those on cereals and grasses are smaller and mainly dirty greenish; they are distinguished from *Sitobion avenae* (above) by the longer siphunculi (about twice as long as the cauda) and by the pale basal segments of the antennae.

Family PEMPHIGIDAE

Aploneura lentisci **(Passerini)**

Colonies of this species occur on the roots of grasses throughout the year, and are most obvious from May to October, but damage caused is of little or no significance. The aphids produce considerable quantities of whitish wax that accumulates around the aphids in cottonwool-like masses. Winged forms occur in large numbers in the summer; in Mediterranean areas, these are able to locate *Pistacia lentiscus*, the primary host, upon which the species then overwinters. Apterae are 1-3 mm long, spindle-shaped and mainly pale to ochreous yellow, with dark, very short legs and antennae **(Fig. 194).**

Fig. 194 Anterior part of body of *Aploneura*

Eriosoma lanigerum **(Hausmann)**
Woolly aphid

Infestations of this notorious pest occur mainly on apple but may also develop on other trees and shrubs (Rosaceae), including various ornamentals. The aphids produce considerable quantities of waxen 'wool', which often contaminates shoots, leaves and fruits. The aphids also cause significant galling of infested wood and heavy infestations lead to considerable disfigurement and disruption of growth; damage is of particular importance on young trees. The often walnut-like galls may split open, allowing canker and other diseases to gain entry.

BIOLOGY
This aphid remains on apple throughout the year. The winter is passed as bare (wax-less) nymphs that shelter in cracks or crannies in the bark of host trees. Activity is resumed in the spring and colonies soon develop beneath conspicuous masses of whitish, waxen 'wool', especially on the shoots, spurs and branches. There are several generations throughout the summer months, and colonies at this time often develop on sucker growth and water shoots. Small numbers of winged aphids may be produced in July but they are of only minor importance in spreading infestations. Egg-laying females (oviparae) appear in September but any eggs they deposit fail to hatch, aborting the sexual phase. Wax-covered colonies of parthenogenetic females persist well into the autumn and finally die out as the nymphs that will overwinter enter hibernation.[8]

DESCRIPTION
Aptera 1.2-2.6 mm long, soft-bodied, purplish-brown, covered with masses of white, mealy wax; *antennae* short, with the third segment elongated **(Fig. 195a);** *siphunculi* pore-like.

[8] It is thought that colonies persist throughout the winter on the roots of host trees but accounts from authors differ as to whether there is a regular seasonal migration from the aerial parts of host plants to the roots and back.

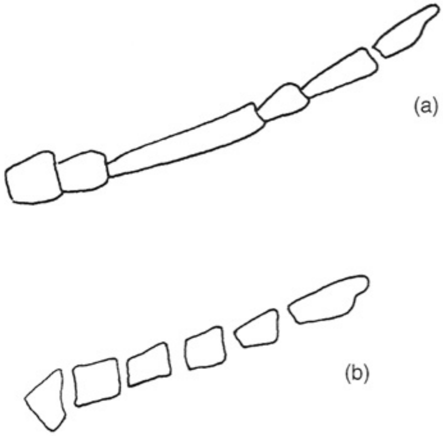


Fig. 195 Antennae of apterous aphids, family Pemphigidae: (a) woolly aphid, *Eriosoma lanigerum;* (b) carrot root aphid, *Pemphigus phenax.*

NOTE Other species of *Eriosoma* are also associated with fruit crops, e.g. *E. ulmi* (L.) (currant root aphid) which, in summer, breeds on the roots of *Ribes,* and *E. lanuginosum* (Hartig) (elm balloon-gall aphid) which, also in summer, occurs on the roots and basal parts of the trunks of pear trees. Both species overwinter on *Ulmus,* the primary host.

***Pemphigus bursarius* (L.)**
Lettuce root aphid

This aphid is a widespread and often important pest of lettuce; the leaves turn yellow and the plants become stunted. Attacks can be very serious and, in dry weather, infested plants may be killed; crops sown from April to June are most likely to be attacked.

BIOLOGY
This species overwinters in the egg stage on *Populus nigra* Ttalica'. In the spring, wingless females initiate characteristic pouch-like galls by feeding on the petioles of young leaves. Small colonies of aphids develop within these structures until, in the early summer, winged forms are reared; they eventually escape through a beak-like opening and migrate to wild and cultivated lettuce and to other Asteraceae, including *Sonchus.* Colonies of wingless aphids then develop on the roots of these summer hosts until the autumn, when winged forms are again produced. These aphids return to *Populus* where egg-laying females (oviparae) eventually deposit winter eggs. Populations on lettuce often persist well into the winter, and a few aphids may survive in the soil to re-infest lettuces planted out in the following year.

DESCRIPTION
Apterous female 1.6-2.5 mm long, elongate-oval, yellowish-white, with a tuft of white wax posteriorly and small, dark abdominal wax plates clearly visible; *antennae* very short; *siphunculi* absent.

***Pemphigus phenax* Borner & Blunck**
Carrot root aphid

This species is a common but minor pest of carrot; it also forms disfiguring galls on *Populus nigra* Ttalica'. Heavily infested carrots are weakened and the quality (and, hence, value) of wax-contaminated roots is reduced.

BIOLOGY
Overwintered eggs on *Populus* hatch in the spring, and aphids move to the unfurling leaves where they induce the formation of mid-rib galls. Each gall becomes an elongate, somewhat wrinkled, reddish swelling (often tinged with yellow laterally), packed with numerous wax-secreting aphids. In summer, winged forms are produced and these migrate to carrot plants where they initiate dense colonies on the roots. The root-feeding aphids produce copious amounts of white waxen 'wool', which may carpet the ground when heavily infested plants are lifted. There is a return migration to *Populus* in the autumn, where winter eggs are laid on the bark, but parthenogenetic colonies may persist throughout the winter on spring-lifted carrot crops; individuals can also survive the winter in the soil.

DESCRIPTION
Aptera (on carrot) 1.6-2.5 mm long, globular, yellowish-white to pale yellow, coated with white wax **(Plate 2f);** *antennae* very short **(Fig. 195b);** *siphunculi* absent.

Family PHYLLOXERIDAE

Viteus vitifoliae **(Fitch)**
Grape phylloxera

This notorious pest was introduced into Europe from North America in the mid-nineteenth century. The pest destroys the young roots of grape vines and also produces extensive callusing of the older roots. European grape vines are especially susceptible to attack and their complete destruction is possible unless they are grafted onto phylloxera-resistant rootstock. The pest can also produce greenish or reddish, wart-like galls on the underside of leaves (cf. galls formed by the grape erineum mite, *Colomerus vitis*, p. 258) but these are of little or no direct significance.

BIOLOGY
In Europe, this pest persists as radicicolae (which breed asexually on the roots of grape vines), each female laying eggs which normally give rise to nymphs that develop into further radicicolae. There are several such generations annually. Occasionally, eggs laid by radicicolae produce nymphs that, instead of becoming radicicolae, invade the aerial parts of the plant and develop into gallicolae. These gallicolae feed and breed within distinctive leaf galls. Nymphs emerging from their eggs either continue to develop in leaf galls as gallicolae or disperse to the roots, where they will develop into radicicolae. Although there is a sexual phase in the life-cycle, this very rarely occurs in Europe.

DESCRIPTION
Asexual (apterous) adult female 1.4 mm long, yellow to yellowish-green and plump-bodied. **Nymph** oval-bodied, whitish to pale yellowish-green.

Family DIASPIDIDAE (armoured scales)

Lepidosaphes ulmi **(L.)**
Mussel scale

This generally abundant scale insect is associated with a wide range of trees and shrubs. Infestations are of particular significance on mature, unsprayed apple trees and pear trees. The shoots and branches become encrusted with scales and heavily infested hosts are weakened.

BIOLOGY
Eggs overwinter, sheltered beneath the protective maternal scale, and hatch in late May or early June. The first-instar nymphs ('crawlers') are relatively active and crawl over the host plant for a few days before becoming sedentary. They then insert their mouthparts and begin to feed, usually on the shoots and branches but occasionally on leaves and developing fruits. They pass through three nymphal instars and reach the adult stage in late July. Eggs are laid from August onwards; the adults then die. There is one generation annually. This insect usually breeds parthenogenetically but some races reproduce sexually, with males appearing in early August.

DESCRIPTION
Adult female scale 2-3 mm long, grey to yellowish-brown, elongate but mussel-shaped (see Fig. 45a). **Adult female** 2.5 mm long, body subelongate, with a distinct pygidium (see Fig. 45b). **First-lnstar nymph** pale yellowish-brown, oval.

Family COCCIDAE (soft scales)

Coccus hesperidum **L.**
Brown soft scale

This generally common, polyphagous scale insect is often present on glasshouse-grown ornamentals and house plants; in favourable areas, including southern England, infestations also occur outdoors. Although attacks are usually unimportant, the quality of host plants in commercial nurseries may be affected adversely by the presence of the scales, sticky honeydew and sooty moulds.

BIOLOGY
Under favourable conditions, this usually parthenogenetic species breeds continuously; it is also viviparous, with mature females producing about a thousand nymphs during a life-span of

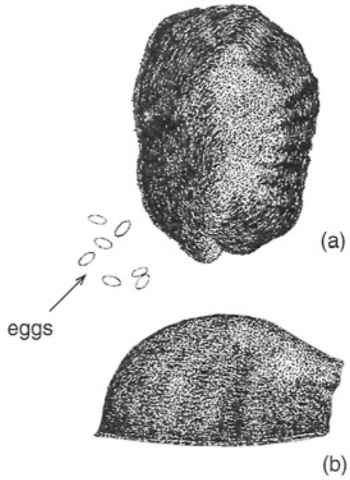
about 3 months. The scales most often settle along the major veins of leaves. Individuals frequently overlap one another to form dense, typically ant-attended colonies. At normal summer glasshouse temperatures, nymphs reach maturity in about 2 months.

DESCRIPTION
Female scale 3.5-5.0mm long, translucent-yellow to brown, with an often blackish median longitudinal ridge and rib-like markings; oval in outline and usually very flat but the exact shape varies according to the substratum. **First-instar nymph (crawler)** 0.5 mm long, pale brown, flat and elongate-oval with a posterior cleft; *eyes* dark purplish.

Parthenolecanium corni **(Bouche)**
Brown scale

The brown scale is a generally common, polyphagous pest of trees and shrubs; hosts include fruit trees, currant, gooseberry, raspberry and various ornamentals. Heavily infested plants are weakened and leaves may fall off prematurely.

BIOLOGY
Eggs of this usually parthenogenetic species hatch from mid-June onwards. First-instar nymphs (the so-called 'crawlers') then invade the leaves and young shoots, upon which they commence feeding. Individuals moult to the motile second instar in August and these continue feeding into the autumn. On evergreen hosts, the nymphs overwinter on the underside of the leaves; prior to overwintering on deciduous hosts, however, the nymphs move to the twigs and branches. Overwintering nymphs are small (c. 0.5 mm long) and gradually darken to orange or brownish. Activity is resumed in March. The nymphs feed and eventually moult into adults about a month later, each having then settled permanently, usually on a branch or twig. The sedentary adult female scales increase rapidly in size and also become distinctly convex and hardened. Several hundred eggs are laid under each



(b)

Fig. 196 Brown scale, *Parthenolecanium corni:* (a) dorsal view - with eggs; (b) lateral view (x7).

protective scale in May or June, the female then dying. Dead scales often remain attached to the bark of host plants for several years. Under glass, there may be two or more generations annually.

DESCRIPTION
Adult female scale 4-6 mm long, chestnut-brown, more or less shiny, tortoise-shaped and strongly convex **(Fig. 196). Egg** minute, white, oval **(Fig. 196a). Nymph** oval, flattened, pale translucent-greenish to brown, with prominent antennae, legs and anal cerci **(Fig. 197).**

Pulvinaria ribesiae **Signoret**
Woolly currant scale

This insect is a locally important pest of currant and gooseberry. Heavily infested bushes are weakened and often become festooned by masses of white, flocculent 'wool'; the insects also excrete considerable quantities of honeydew, upon which sooty moulds develop.

BIOLOGY
This species overwinters as mated adult females. These eventually mature in May, each then producing a large, white ovisac that pushes the scale away (posteriorly) from the host twig. The

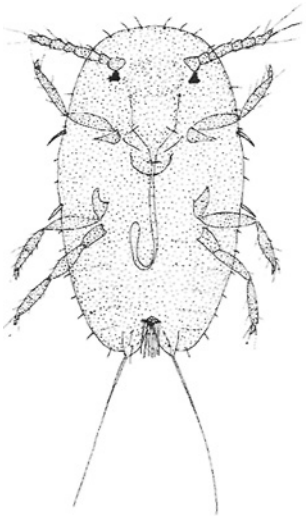


Fig. 197 Brown scale, *Parthenolecanium corni:* first-instar nymph (xlOO).

female then dies. Eggs, often up to a thousand in each ovisac, hatch from June onwards. The young nymphs then swarm over the foodplant and eventually settle on the 1-year-old wood. Here they begin feeding and, after passing through three instars, reach the adult stage, usually in September or October. After mating, the short-lived males die.

DESCRIPTION

Female scale up to 6 mm long, dark brown, oval, convex with a distinct posterior cleft. **Nymph** pale greyish-brown to brownish-orange, flat and oval with a distinct posterior cleft. **Male scale** 1mm long, whitish, boat-shaped. **Adult male** 1mm long, mainly pinkish; *legs and antennae* brownish; *forewings* broad; *caudal filaments* very long.

Pulvinaria regalis **Canard**
Horse-chestnut scale

This American species is associated with various ornamental trees and is nowadays a common sight on roadside trees in towns and cities in southern England; it is also now present in continental Europe (e.g. in parts of northern France). Prior to 1960, it was unknown in Europe. Although attacked trees are often heavily infested, effects on growth appear to be minimal.

BIOLOGY

This pest overwinters as first-instar nymphs, which continue feeding but grow only slowly. In the spring, following bud-burst, development is rapid and the adult stage is reached in May. This species is an unusual scale insect in that its nymphal and adult stages are surprisingly mobile; adult females, for example, commonly migrate from their feeding sites to the trunk and main branches where they will eventually lay eggs. Reproduction is usually parthenogenetic, although males are by no means infrequent.

DESCRIPTION

Adult female scale 7 mm long, brown, somewhat darker centrally; rounded in outline but tapered anteriorly, with a pronounced posterior cleft. **Nymph** oval, flattened, brown with a distinct posterior cleft.

Family PSEUDOCOCCIDAE (mealybugs)

Planococcus citri **(Risso)**
Citrus mealybug

This mealybug is often abundant on glasshouse ornamentals, especially under hot, humid conditions. Vegetable crops such as tomato are also attacked. The pinkish eggs are laid in large batches and then surrounded by cottonwool-like masses of wax; these conspicuous ovisacs often attract attention. The adults are 3-4mm long and pinkish, coated with whitish wax; the peripheral and caudal waxen processes are characteristically short and stout (cf. glasshouse mealybug, *Pseudococcus affinis,* below).

Pseudococcus affinis **(Maskell)**
Glasshouse mealybug

This mealybug is one of the most frequently encountered species on glasshouse crops. Heavy infestations debilitate host plants and sometimes cause premature leaf loss. The mealybugs also contaminate plants with honeydew, upon which sooty moulds develop.

BIOLOGY
Mealybugs breed continuously whilst conditions remain favourable, and there is a succession of overlapping generations throughout the year. Eggs are deposited in batches, often in the axils of leaves, each batch surrounded by cottonwool-like masses of wax that form a loose ovisac. Following egg hatch, the nymphs wander over host plants but they will often accumulate within curled leaves or beneath leaf sheaths. The adults are also mobile.

DESCRIPTION
Adult 4mm long, pinkish, coated with whitish wax; *caudal filaments* about half as long as body. **Egg** minute, oval, pinkish. **Nymph** similar in appearance to adult but smaller.

Pseudococcus longispinus (Targioni-Tozzetti)
Long-tailed mealybug

The long-tailed mealybug is often common in glasshouses. It is distinguished from the previous species by its smaller size (body *c.* 2.5 mm long) and by the distinctive caudal filaments, which are noticeably longer than the body.

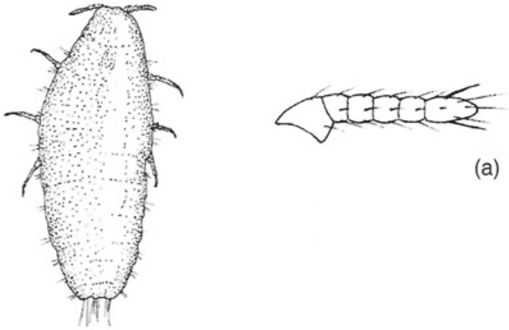


Fig. 198 Root mealybug, *Rhizoecus falcifer* (x40): (a) antenna (further enlarged).

Rhizoecus falcifer **Kiinckel de Herculais**
Root mealybug

Colonies of root mealybugs often occur on the roots of glasshouse plants; infestations are most often found on ornamentals. The foliage of attacked plants becomes dull. Also, heavily infested plants eventually wilt. The insects shelter in masses of whitish wax and breed parthenogenetically, there being a succession of generations throughout the year. Adults are elongate, 1.0-2.3 mm long, and greenish-yellow but coated liberally in whitish wax. They are readily distinguished from root aphids by their stubby, 5-segmented, geniculate antennae **(Fig. 198);** they also have very short waxy anal appendages.

ORDER COLEOPTERA (BEETLES)

Family CARABIDAE (ground beetles)

Harpalus rufipes (Degeer)
Strawberry seed beetle

Infestations of this generally common carabid often occur in strawberry fields during the fruiting period. The adult beetles remove seeds from the ripening fruits and, particularly if seeds are deeply set, will also injure the surrounding flesh. Linnets {*Carduelis cannabina* (L.)) also remove seeds from ripening strawberries but cleanly and from the more exposed parts of fruits.

BIOLOGY
Larvae usually overwinter in the grassy surroundings of fields. They emerge in the spring to feed on invertebrates and seeds of various plants, especially *Chenopodium album* and *Lolium;* unlike the adults, however, they do not attack strawberry fruits. Larvae usually complete their development by July and then pupate. Young

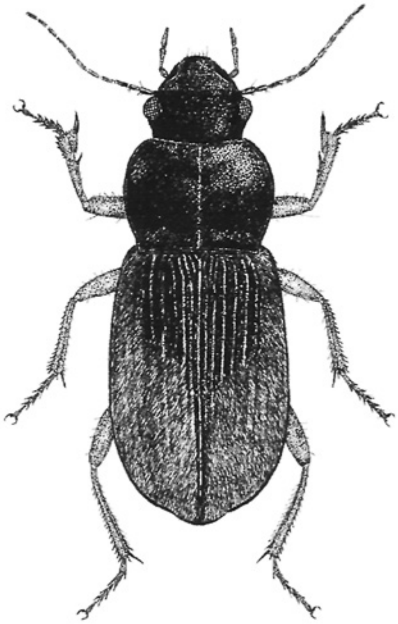


Fig. 199 Strawberry seed beetle, *Harpalus rufipes* (x4).

adults emerge, and eggs are eventually laid in the soil a few centimetres below the surface. The eggs hatch shortly afterwards and larvae feed into the autumn before hibernating. A proportion of the adult population also overwinters.

DESCRIPTION

Adult 11-17 mm long, dull black with a yellowish pubescence on the elytra **(Fig. 199);** *legs and antennae* reddish.

***Zabrus tenebrioides* (Goeze)**
Cereal ground beetle

In mainland Europe, this carabid is an important pest of barley, maize, rye and wheat; it is also associated with grasses, especially *Poa pratensis.* In recent years, locally important outbreaks have occurred in cereal crops in several parts of southern England, usually on medium-textured calcareous soils. Damage is characteristic, the larvae causing extensive shredding of leaves and shoots **(Plate 3a),** and also dragging plant tissue down into their subterranean burrows; heavy infestations lead to the development of large patches or extensive areas of dead plants. Attacks are encouraged by continuous cereal growing or by cereal/grass rotations, and by the presence in fields of grass weeds and cereal volunteers; also, attacks are most likely to occur in years when the weather from late summer into early autumn remains warm and dry.

BIOLOGY

Adults occur from late June or early July onwards. They are active at night and feed on the leaves and other parts of cereals and grasses. Eggs are laid in the soil from mid-August onwards. They are either deposited singly or in small groups, 20 cm or more below the surface, and hatch in about 2 weeks. Each larva inhabits an earthen burrow which extends for a considerable depth and into which (at night) portions of leaves are dragged, to be consumed during the daytime. The larvae feed throughout the autumn and winter, and they remain active except in cold weather; cool, wet conditions are unfavourable for their survival. They pass through three instars and complete their development in the following May. Pupation occurs in the soil and adults emerge 2-3 weeks later.

DESCRIPTION

Adult 14-18 mm long, mainly black with partly reddish legs and reddish-brown antennae; *pronotum* heavily punctured posteriorly; *wings* fully developed **(Plate 3b). Larva** up to 30 mm long; *body* greyish-white to creamish-white, with brown dorsal plates and small lateral plates on each abdominal segment; *head* brownish-black; *mandibles* large and powerful; *thorax* mainly brown; *thoracic legs* well developed; *ninth abdominal segment* terminating in a pair of spinose cerci **(Plate 3c).**

Family HYDROPHILIDAE (mud beetles)

***Helophorus nubilus* F.**
Wheat shoot beetle

The wheat shoot beetle is an occasional and minor pest of wheat and, occasionally, oats;

attacks typically occur on crops that follow a grass ley. The larvae, which transfer from the ploughed-in grass, bite into the base of the shoots of the young cereal plants; the centre shoots may then turn yellow. Damaged shoots usually have a distinct, often ragged, hole at the base; they may also be severed. Unlike certain other ley pests (e.g. frit fly, *Oscinella frit*, p. 195; wheat flea beetle, *Crepidodera ferruginea*, p. 141) the larvae do not enter the shoot but may be found (although usually with difficulty) in the surrounding soil. In the British Isles, infestations occur mainly in eastern England.

BIOLOGY

Adults occur throughout the spring and summer, but eggs are not laid until the autumn. The larvae feed from November onwards and complete their development in the following spring. Pupation usually occurs in April or May, and adults usually appear from May onwards.

DESCRIPTION

Adult 3-4 mm long, dirty yellow, marked with black; *pronotum* hood-like and ridged longitudinally; *elytra* prominently ridged longitudinally. **Larva** up to 7 mm long; *body* mainly white, with brownish or blackish dorsal plates; *head* dark brown; *thoracic legs* short; *anal cerci* moderately long.

Helophorus porculus **Bedel;** ***H.*** *rufipes*
(Bosc d'Antic)
Turnip mud beetles

Both species of turnip mud beetle are widely distributed but minor and sporadic pests of turnip and certain other brassicas (cabbage, kale and swede); they may also attack other plants, including beans and lettuce. Adults remove sections of tissue from within or around the edges of leaves. The larvae more frequently tunnel in the roots and stems, causing plants to rot.

BIOLOGY

Adults occur from June onwards, and eggs are deposited in the soil during July and August. The eggs hatch in the autumn and the larvae then attack suitable host plants. The larvae feed mainly within the stems and roots, and remain active throughout the winter. They are fully grown by March or early April. Each then pupates in a small earthen cell a short distance below the soil surface. There is just one generation annually.

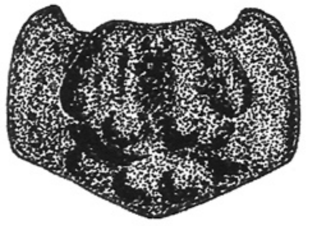


Fig. 200 Pronotum of turnip mud beetle, *Helophorus rufipes.*

DESCRIPTION

Adult 4-5 mm long, mainly dirty yellow, marked irregularly with black; *pronotum* with an irregular, wart-like sculpturing **(Fig. 200);** *elytra* prominently ridged longitudinally. *Helophorus rufipes* is the slightly larger species and the anterior (humeral) angles of the elytra are dentate - they are rounded in *H. porculus.* **Larva** up to 8 mm long; *body* creamish-white, with brownish or blackish dorsal plates on the thoracic and abdominal segments; *anal cerci* present.

Family SILPHIDAE (burying beetles)

Aclypea opaca (L.)
Beet carrion beetle

The beet carrion beetle is associated mainly with members of the Chenopodiaceae and was formerly an important pest of mangold and sugar beet crops, especially in continental Europe. Attacks have also been noted on various other plants, including cereals, potatoes and vegetable brassicas, smooth-edged holes being made in the leaves. If populations are large, adults and larvae cause significant damage to the foliage of beet seedlings, especially on backward, slowly germinating crops. Infested leaves are often daubed with sticky, black excrement.

BIOLOGY
Adults overwinter in sheltered situations in fields or hedges, or at the edges of copses or open woodlands. They appear in the spring and feed on various plants before migrating to beet crops. Eggs are then deposited in the soil in association with host plants, mainly in April, May or June, each female laying about 100-120. The eggs hatch about a week later. Larvae then feed on the foliage for up to 3 weeks; they may also attack the plant roots. Fully grown larvae wander away from host plants and eventually pupate in the soil, close to the surface, each in an earthen cell. New adults emerge about 2 weeks later and almost immediately seek overwintering quarters. The period of egg laying is protracted and all stages of the pest may occur together; there is, however, just one generation annually.

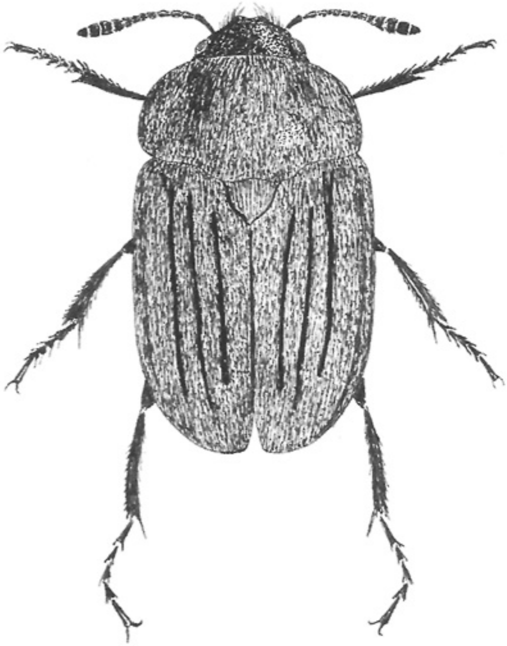


Fig. 201 Beet carrion beetle, *Aclypea opaca* (x6).

DESCRIPTION
Adult 9-12 mm long, flattened and broad-bodied, dull black, clothed in short golden-brown hairs; *elytra* finely punctured and with three ornate longitudinal ribs **(Fig. 201). Egg** shiny yellowish-white, spherical, 1-2 mm across. **Larva** up to 15 mm long; *body* mainly black and shiny; somewhat woodlouse-like, with prominent, laterally flanged tergites and elongate processes on the last abdominal tergite; *antennae* long, 3-segmented **(Fig. 202).**

Fig. 202 Larva of beet carrion beetle. *Aclypea opaca* (x5).

Family SCARABAEIDAE (chafers, dung beetles, etc.)

***Amphimallon solstitialis* (L.)**
Summer chafer

Larvae of this polyphagous, southerly distributed species often attack beet, cereals, grasses, potato and various horticultural plants. They sever the roots or bore into tubers or tap roots and, particularly in their second summer, are capable of causing considerable damage. Attacks are most likely to occur where crops are planted in recently ploughed-up grassland.

BIOLOGY
Adults occur in June and July, and are particularly active on warm evenings. The eggs, which are laid in the soil, hatch after several weeks. The

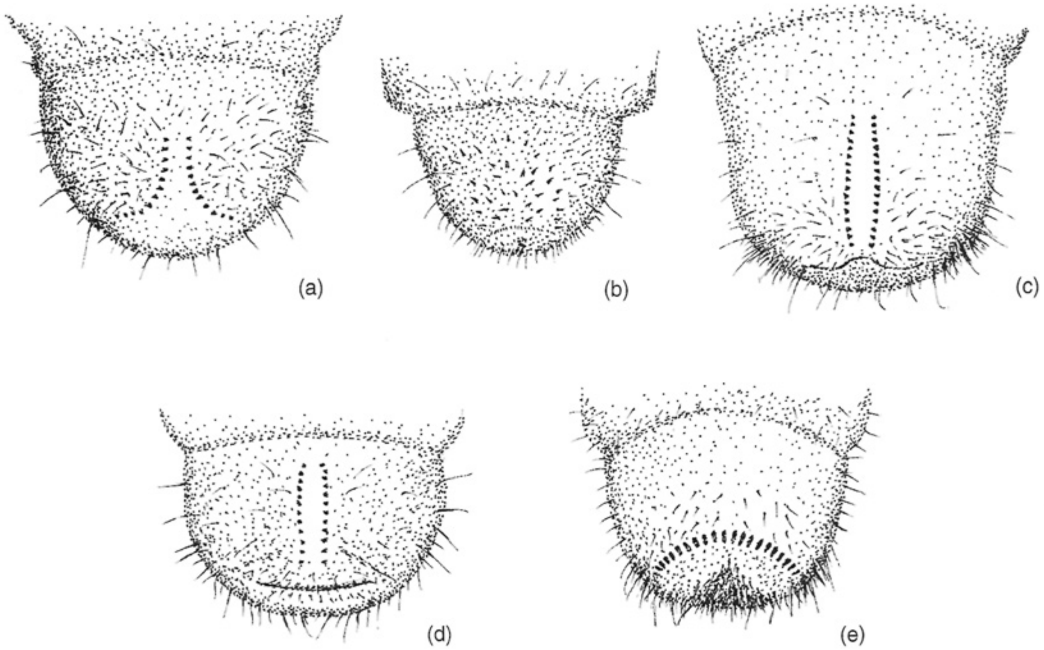


Fig. 203 Anal segments of chafer grubs: (a) *Amphimallon solstitialis;* (b) *Hoplia philanthus;* (c) *Melolontha melolontha;* (d) *Phyllopertha hordeola;* (e) *Serica brunnea.*

larvae feed briefly during the autumn and then hibernate; they recommence feeding in the spring and usually become fully grown by the autumn. Larvae again overwinter and eventually pupate in the spring. If conditions are unfavourable, development may extend over a further year.

DESCRIPTION
Adult 14-18 mm long, yellowish-brown and hairy; *pronotum* shiny; *elytra* dull and partly ribbed longitudinally. **Larva** up to 30 mm long; *body* mainly white; *head* yellowish-brown; *legs* pale yellowish-brown; *anal segment* partly translucent, with two posteriorly diverging rows of spines above the anal slit **(Fig. 203a).**

Cetonia aurata (L.)
Rose chafer

Larvae of this minor pest feed mainly on the roots of grasses, but they will sometimes also attack those of crops planted in recently ploughed-up grassland. Individuals, which develop over 2 or 3 years, are whitish and up to 30 mm long, with the head, legs and body hairs reddish; also, the body hairs are arranged in distinct, transverse rows. The adult chafers are 14-20 mm long and metallic golden-green with wavy, silvery markings; the underside of the body is purplish-red. Adults occur from late May onwards and often feed in the daytime on open blossoms of Rosaceae, UmbeUiferae and many other plants.

Hoplia philanthus (Fuessly)
Welsh chafer

This chafer is a widely distributed and locally common, but usually minor, pest. The adults occur in late June and July, and often swarm in warm, sunny weather. Eggs are laid in the soil, mainly in permanent grassland, and take several weeks to hatch. The larvae feed on grass roots from August or September onwards and, if numerous, can cause severe damage, with grass often dying out in patches. Larvae are up to 22 mm long, whitish and translucent, with numerous gingery body hairs and spines; the head is pale yellowish-brown with powerful, matt-black mandibles; also, the body is strongly flexed, with the head held tightly against the anal segment; the spines on the anal segment are arranged irregularly **(Fig. 203b).** Adults are 7-11 mm long and black, with reddish-brown elytra and reddish legs.

Melolontha melolontha (L.)
Cockchafer

Larvae of this large chafer occur mainly in grassland, although the adults tend to be most numerous in association with forests, woods and hegderows. The larvae are capable of causing considerable damage, as they bite through the roots and burrow into other subterranean parts of plants. Cereals, hop, lettuce, potato, strawberry and sugar beet are particularly vulnerable, especially when such crops are planted in recently ploughed-up pasture. Adult cockchafers graze on the foliage and flowers of shrubs and trees and are considered important forestry pests. The adults also attack developing fruitlets of fruit trees, removing parts of the flesh; bites sometimes reach down to the core. Chafer-damaged fruits either fall prematurely or remain on the tree; in the latter case, the injured tissue heals over and, depending upon the degree of injury, develops into corky patches or pits. Similar fruitlet damage is caused by caterpillars of pests such as clouded drab moth, *Orthosia incerta* (p. 243), and winter moth, *Operophtera brumata* (p. 231).

BIOLOGY
Adult cockchafers are active at night in May and early June, and are often attracted to lighted windows. They feed on the foliage of various shrubs and trees. They often roost in trees and bushes during the daytime and remain in a comatose state even when disturbed. Eggs are deposited deeply in the soil, usually at a depth of 60 cm or more, typically in batches of 12-30. They hatch in about 6 weeks. Larvae then feed on the subterranean parts of plants for up to 3 years before becoming fully grown, passing through three instars. They then pupate, usually in their third summer, each in an earthen cell. The adult stage is reached about 6 weeks later, but individuals remain in the pupal cell and do not emerge from the soil until the following spring. Mass emergence of adults often occurs at regular intervals, e.g. every 3 years, coinciding with the main local developmental phase of the larvae.

DESCRIPTION
Adult 20-30 mm long, pale chestnut-brown with a darker head and pronotum; *elytra* partly clothed in whitish hairs; *abdomen* protruding beyond the elytra and terminating in a blunt spine; *antennae* with six (in female) or seven (in male) lamellae. **Egg** 3 x 2 mm when newly laid, yellowish or whitish. **Larva** up to 50 mm long; *body* mainly white and sac-like; *head* brown; *anal segment* translucent, the anal slit wavy, transverse and surmounted by two longitudinal, parallel rows of spines **(Fig. 203c).**

Phyllopertha horticola (L.)
Garden chafer

Infestations of this often abundant chafer are most frequent in grassland, including golf courses and other amenity areas. The larvae destroy the root system of the turf, and this results in the appearance of large, dead patches. The loosened turf is often removed by birds, such as rooks, that commonly search infested areas for the grubs. Fine-leaved grasses are most susceptible to chafer attack; broader-leaved species, including cocksfoot and rye-grass, are more tolerant. Damage is especially severe on lighter soils and is also of particular significance on wet, upland pastures. Although primarily pests of grass, the larvae will also damage crops planted in recently ploughed-up grassland. The adult chafers sometimes browse on the leaves and developing apple and pear fruitlets, and may also cause minor damage to various other plants.

BIOLOGY

Adults are active mainly in May and June, and often swarm in sunny weather. They feed on the flowers, fruits and leaves of various herbaceous and other plants. Eggs are laid in the soil, usually deposited singly but close together, each in a small earthen chamber. Larvae feed from June or July onwards. They attack plant roots and typically rest with the head adpressed to the anal segment **(Plate 3d).** Individuals are fully grown by the autumn but they do not pupate until the following spring.

DESCRIPTION

Adult 7-11 mm long, distinctly hairy; *head and thorax* metallic bluish-green; *elytra* reddish-brown; *legs* black. **Larva** up to 15 mm long; *body* mainly white; *head* pale yellowish-brown; *anal segment* translucent, the anal slit transverse and surmounted by two parallel rows of spines **(Fig. 203d).**

***Serica brunnea* (L.)**
Brown chafer

Minor infestations of this locally common chafer sometimes occur on crops, such as potato, growing in fields adjacent to forests or woodlands. Root damage is also reported in wooded areas on young spruces grown as Christmas trees. Adults are 7-11 mm long and mainly reddish-brown; they occur throughout the summer months. The larvae, which usually take 2 years to complete their development, reach 18mm in length and are creamish-white with a pale yellowish-brown head; the body bears reddish-brown hairs and the anal slit is surmounted by an arc of spines **(Fig. 203e).**

Family ELATERIDAE (click beetles)

***Agriotes lineatus* (L.)**
A common click beetle

The larvae of click beetles (commonly known as 'wireworms') are important, polyphagous pests. They attack the subterranean parts of plants, and are usually most numerous in permanent grassland, where populations may reach or exceed several million per hectare. After destruction of infested grassland (e.g. by ploughing), surviving wireworms readily transfer their attention to following crops. Damage is most severe in spring and early summer, especially on potato tubers and on vegetable crops such as celery, leek, lettuce and onion; infestations may also be of significance on beet, hops, mangold, oats, spinach, strawberry, wheat (especially in the second year following grass), and on many other crops. Some plants, including barley, beans, clover, fodder brassicas, linseed, lucerne, mustard, oilseed rape, peas and rye, are resistant to attack. Wireworms browse on the roots or bite through the stems at about soil level; they also produce ragged holes in the basal parts of stems or bore into planted seeds, swollen tap roots or tubers, producing distinctive, small, rounded entry holes.

BIOLOGY

Adult click beetles are active from April to June. Eggs are then laid in the soil in batches of up to 100, usually amongst grass or other vegetation. The eggs hatch 5-6 weeks later. Wireworms (larvae) develop slowly, especially in their later instars, development usually extending over 4 or 5 years. They cause most damage in early spring, especially from March to May, with a second period of activity in the late summer or early autumn. Pupation takes place in August of the final year of larval development, each larva first forming an earthen cell 10 cm or more below the surface. The adult stage is reached 3-4 weeks later; however, the beetle does not emerge but remains within the pupal cell until the following spring.

DESCRIPTION

Adult 7-10 mm long and mainly dark yellowish-brown, with a darker head; *elytra* with alternating dark and pale longitudinal striations; *pronotum* relatively long, with a moderately distinct median longitudinal cleft **(Fig. 204). Egg** 0.6 mm long, more or less oval, whitish. **Larva** up to 25 mm long, shiny yellowish-brown, with a darker head, powerful jaws and small thoracic

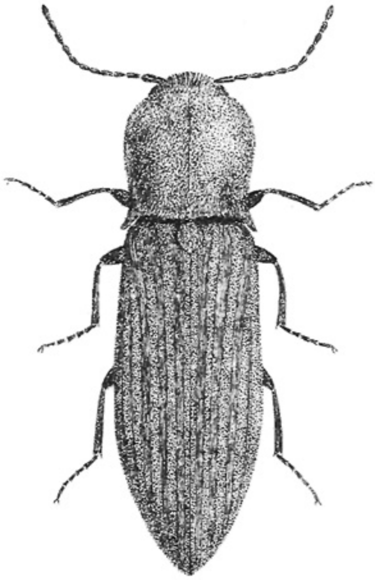


Fig. 204 Adult click beetle, *Agriotes lineatus* (x7).

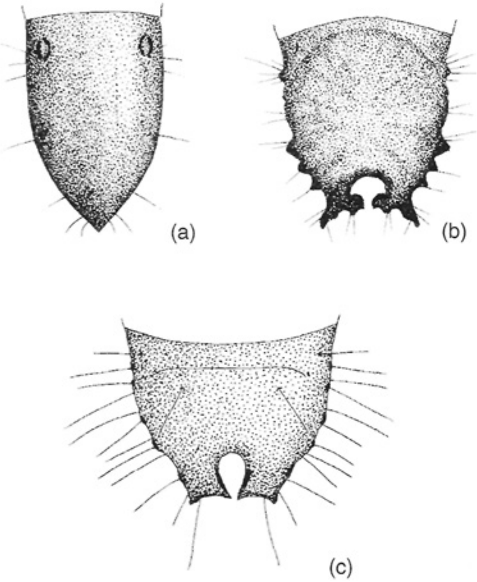


Fig. 205 Terminal body segment of various wireworms: (a) *Agriotes lineatus;* (b) *Athous haemorrhoidalis;* (c) *Ctenicera* sp.

legs; *ninth abdominal segment* pointed and with a pair of distinctive dorsolateral pits **(Fig. 205a).**

***Agriotes obscurus* (L.); A. *sputator* (L.)**
Common click beetles

These two species are similar in habits to *Agriotes lineatus* (p. 132). Although both are also widely distributed, *A. obscurus* is most abundant in northerly districts, especially on lighter soils with a high organic content; *A. sputator* has a more southerly distribution. Adults of *A. obscurus* are 7-10 mm long and uniformly dark brown, with a relatively large, densely punctured pronotum; those of *A. sputator* are 6-7 mm long and mainly reddish-brown, with the pronotum somewhat darker and relatively shiny. Larvae of all three species are very similar in appearance.

***Athous haemorrhoidalis* (F.)**
Garden click beetle

Adults of this generally common click beetle are reddish-brown and up to 12 mm long. They occur mainly from mid-May to July and, in the adult stage, are usually the most frequently encountered species. The larvae (wireworms) are slightly flatter than those of *Agriotes* and the ninth abdominal segment, which lacks the dorsolateral pits, is bifurcated posteriorly and has an ornamented outline **(Fig. 205b).**

***Ctenicera cupreus* (F.)**
Upland click beetle

This locally common species occurs mainly in upland pastures. The larvae (known as 'upland wireworms') take up to 5 years to complete their development, and usually then pupate in late July or early August. Adults emerge in the following year and occur in greatest numbers in June and July. Although capable of inflicting considerable damage, upland wireworms are rarely sufficiently numerous to cause significant damage. Individuals are relatively stout-bodied, with the ninth abdominal segment bifurcated posteriorly by a bulb-shaped notch **(Fig. 205c).** Adults are 11-16 mm long and mainly dark

Fig. 206 Antenna of female upland click beetle, *Ctenicera cupreus.*

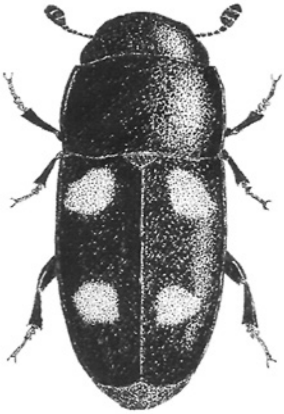


Fig. 207 Adult of *Glischrochilus hortensis* (xlO).

metallic green or dark coppery, sometimes with partly yellowish-tinged elytra; the antennae of males are long and each bears eight prong-like projections; the antennae of females are serrated, with most flagellar segments triangular **(Fig. 206).**

Family NITIDULIDAE

Glischrochilus hortensis (Fourcroy)

Adults of this relatively common beetle are sometimes reported in summer congregating on, and causing minor damage to, the ripening grains of bird-damaged cobs of maize or sweet corn. Similar accumulations of beetles are reported on mechanically damaged or diseased turnip roots and on outdoor tomatoes; locally significant damage to the ripening fruits of autumn-fruiting strawberries is also reported. Such attacks are most likely to occur in hot, dry weather, when the beetles seek suitable sources of moisture. Larvae feed on the ground on rotting vegetable matter and are of no pest status. The adult beetles are 4-6mm long, black and shiny, with four orange-red spots on the elytra **(Fig. 207).**

Meligethes aeneus (F.)
Pollen beetle

This generally abundant beetle is associated mainly with members of the Brassicaceae. The adults and larvae often cause damage to oilseed rape, white mustard and other brassica seed crops, including cabbage and swede. Adults bite into the buds and this leads to abortion and, potentially, loss of yield. On winter rape, which has considerable powers of compensation and is usually past the vulnerable bud stage before the majority of adults emerge from hibernation, economic damage is rare; spring rape is more vulnerable and also more susceptible, as it flowers later in the season and is less robust. Larvae, which feed in the open blossoms, may also cause abortion of young pods but such damage is of little or no significance. In recent years, large numbers of young adults reared on oilseed rape crops have migrated to, and caused damage to, autumn-grown vegetable crops, especially the developing heads of calabrese and cauliflower; the beetles also invade various ornamental flowering crops in search of pollen, and have often then become a local nuisance.

BIOLOGY

Adults appear in the spring, from late April or early May onwards, and are usually active until June. They often congregate in large numbers on brassicaceous plants, including oilseed rape and weeds such as *Sinapis arvensis*, where they bite into the buds and opening flowers and feed on the anthers and exposed pollen. Eggs are laid in the flower buds and hatch about 7-10 days later.

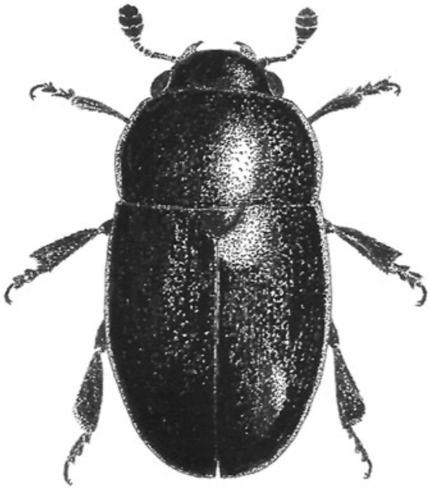


Fig. 208 Pollen beetle, *Meligethes aeneus* (x25).

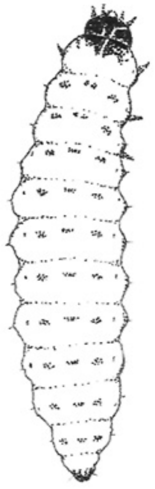


Fig. 209 Larva of pollen beetle. *Meligethes aeneus* (x!6).

The larvae develop within the opening buds and flowers for 3-4 weeks, passing through just two instars. Fully grown individuals then drop to the ground where they eventually pupate, each in a small earthen cell. New adults emerge in **July.** They then migrate to open flowers of various kinds of plant, where they feed on pollen. They then seek suitable overwintering quarters in the soil. There is only one generation a year.

DESCRIPTION

Adult 1.5-2.7 mm long, mainly black, with a metallic bronzy-green tinge; *elytra* finely punctured **(Fig. 208). Egg** 0.8 x 6.3 mm, elongate with rounded ends, translucent-whitish. **Larva** up to 4 mm long; *body* creamish-white, with dark brown to black thoracic and abdominal plates; *head* black; *legs* blackish **(Fig. 209);** *anal plate* slightly indented posteriorly (cf. *Meligethes viridescens,* below).

***Meligethes viridescens* (F.)**
Bronzed pollen beetle

This pollen beetle is essentially similar to *Meligethes aeneus* (above) but, in the British Isles, is usually far less numerous and also occurs slightly later in the season. It is a more significant pest in the warmer parts of continental Europe. Compared with *M. aeneus,* the adults are slightly larger, the legs paler and the elytra more coarsely, but less densely, punctured; larvae are also larger (up to 5 mm long when fully grown) with, in addition to detailed microscopical differences, the anal plate more strongly indented posteriorly.

Family CRYPTOPHAGIDAE (mould beetles)

***Atomaria linearis* Stephens**
Pygmy mangold beetle

This locally abundant pest is associated mainly with mangold and sugar beet; adults also occur on red beet and spinach but attacks on these crops are rarely serious. In the British Isles, infestations are most frequent in southeastern England. The adult beetles bite into the roots and hypocotyl of plants, producing characteristic pits that soon turn black (see also damage caused by blind springtails, *Onychiurus* spp., p. 87). Heavy attacks on seedlings may lead to significant loss of plants, whereas those on the roots of older plants may result in distortion. Adults also feed on furled leaves at the heart of young plants, to produce small holes and notches that become obvious as the foliage unfolds; damaged leaves may later tear and appear ragged, but such damage is unimportant. Larvae also feed on the roots but their depredations are of little significance.

BIOLOGY
Adults appear in the spring and make mass dispersal flights from 'old' beet fields when temperatures exceed 20°C. Eggs are laid in the soil from April or May onwards. Larvae feed on the roots of host plants for up to 6 weeks and then pupate. Adults emerge soon afterwards. There are two main generations annually, but egg laying is protracted so that breeding appears to be continuous throughout the summer months. Populations in infested fields are often considerable and may exceed several million per hectare by the end of the season. The winter is passed in the adult stage, with individuals hibernating in the ground.

DESCRIPTION
Adult 1.3-1.5mm long, brown and elongate, the body surface finely punctured; *antennae* prominent, 11-segmented and slightly clubbed **(Fig. 210).** **Larva** up to 3 mm long; *body* elongate and whitish, with several short setae and longer bristles on each segment; *anal segment* terminating in a pair of short, curved projections.

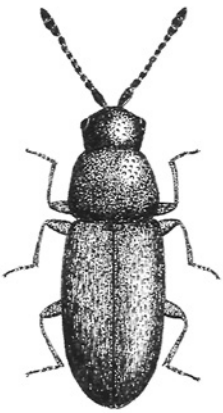


Fig. 210 Pygmy mangold beetle, *Atomaria linearis* (x30).

Family BYTURIDAE

Byturus tomentosus (Degeer)
Raspberry beetle

This beetle is an important pest of blackberry, loganberry and raspberry. The adults, if present in large numbers before blossoms open, can cause considerable damage to flower buds. Most significant damage, however, is caused by the larvae, which feed within the developing fruits and lead to the appearance of shrivelled, distorted fruits with numerous brown, hardened drupelets. The larvae may also contaminate consignments of fruit sent for processing.

BIOLOGY
Adults are active in sunny weather from May onwards. They often then feed on the open blossoms of fruit trees and other trees, especially *Crataegus monogyna.* Later, they migrate to raspberry and other *Rubus* hosts where they feed on the buds and open blossoms. Eggs are deposited in the flowers about a week later. The eggs hatch in about 10 days, usually during the green- to early pink-fruit stage. The larvae feed on the developing drupelets and also bore into the fruit plug. They become fully grown in about 5 weeks. They then enter the soil to pupate, each in a small earthen cell formed a few centimetres below the surface. The adult stage is attained by the autumn but the adults do not emerge until the following spring, individuals overwintering *in situ.* There is just one generation each year.

DESCRIPTION
Adult 3.5-4.5mm long, brown, coated with a fine, yellowish-brown to grey pubescence. **Egg** 1.2 x 0.4 mm, creamish-white and shiny. **Larva** up to 8 mm long; *body* pale yellowish-brown, with darker dorsal tergites and with a pair of dorsal cerci on the penultimate abdominal segment; *thoracic legs* well developed; *head* shiny brown (see Fig. 69).

Family COCCINELLIDAE (ladybirds)

***Subcoccinella vigintiquattuorpunctata* (L.)**
Twentyfour-spot ladybird

This widely distributed species is associated mainly with clover and lucerne. Both adults and larvae scarify leaves and remove the surface tissue to form a series of parallel grooves. Affected parts of the foliage appear whitish. In addition to members of the Fabaceae, damage may also occur on the foliage of other crops, including potato and tomato.

BIOLOGY
Adults hibernate in various sheltered situations. They become active in the following May, and eggs are then laid in batches on the leaves of host plants. Larvae feed for several weeks before pupating, and young adults appear about a week later. There are usually two generations annually.

DESCRIPTION
Adult are 3-4 mm long, extremely variable in appearance; *head and legs* usually reddish-orange; *pronotum* reddish-orange with a central black spot; *elytra* range from reddish-orange, usually with from eight to ten irregular black marks, to almost entirely black. Egg 0.5-0.6 mm long, elongate, pale yellow. **Larva** 4.4 x 2.0 mm; *body* elongate-oval, yellowish, variably marked with dark brown; *thorax and abdomen* with numerous tubercles bearing branched setae.

Family BRUCHIDAE (pulse beetles)

***Bruchus rufimanus* Boheman**
Bean beetle

This generally common beetle is usually a minor pest of broad bean and field bean; it will also, occasionally, attack pea. In spring, the adults feed on the pollen and petals of the flowers but damage caused is of no significance. The larvae feed on seeds inside the developing pods. Characteristically, they bore within the cotyledons of the young seeds without destroying the germ; germination of damaged beans kept for seed, therefore, is often unimpaired. A previously infested bean (seed) may be recognized by the presence of a relatively large hole, c. 2 mm in diameter, through which the new adult beetle has emerged. One consequence of such damage in stored beans is contamination, owing to the frequent lodging of wild oat seeds in these emergence holes. Infestations of this pest are encouraged by hot, dry summers. Although infested beans may be taken into store, this insect is not a storage pest, as the larvae are unable to invade, or to survive in, dried beans.

BIOLOGY
Adults hibernate amongst leaf litter and in various other sheltered situations, emerging in the late spring. Eggs are laid singly on the outside of the developing pods of beans during April or May. The eggs hatch in up to 1-3 weeks, depending on temperature. The larvae immediately bore through the pod wall and attack the developing seeds. Each larva bores within the seed and becomes fully grown 2-3 months later. There are four larval instars. Pupation occurs within the attacked seed, the larva firstly boring to the bean surface and making a rounded hole covered only by the opaque outer seed coat. The adult stage is attained about 2 weeks later, but individuals usually remain within the pupal chamber for an extended period and may not emerge until after the crop has been harvested and placed in store; some adults may remain within infested beans until the following spring. Young adults are often common in the vicinity of bean crops during the later summer and autumn, before they enter hibernation. There is just one generation annually.

DESCRIPTION
Adult 3-5 mm long, mainly black, clothed with greyish to creamish-white hairs; *elytra* black, marked with irregular patches of pale hairs, and noticeably shorter than the abdomen; *antennae* with the basal four segments reddish; *legs* relatively long, with the anterior femora, tibiae and

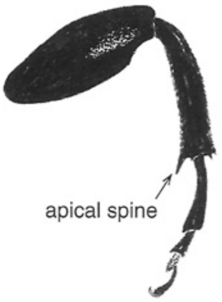


Fig. 211 Hindleg of bean beetle, *Bruchus rufimanus.*

tarsi reddish; *hind tibiae* with a distinctive apical spine **(Fig. 211). Egg** 0.5 x 0.25mm, oval and flattened, yellowish-green. **Larva** up to 6 mm long; *body* creamish-white; *head* brown, with powerful mandibles; *thoracic legs* present but minute.

***Bruchus pisorum* (L.)**
Pea beetle

This pest is associated only with pea crops. the larvae feeding within the developing seed. Although virtually cosmopolitan in distribution and often common in continental Europe, infestations in the British Isles occur only on imported infested seed. The adults (4.0-4.5 mm long) are similar in appearance to those of *Bruchus rufimanus* (p. 137) but distinguished by the black anterior femora and by the absence of a spine on the hind tibia.

Family CHRYSOMELIDAE (leaf beetles)

***Aphthona euphorbiae* (Schrank)**
Large flax flea beetle

Infestations of this widely distributed flea beetle are associated mainly with flax and linseed. Small pits or notches are made in the cotyledons, hypocotyls, leaves and stems; the beetles can also feed on the germinating seeds before the cotyledons have emerged from the soil. Most damage occurs in April and early May, and attacks are particularly severe if seedling growth and, hence, crop establishment is retarded; in some cases whole crops may be lost. New adults, reared in the summer, attack the leaves and developing seed capsules of older plants; heavy infestations lead to stunting and distortion but are of lesser significance than spring attacks. Minor damage is also caused to the foliage of various other plants, including apple, beet, cereals and strawberry.

BIOLOGY
Adults hibernate in herbage in hedgerows and woodlands, and usually emerge in April but typically slightly later in the season than the flax flea beetle, *Longitarsus parvulus* (p. 144). They then feed on the leaves of various plants, and often cause damage to the seedlings of flax and linseed. After mating, eggs are laid in the soil at a depth of 5-10mm, close to the roots of host plants. The eggs hatch in approximately 2-3 weeks. The larvae then burrow into the roots of flax, linseed and weeds such as *Euphorbia, Plantago, Sisymbrium officinale* and *Taraxacum officinale,* where they feed for about 4 weeks. When fully grown, they escape back into the soil where they pupate, and new adults emerge approximately 9 days later. These new adults feed from mid-July to August and then seek overwintering sites. There is just one generation annually.

DESCRIPTION
Adult 1.5-2.0mm long, black with a blue or greenish metallic sheen; *prothorax and elytra* finely punctured; *antennae* yellowish-red, the apical five segments dusky; *legs* mainly yellowish-red (cf. flax flea beetle, *Longitarsus parvulus,* p. 144).

***Cassida nobilis* L.**
Beet tortoise beetle

This beetle is a sporadic and usually minor pest of mangold and sugar beet. Various other members of the Chenopodiaceae are also attacked. Adults and larvae bite holes into the underside of the cotyledons and leaves of host plants, often leaving the upper epidermis intact; initial damage is similar to that caused by flea beetles (q.v.). Attacks are usually of only minor importance, but heavily infested plants may become extensively holed and skeletonized. Noticeable damage is unusual in the British Isles, and tortoise beetles tend to be of greater significance in continental Europe.

BIOLOGY

Adults of this univoltine species overwinter in various sheltered situations and usually emerge in the following April. Eggs are laid singly or in small groups on the underside of the cotyledons or leaves of host plants; they hatch about 2 weeks later. Larvae occur from mid-May onwards. They develop through four instars and are fully grown in about a month. They then pupate, each pupa adhering to the undersurface of a leaf. New adults emerge about 2 weeks later. Larvae of tortoise beetles often cover their bodies with frass and with cast-off skins of earlier instars, presumably for protection.

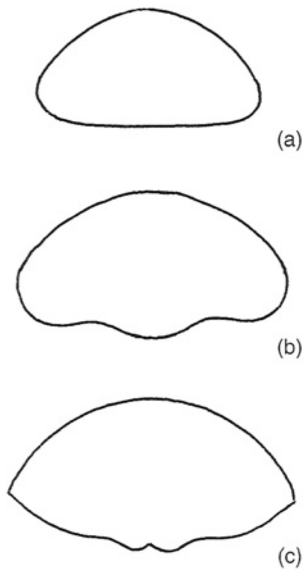


Fig. **212** Outline of the pronotum of various tortoise beetles, *Cassida* spp.: (a) *C. nobilis;* (b) *C. nebulosa;* (c) *C. vittata.*

DESCRIPTION

Adult 3.5-5.5 mm long, elongate-oval and tortoise-like; *pronotum and elytra* pale brown to greenish-yellow, with deep longitudinal rows of punctures on the latter; there is also often a reddish or purplish metallic band along the elytral suture; *pronotum* with the hind angles broadly rounded **(Fig. 212a)** (cf. *Cassida vittata,* below); *underside of body* mainly black. **Larva** up to 6mm long, pale, bluish-green and slug-like, with numerous barbed, lateral spines; *body* terminating in a simple, forked, tail-like process, which is usually held erect over the abdomen. **Pupa** 3.5-5.5 mm long, green and flattened; *pronotum* broad with a spiny border; *abdomen* with five pairs of fleshy, spinose lateral papillae and four small posterior projections.

Cassida nebulosa L.
Cloudy tortoise beetle

This widely distributed species, which occurs throughout Eurasia, is also associated with Chenopodiaceae, and may occur on crops such as sugar beet. However, eggs are usually deposited on weeds such as *Atriplex patula* and *Chenopodium album.* Adults are 5.0-7.5 mm long, distinctly oval and mainly metallic-green to brownish above, with irregular black markings on the elytra and prominent, raised elytral interstices; the suture between the pronotum and elytra is distinctly wavy **(Figs 212b and 213).** Both larvae and pupae possess relatively long, narrow, tail-like processes. The biology of this species is similar to that of *Cassida nobilis* (above), but there may be two generations annually.

Cassida vittata de Villers

Adults or larvae of this often bivoltine species are associated with various kinds of Chenopodiaceae and may, occasionally, cause damage to sugar beet; infestations in the British Isles, however, are rare. Adults are 4.5-6.5 mm long and green with a metallic purplish to golden-green sutural band along the elytra; they are readily distinguished from those of *Cassida*

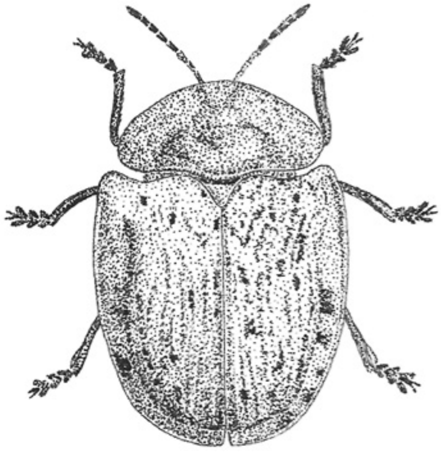


Fig. 213 A tortoise beetle, *Cassida nebulosa* (x8).

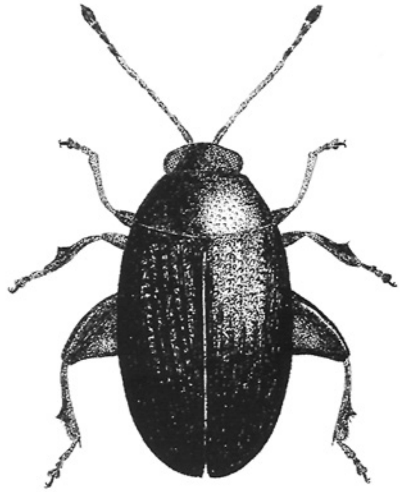


Fig. 214 Mangold flea beetle, *Chaetocnema concinna* (x25).

nobilis (p. 138) by the more pointed hind angles of the pronotum **(Fig. 212c).**

Chaetocnema concinna (Marsham)
Mangold flea beetle

Adults of this widespread and often abundant flea beetle feed on various weeds (Polygonaceae), including *Polygonum aviculare* and *Rumex;* they also attack beet and mangold, and are sometimes noticed on unrelated crops such as rhubarb and strawberry. The adults bite out small, circular pits in the cotyledons and leaves; these feeding punctures often coalesce and, later, develop into holes as the plant tissue grows. Extensive feeding leads to defoliation and to the death of growing points. Infestations are particularly damaging on slow-growing beet seedlings (e.g. in cold, dry conditions); attacks on older plants are of little or no significance. Larvae, although attacking plant roots, are of no significance.

BIOLOGY

The adult beetles overwinter in herbage along ditches and dykes, in hedgerows and woods, and in other situations. They begin to emerge in the following spring, from March or early April onwards. They then immediately seek host plants upon which to feed. The overwintered beetles are active in warm, calm, sunny weather and often occur in beet fields from mid-April to June. Eggs are laid in the soil at the base of host plants (Polygonaceae); they hatch 2-4 weeks later. The larvae feed on the roots for up to 6 weeks. They then pupate and new adults appear after a further 2 weeks, usually from July onwards. These young adults feed throughout the summer before seeking overwintering sites.

DESCRIPTION

Adult 1.5-2.0 mm long, black to bronzy-black and shiny, with deeply punctured elytra and a pointed projection on each middle and hind tibia **(Fig. 214). Larva** up to 6 mm long; *body* mainly white; *head* small, brown; *thoracic legs* small; *prothoracic plate and anal plate* light brown.

Chrysolina menthastri (Suffrian)
Mint leaf beetle

This beetle feeds on wild *Mentha* and is sometimes a pest of cultivated mint. Individual adults or larvae cause little damage but, when the pest is numerous, attacks can lead to considerable defoliation.

BIOLOGY

Adult beetles appear from late April or early May onwards. They feed on the leaves of mint plants, usually devouring the edges. The beetles often rest in the leaf axils during the daytime but drop to the ground and feign death when disturbed. Eggs are deposited in raft-like groups, mainly in June and July; they hatch 1-2 weeks later. Although the larvae are not gregarious, and individuals disperse soon after egg hatch, several commonly occur on the same host plant. The larvae feed mainly at night and become fully fed in about 4 weeks; there are four larval instars. Larvae then enter the soil but do not pupate until the following spring.

DESCRIPTION

Adult 8-12 mm long, hemispherical, brilliant metallic green, often tinged with gold or coppery-bronze, and finely punctured. **Egg** 2.0 x 0.8 mm, creamish-white. **Larva** up to 10 mm long, shiny purplish-black to black; *abdomen* broad, fleshy and distinctly humped. **Pupa** 8.0-8.5 mm long, deep yellow.

Crepidodera ferruginea (Scopoli)
Wheat flea beetle

Larvae of this flea beetle are associated with grasses and various weeds, and are often common in established leys. If infested pasture is ploughed-up and subsequently drilled with wheat or other cereal crop, the larvae may transfer to the new hosts. The larvae bore into the central shoots, each leaving a minute entry hole in the base; infested shoots eventually turn yellow **(Plate** 3e). Symptoms are usually most evident in spring and are superficially similar to those caused by shoot-mining dipterous larvae, such as wheat bulb fly, *Delia coarctata*, p. 197 (q.v.).

BIOLOGY

Adults occur from June to mid-September, and eggs are deposited in the soil at the base of various plants from August onwards. The eggs hatch within 3-4 weeks. The larvae then invade

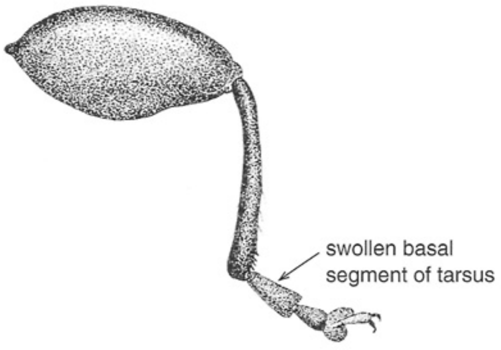


Fig. 215 Hindleg of wheat flea beetle, *Crepidodera ferruginea.*

Carduus, Cirsium, wild grasses and various other weeds, to feed in the coleoptiles and shoots of seedlings and in the basal tissue of older plants. They vacate those that rot or die and readily transfer to adjacent hosts. The larvae pass the winter in the soil and re-invade host plants early in the spring, to become fully grown in May. They then pupate in the soil and adults emerge about a month later.

DESCRIPTION

Adult 3-4mm long, mainly reddish-brown to yellowish-red; *elytra* with relatively large and regularly spaced punctures; *antennae* 11-segmented; *legs* yellow, the first tarsal segment noticeably swollen **(Fig. 215). Egg** 0.75 x 0.45 mm, oval, yellow, darkening soon after being laid. **Larva** up to 5 mm long; *body* creamish-white and with a distinct anal pseudopod; *pinacula and dorsal plates* pale brown; *head* brown marked with black; *thoracic legs* small and partly black; *anal plate* brownish-black.

Crioceris asparagi (L.)
Asparagus beetle

This beetle is a generally common and important pest of vegetable asparagus; infestations also occur on ornamental asparagus and on *Asparagus officinalis.* Adults and larvae feed voraciously on the foliage; they also strip sections from the bark of the stems and branches, and contaminate host plants with black excrement. Heavily infested plants are defoliated, weakening the crowns and reducing yields.

BIOLOGY
Adults hibernate in sheltered situations, such as hollow stems or soil crevices, and become active in the spring. They then disperse to asparagus plants, where they begin to feed and where mating takes place. Eggs are deposited on the fronds in short rows from late June onwards. They hatch in about a week. The larvae feed for about 3 weeks, passing through three instars. They then pupate in the soil, each in a parchment-like cocoon formed a few centimetres below the surface. The next generation of beetles appears 2-3 weeks later. There are usually two overlapping generations annually.

DESCRIPTION
Adult 6-7 mm long; *head* shiny blue-black; *thorax* reddish, black-edged; *elytra* yellow and black, the former colour forming six pale spots and the latter a central band and three crossbands **(Fig. 216). Egg** 1.2-1.6mm long, elongate-oval with a flat base **(Fig. 217a);** greenish-grey, becoming darker close to hatching. **Larva** up to 8 mm long; *body* dark, greenish-grey, distinctly wrinkled and sac-like, with several short, fleshy abdominal prolegs, including a well-developed central proleg (pseudopod) on the anal segment; *head, prothoracic plate and thoracic legs* shiny black **(Fig. 217b).**

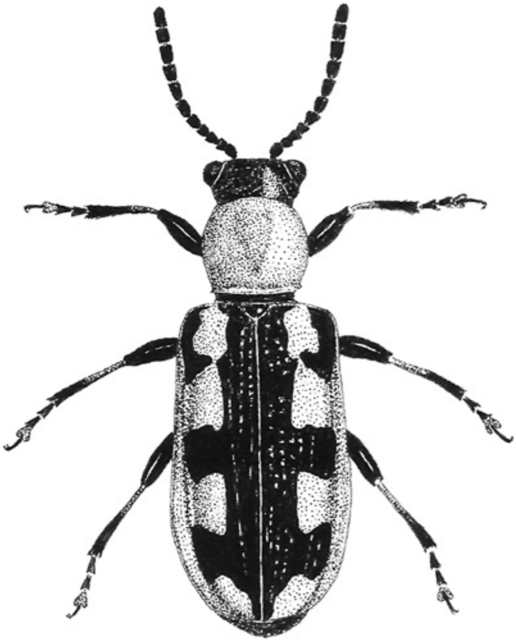


Fig. 216 Asparagus beetle, *Crioceris asparagi* (x10).

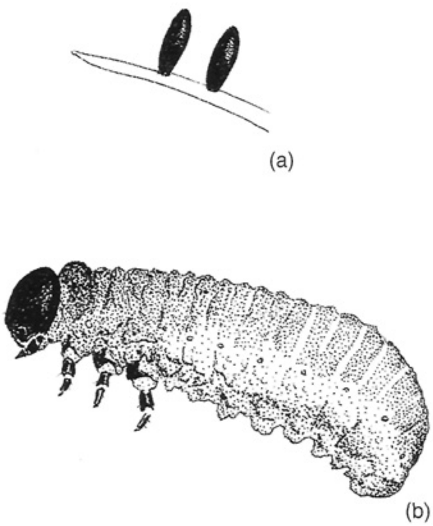


Fig. 217 Asparagus beetle, *Crioceris asparagi:* (a) eggs; (b) larva (x7.5).

***Crioceris duodecimpunctata* (L.)**
Twelve-spotted asparagus beetle

This species is a pest of asparagus in continental Europe but is not recorded from the British Isles. In spring, adults of the first generation attack the emerging asparagus shoots; mating and egg laying occur at about the flowering stage, the eggs being deposited at the tips of the fronds. Larvae feed on the developing asparagus berries for approximately 10 days and then pupate in the soil, each in an earthen chamber. There are two generations annually. Adults (5-6 mm long) are mainly orange-red, with 12 prominent black spots on the elytra. Larvae (up to 8 mm long) are yellow, with a black head.

Galerucella grisescens (Joannis)

Although recorded mainly on *Hydrocharis morsus-ranae* and *Lysimachia vulgaris* this wetland species will also feed on other plants, including cultivated rhubarb. Adults and larvae graze on the leaves and can cause noticeable, but economically insignificant, damage. Adults are 4-5 mm long and mainly brownish-yellow with black antennae. The larvae (up to 7 mm long) are mainly black and shiny, although paler-bodied with distinct pinacula when young.

Gastrophysa viridula (Degeer)
Dock beetle

This generally common species occurs mainly on *Rumex.* The adults and larvae graze the surface and also bite out large holes in the leaves between the major veins. Infestations also occur on crops of rhubarb, and on certain other cultivated plants, the insects causing minor damage to the leaves and petioles.

BIOLOGY

Adults emerge from hibernation in late March or April. They then invade host plants to feed on the leaves. After mating, impregnated females (each now with a greatly distended abdomen) deposit groups of eggs on the underside of the leaves, each egg being placed more or less flush with the leaf surface. Eggs hatch 1-2 weeks later. The larvae feed for about 3 weeks, passing through three instars. When fully grown, they drop to the ground and enter the soil to pupate a few centimetres below the surface. Adults of the next generation appear 1-2 weeks later. There are usually three overlapping generations annually.

DESCRIPTION

Adult 4-6 mm long, metallic green, but sometimes blue to purplish or coppery; *legs and antennae* black; *thorax and elytra* distinctly punctured; in impregnated female, the black and greatly swollen abdomen protrudes beyond the tips of the elytra. **Egg** 1.5 x 1.0mm, elongate-oval, pale yellow and shiny. **Larva** up to 8 mm long; *body* sausage-shaped and shiny black; *head* shiny black; *thoracic legs* well developed; *anal pseudopod* prominent.

Gastrophysa polygoni (L.)
Polygonum leaf beetle

This often abundant beetle is associated with *Polygonum aviculare* and is not normally a pest. However, the adults sometimes move into adjacent crops, including bean and beet, to cause slight but insignificant damage; in continental Europe, the beetles are sometimes reported as pests of buckwheat. The beetles frequently rest on leaves of cereals, especially on weedy headlands, and are then often mistaken for cereal leaf beetles, *Oulema melanopa* (p. 145). Adults are 3.5-4.5 mm long, with a bright, metallic-blue head and thorax, purplish-black elytra and mainly orange legs and antennae; they are broader and more rounded in outline than adults of *Oulema.*

Leptinotarsa decemlineata (Say)
Colorado beetle

The Colorado beetle is a notorious pest of potato. Infestations may also occur on related plants, including aubergine, tomato and common related weeds (Solanaceae) such as *Solanum dulcamara* and *S. nigrum.* The pest is of North American origin and was first noted in Europe in 1877, where it is now widely distributed; although often accidentally introduced, it is not established in the British Isles. The adults attack the leaves of host plants, but most damage is caused by the larvae. They feed ravenously and heavy infestations often lead to complete defoliation; infested plants are also contaminated by masses of black, wet frass excreted by both adults and larvae. Severe damage, often resulting in 50% yield loss, is most likely to occur in hot, dry summers. Direct feeding on potato tubers may occur, but usually only in store.

BIOLOGY

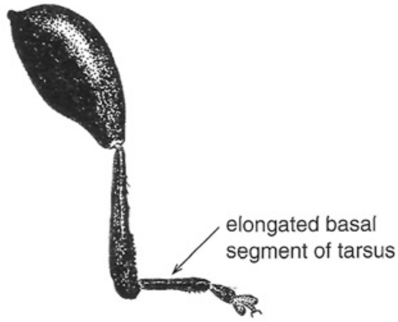
Adults hibernate deep in the soil, often up to half a metre below the surface. They emerge in the following year, usually in June, and then seek host plants on which to feed. In areas where the pest is well established and routine insecticidal sprays are applied to potato crops, infestations are usually most readily detected on volunteer potato plants that have emerged in crops such as cereals. Eggs are laid in batches of 20-80 on the underside of the leaves, each female being capable of depositing many hundreds of eggs over a month or more. The eggs hatch in about a week and the larvae then feed for about 3-5 weeks, passing through four instars. Fully grown larvae enter the soil to pupate in earthen cells. New adults emerge 2-3 weeks later. These beetles feed on potato foliage during the summer, and some may lay eggs to produce a second brood of larvae, before eventually overwintering. Any second-brood larvae that successfully complete their development before the potato haulm dies down in the autumn, pupate in the soil to produce new adults in the following year. Adults have a life span of up to 2 years. As a result of this and the protracted period of egg laying, the generations often overlap so that, during the summer months, all stages of the pest may be found together.

DESCRIPTION

Adult 10 mm long, distinctly hemispherical; *head, thorax, legs and antennae* orange, marked with black; *elytra* longitudinally striped alternately black and yellow **(Plate 3f). Egg** 1.2 mm long, yellowish-orange. **Larva** up to 12mm long; *body* sac-like, at first reddish-brown, later reddish-orange, with two rows of prominent black spots along either side; *head, prothoracic plate and anal plate* black; *abdomen* with several short, fleshy prolegs, including a well-developed pseudopod on the anal segment (see Fig. 75).

Longitarsus parvulus (Paykull)
Flax flea beetle

This widely distributed pest occurs most commonly on flax and linseed. Damage is similar to that caused by *Aphthona euphorbiae* (p. 138); both pests have a similar life history but adults



H / elongated basal
IH / segment of tarsus

Fig. **218** Hindleg of flax flea beetle, *Longitarsus parvulus.*

of *Longitarsus parvulus* tend to emerge from hibernation slightly earlier in the spring. Adults are 1.2-1.6 mm long and black or brown, with a slightly metallic lustre; the elytra are finely punctured and, characteristically, the basal segment of each hind tarsus is elongated **(Fig. 218).**

Oulema lichenis Voet

Infestations of this beetle occur mainly on wheat, especially on less-hairy-leaved cultivars. Various other cereals (but not oats), and grasses such as cocksfoot, are also attacked. Adults and larvae cause direct damage to the foliage of host plants. They graze away longitudinal strips of epidermis from the upper surface of the leaves, between the veins, the damaged tissue appearing pale brown to whitish. Infestations on flag leaves are especially important and the loss of photosynthetic tissue can have an adverse effect on plant development; spring cereals are more susceptible than winter crops. The beetles are also capable of transmitting viruses, notably cocksfoot mottle virus. Although often of considerable significance in continental Europe, in the British Isles this pest is unimportant and far less abundant than the following species.

BIOLOGY

Adults of this univoltine species hibernate amongst plant debris and in various other situations, reappearing in April. They then invade wheat crops to feed on the leaves. Eggs are laid about 6 weeks later, mainly on the upper leaves of host plants. They usually hatch within 10 days. The sluggish larvae feed openly on the leaves for up to 2 weeks and pass through four instars; most individuals occur on the flag leaf. When fully grown, each spins a white, cottonwool-like cocoon (c. 6mm across), usually on the upper surface towards the base of a leaf. Adults emerge in about 2 weeks, usually from late July onwards. The total life-cycle from egg to adult occupies about 5 weeks (cf. *Oulema melanopa*, below) but, especially at the pupal stage, may be extended considerably by lower than normal temperatures. The egg-laying period tends to be protracted so that, during the summer, all stages of the pest often occur together. Development of the pest is favoured by high spring and summer temperatures; cool and wet conditions are detrimental to larval and pupal survival.

DESCRIPTION

Adult 3-4 mm long, mainly black to bluish-black; *elytra* distinctly metallic; *antennae* prominent, 11-segmented; *thorax* relatively broad **(Plate 4a)** (cf. *Oulema melanopa*, below). **Egg** 1 mm long, shiny ochreous-yellow. **Larva** up to 5 mm long; *head* black; *body* dirty yellow and shiny, coated with slimy brownish to blackish excrement (except in the final stages of development) **(Plate 4b)** (cf. *O. melanopa*, below).

Oulema melanopa (L.)
Cereal leaf beetle

This beetle is an often common but usually minor pest of cereals, including sweet corn, and grasses; minor infestations also occur on ornamental grasses. Damage is identical to that caused by *Oulema lichenis* (above); the beetles are also virus vectors.

BIOLOGY

The life-history of this species is essentially similar to that of *Oulema lichenis* (above), except that pupation occurs in the soil and development from egg to adult tends to be less rapid, averaging about 6 weeks. Further, larvae remain coated in excrement throughout their development. In common with the previous species, development is favoured by hot, dry conditions.

DESCRIPTION

Adult 4.0-4.8mm long; *head and antennae* black; *thorax* light reddish-brown; *legs* reddish-yellow with blackish tarsi; *elytra* bluish-green, elongate and noticeably broader than thorax. **Egg** 1 mm long, elongate-oval, shiny yellow. **Larva** up to 6 mm long; *head* shiny black; *body* dirty yellowish, coated with brownish or blackish excrement **(Plate 4c).**

NOTE Adults of the polygonum leaf beetle, *Gastrophysa polygoni* (p. 143), are often present in cereal crops and are frequently mistaken for those of *Oulema melanopa*. Polygonum leaf beetles are broader and more rounded in outline than adults of *Oulema*. They feed on *Polygonum aviculare* but do not attack cereals or grasses.

Phaedon cochleariae (F.)
Watercress beetle

This beetle was formerly a common, widely distributed pest of brassica crops (Brassicaceae), including cabbage, cauliflower, mustard and watercress. Attacks on vegetable crops are generally of no importance, although the adults and larvae may be a problem in watercress beds, particularly during the late spring and summer. Most significant damage occurs on brassica seed crops, especially white mustard. Adults and larvae feed on the leaves of host plants and sometimes cause extensive defoliation; they also strip away the outer tissue of the stems and this has a deleterious effect on flowerhead development. Feeding also occurs directly on the buds and young pods, the pest being capable of causing considerable loss of yield. Nowadays, however, attacks tend to be sporadic and this insect is of only minor importance.

BIOLOGY

Adults emerge from hibernation in April and May. They then attack the foliage of host plants. Eggs are eventually deposited in small cavities bitten into the leaf surface **(Plate 4d).** The eggs hatch about 2 weeks later. Larvae pass through three instars and are fully fed in about 3 weeks. They then drop to the ground to pupate a few centimetres below the surface. New adults emerge about 12 days later, usually in June and July. These adults give rise to a further generation of larvae that produce adults in August and September. In favourable situations, when the rate of development is enhanced, there may be three generations in a year.

DESCRIPTION
Adult 2.5-3.5 mm long, bright metallic-blue, oval and somewhat bulbous; *thoracic disc* distinctly punctured; *elytra* each with eight fine longitudinal lines of punctures **(Fig. 219).** **Egg** 1mm long, oval, yellow. **Larva** up to 6 mm long; *body* brownish-yellow to dark grey; *pinacula* black and prominent; *head* black; *thoracic legs* black, marked with yellow **(Plate 4e).**

Phaedon armoraciae (L.)
Mustard beetle

Adults are similar in appearance to those of *Phaedon cochleariae* (above) but are slightly larger (3-4 mm long) and less brightly coloured. They sometimes cause minor damage to brassica crops (Brassicaceae), including watercress, but nowadays attacks are generally uncommon.

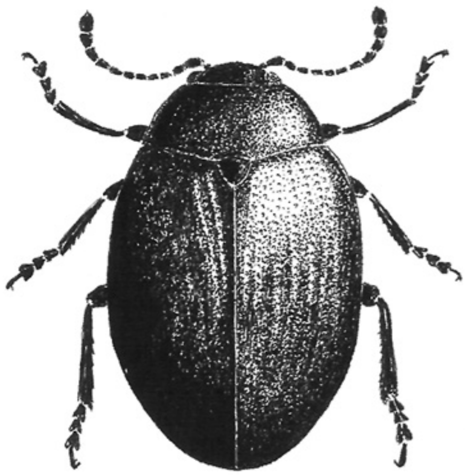


Fig. 219 Watercress beetle, *Phaedon cochleariae* (x!8).

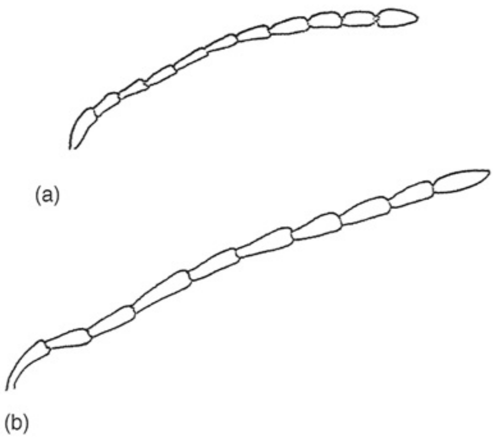
Phaedon tumidulus (Germar)
Celery leaf beetle

This beetle is associated with various umbelliferous plants and sometimes attacks cultivated celery and parsley. The adults notch the edges of expanded leaves and sometimes also feed on the heart leaves. Damage, however, is of limited importance. Adults (2.5-3.0mm long) are usually greenish-black but are sometimes bluish or bronzy; they are distinguished from other species of *Phaedon* by the very shiny, smooth thoracic disc.

Phyllotreta cruciferae (Goeze)
A turnip flea beetle

This flea beetle is a generally common pest of Brassicaceae, including cabbage, cauliflower, kale, radish, turnip and watercress, and ornamentals such as nasturtium, stock and wallflower. Adults make small punctures in the cotyledons and leaves. These pit-like blemishes often coalesce, and damaged areas frequently develop into holes as the plants grow. Attacks are usually most serious in April and May, especially on seedlings or recent transplants whose growth is retarded by cold conditions or lack of moisture. Larvae burrow into the roots of host plants. They destroy the outer tissue and often cause extensive damage to the base of radish plants.

BIOLOGY
Adults are active from early spring onwards, when they feed on the leaves and cotyledons of cabbage, radish and turnip, and certain other members of the Brassicaceae. Eggs are deposited in the soil, close to host plants, usually in batches of 20-30; they hatch about 2 weeks later. The larvae attack the roots and feed externally for about 2 weeks. Individuals then pupate and new adults emerge another 2 weeks later, usually in late June, July or August. There is just one generation each year.



(b)

Fig. 220 Antennae of adult flea beetles: (a) genus *Phyllotreta;* (b) genus *Psylliodes.*

DESCRIPTION

Adult 1.8-2.4mm long, metallic greenish-black, somewhat rounded in outline; *antennae* 11-segmented **(Fig. 220a)** (cf. cabbage stem flea beetle, *Psylliodes chrysocephala*, p. 149), mainly black, with the second and third segments red or reddish; *legs* black. **Egg** 0.3 mm long, oval, yellowish-white, with dark plates and pinacula on the thoracic and abdominal segments. **Larva** up to 6 mm long; *body* white and slender; *head* black; *thoracic legs* very short.

***Phyllotreta nemorum* (L.)**
Large striped flea beetle

This flea beetle is a common pest of vegetable brassica crops, especially radish and turnip; brassicaceous ornamentals, such as wallflower, are also attacked. Adults cause a pitting of cotyledons and leaves, and the larvae form small, pale, linear to blister-like leaf mines that eventually dry out. Attacks are most serious on young plants, especially in hot, dry weather when growth is retarded by lack of moisture. Larvae are unable to penetrate into heavily waxed plants such as cabbage, cauliflower, rape and swede.

BIOLOGY

Adults occur from April onwards, and eggs are laid on the surface tissue of host plants or in the

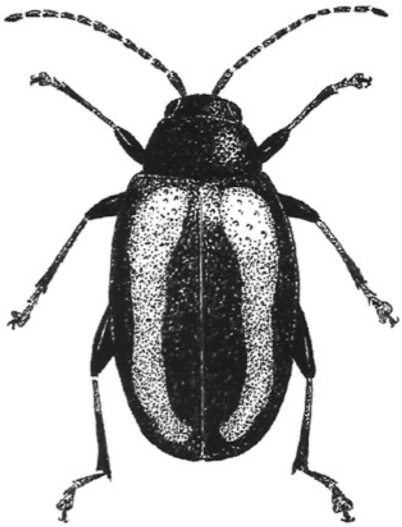


Fig. 221 Large striped flea beetle, *Phyllotreta nemorum* (xl8).

soil, typically in batches of three or four. The eggs hatch in 8-10 days, and the larvae immediately burrow into the leaves to feed. On suitable hosts, they mine within the leaves, petioles and stems for 2-3 weeks; they then enter the soil to pupate in earthen cells. Adults appear about 2 weeks later, usually in July. The young adults enter hibernation in September, hiding away in debris and litter. There is just one generation annually.

DESCRIPTION

Adult 2.5-3.0mm long, black with a pair of widely spaced, sinuous, yellow bands on the elytra, the black area between them widening both anteriorly and posteriorly **(Fig. 221);** *tibiae* reddish-yellow (cf. *Phyllotreta undulata*, p. 148). **Egg** yellow, spherical. **Larva** up to **6mm** long; *body* elongate and yellowish, with blackish plates on the thorax; *head* blackish.

***Phyllotreta vittula* Redtenbacher**
Barley flea beetle

Minor infestations of this flea beetle occur on grasses and cereals, including sweet corn. Adults graze the upper surface of the leaves, removing narrow strips of tissue between the veins; damaged areas appear whitish. Leaf symptoms are similar to those produced by cereal leaf beetles, *Oulema* spp. (p. 144 *et seq.)* but the stripes are much narrower and usually far less extensive. Barley flea beetles also feed on beet and brassica crops, such as cabbage, radish and turnip; they cause typical flea-beetle injury that, on seedlings in the spring, may be of some significance (see under *Phyllotreta cruciferae,* p. 146); the larvae also feed in the stems.

BIOLOGY
Adults become active in the spring, from March or April onwards. They often occur in association with brassica plants and also invade grasses and cereals. Eggs are laid in May and June. The larvae feed within the stems of brassicas and various other plants, eventually pupating in the soil. New adults appear in July or August. They feed briefly before seeking overwintering sites amongst debris on the ground.

DESCRIPTION
Adult 1.5-1.8mm long, black with a wide longitudinal, yellow stripe along each elytron; distinguished from *Phyllotreta nemorum* (p. 147) by the smaller size, the narrower, straighter elytral band, the more parallel-sided elytra and mainly black tibiae. **Larva** up to 4mm long; *body* whitish and relatively slender; *head* blackish; *anal segment* with a minute tail-like peg (pseudopod).

***Phyllotreta aerea* Allard**
Small black flea beetle

This southerly distributed flea beetle is 1.5-1.8 mm long and mainly black, with the elytra moderately but closely punctured, and the second and third antennal segments reddish-brown. The life-cycle and habits are similar to those of *Phyllotreta cruciferae* (p. 146).

***Phyllotreta atra* (F.)**
A turnip flea beetle

This species is a generally abundant pest of vegetable brassica crops, including cabbage, radish and turnip. The life-cycle and habits are similar to those *of Phyllotreta cruciferae* (p. 146). Adults are 2.0-2.5 mm long and black, with elongate, strongly punctured elytra; the antennae are mainly black, with the second and third segments reddish-brown. In the British Isles, this pest is particularly common in eastern England.

***Phyllotreta consobrina* (Curtis)**
A turnip flea beetle

This southerly distributed but local species is 1.8-2.0 mm long, oval-bodied and black with a bronzy or bluish sheen; the elytra are moderately punctured, and the legs and antennae are entirely black (cf. *Phyllotreta nigripes,* below). The life-cycle and habits are similar to those of *P. cruciferae* (p. 146).

***Phyllotreta diademata* Foudras**
Crown flea beetle

This widely distributed species is small (1.8-2.0mm long) and mainly black, with strongly punctured elytra and the first three or four antennal segments reddish-brown. The biology and habits are similar to those of *Phyllotreta cruciferae* (p. 146).

***Phyllotreta nigripes* (F.)**

This flea beetle is more abundant in southerly areas and appears somewhat earlier in the spring than other related species. Adults are 2.0-2.5 mm long, and black with a metallic blue or metallic green sheen and very finely punctured elytra (cf. *Phyllotreta consobrina,* above); the antennae are entirely black; the legs are black with brownish tibiae. Larvae are mainly white with reduced thoracic and abdominal plates. Adults feed on various members of the Brassicaceae, and larvae attack the roots of such plants.

***Phyllotreta undulata* Kutschera**
Small striped flea beetle

The small striped flea beetle is often an abundant pest of Brassicaceae, including watercress and various other vegetable crops. Adults and larvae cause typical flea beetle damage (see *Phyllotreta cruciferae*, p. 146); the adults are also vectors of turnip yellow mosaic virus. The biology is essentially similar to that of *P. nemorum* (p. 147). Adults are 2.0-2.3 mm long and black with a pair of centrally narrowed yellow bands on the elytra, the black area between them narrowing noticeably both anteriorly and posteriorly; the tibiae are mainly black, with just the basal third yellow (cf. *P. nemorum*, p. 147). Larvae are up to 5 mm long, creamish-white and relatively narrow-bodied.

NOTE Differences between similarly coloured species of *Phyllotreta* are often difficult to appreciate without microscopic examination and reference to specialist keys. The above-mentioned "descriptions' are intended merely as general guides.

Psylliodes affinis **(Paykull)**
Potato flea beetle

This species is a locally common but minor pest of potato; it is also associated with weeds such as *Solarium dulcamara* and *S. nigrum*. Larvae mine within the roots, but most noticeable damage is caused by newly emerged adults which graze on the foliage during the late summer and early autumn before hibernating.

BIOLOGY
Adult beetles emerge from hibernation in May but sometimes earlier. Eggs are laid in June, either placed singly or in small groups just below soil level, close to host plants. They hatch about a week later. The larvae attack the softer parts of roots and feed for about a month before pupating. New adults emerge about a month later; they feed on the foliage of Solanaceae and then hibernate. There is just one generation annually.

DESCRIPTION
Adult 2-3 mm long, reddish-brown to pale yellowish-brown with the underside of the body, femora and elytral suture black; *antennae* 10-segmented **(Fig. 220b). Egg** 0.6-0.7mm long, elongate-oval, yellowish-white. **Larva** up to 6 mm long; *body* whitish; *head, prothoracic plate and anal plate* pale brown.

Psylliodes chrysocephala (L.)
Cabbage stem flea beetle

The cabbage stem flea beetle is a locally common pest of winter oilseed rape; infestations may also occur on overwintering vegetable brassicas. The adults bite out irregular holes in the leaves but such damage is usually unimportant unless plants are small and growth is slow. Larval infestations of stems, petioles and growing points are usually more serious, and damaged tissue typically rots and turns brown; larval-damaged plants are also particularly liable to infection by canker *(Leptosphaeria maculans).* Larval damage to growing points causes discoloration and distortion. Heavily infested plants are weakened, stunted, malformed and, sometimes, multi-stemmed **(Plate 4f);** if small, plants may wilt and die. Light attacks, although not always significant on older plants, can reduce the size of heads of autumn cauliflowers. Adults may be brought into store with harvested rape-seed; however, they do not cause damage and do not constitute a storage problem, as they soon disperse.

BIOLOGY
Young adults are often abundant during July, following their emergence from the pupal stage, and may often be found in vast numbers amongst harvested rape-seed being carried away from fields in trailers. They remain active at or near emergence sites for 2-3 weeks but then aestivate, to reappear in September. They then migrate to new host plants, where they feed and mature. Eggs (up to 150 per female) are then laid in the soil close to brassica plants, mainly from September to November but sometimes later. Most eggs hatch from early October to December, but cold weather can delay hatching until the late winter or early spring. Young larvae invade the petioles from above and also enter the stems, boring into the tissue and feeding gregariously within the pith; at intervals, they break through the epidermis so their galleries remain partly open; growing points may also be attacked. Larvae feed throughout the winter and early spring, passing through three instars. When fully grown, they enter soil and pupate; adults appear

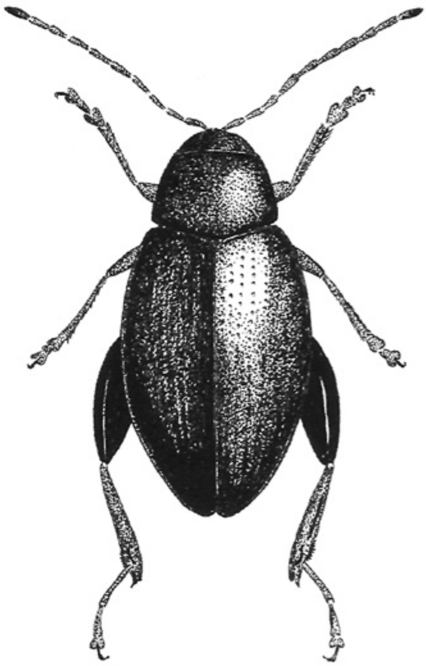


Fig. 222 Cabbage stem flea beetle, *Psylliodes chrysocephala* (xl2).

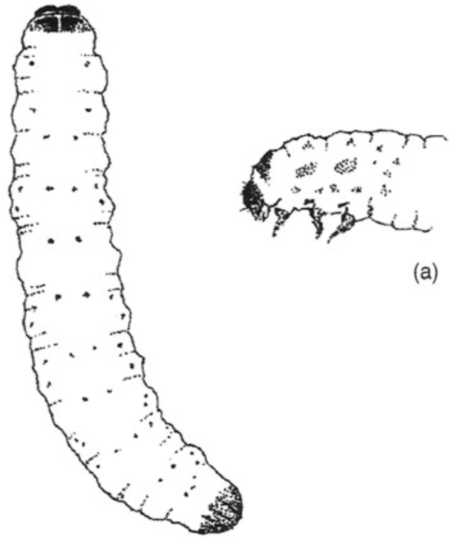


Fig. 223 Larva of cabbage stem flea beetle, *Psylliodes chrysocephala:* (a) head and thorax (xlO).

in the early summer. There is just one generation annually.

DESCRIPTION

Adult 4-5 mm long, metallic bluish-green to metallic greenish-black, but sometimes bronzy **(Fig. 222);** *antennae* 10-segmented (see Fig. 220b) (cf. *Phyllotreta* spp., Fig. 220a). **Egg** 0.5 mm long, elongate-oval, yellowish to yellowish-orange. **Larva** up to 8 mm long; *body* whitish; *head, prothoracic plate, anal plate and pinacula* black; *thoracic legs* well developed **(Fig. 223)** (cf. cabbage leaf miner, *Phytomyza rufipes*, p. 192; cabbage stem weevil, *Ceutorhynchus pallidactylus*, p. 156; *Scaptomyza flava* p. 185). **Pupa** 5 mm long, white.

***Psylliodes attenuata* (Koch)**
Hop flea beetle

This uncommon pest is associated with hop. It occasionally causes damage to young growth but attacks are rarely important and usually of most significance in nursery beds. Adults hibernate throughout the winter. They emerge in the spring and eventually deposit eggs in the soil around the base of host plants. The larvae are up to 6 mm long and mainly whitish, with a reddish-brown head, prothoracic plate and anal plate. They feed on the roots for about a month and then pupate. New adults occur from late July or early August to October or November. The adults are 2-3 mm long and black with a bronzy or greenish sheen. Before hibernating, they graze on the foliage and will sometimes also attack the young, ripening cones, within which they often shelter during inclement weather.

Family ATTELABIDAE (leaf-rolling weevils)

***Rhynchites caemleus* (Degeer)**
Apple twig cutter

This weevil is a locally common pest of apple; infestations sometimes also occur on other fruit trees. Adults cause damage, usually in June. They sever the tips of young shoots which then either fall to the ground or keel over and wither whilst remaining temporarily suspended by a piece of rind. Damage to young trees is sometimes severe but attacks on established trees are of little or no significance.

BIOLOGY
Adults occur from May onwards and are especially active in warm, sunny weather when they fed on the foliage of apple trees and other hosts. Eggs are deposited in early June, each inserted in a young vegetative shoot, a few centimetres from the tip. The egg-laying female then severs the shoot just below the point of oviposition. Larvae feed within the shoots for up to 4 weeks and then escape to pupate, each in a small cell formed a few centimetres below the surface of the soil. New adults appear towards the end of the summer and eventually hibernate.

DESCRIPTION
Adult 2.5-4.5 mm long, relatively broad-bodied and shiny metallic blue, clothed with black hairs. **Egg** oval and translucent. **Larva** 3-4 mm long; *body* whitish; *head* brownish.

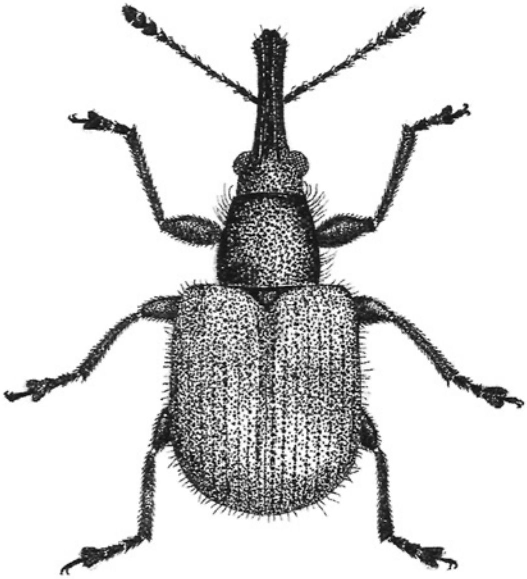


Fig. 224 Apple fruit rhynchites weevil, *Rhynchites aequatus* (x20).

***Rhynchites aequatus* (L.)**
Apple fruit rhynchites

This locally distributed species is a minor pest on fruit trees, especially apple. The adults sometimes attack buds in the spring but cause most damage by drilling large numbers of small, cylindrical holes into developing fruitlets. Eggs are laid singly at the base of some of these holes. Larvae later feed on the flesh for a period of about 3 weeks. Fully fed larvae eventually pupate in the soil. Adults are 2.5-4.5 mm long **(Fig. 224)** and purplish to bronzy with reddish-brown elytra.

***Rhynchites germanicus* Herbst**
Strawberry rhynchites

This weevil is a local pest of strawberry; attacks also occur on cane fruits. Adults become active in the early spring. They then feed on the young foliage of strawberry and various *Rubus* hosts. They also damage the blossoms and other vegetative tissue. On strawberry, eggs are deposited in holes made in the petioles, in the stalks of the blossom trusses and in the tips of the stolons, often in small groups of up to four (cf. strawberry blossom weevil, *Anthonomus rubi,* p. 154). Tissue beyond an oviposition point, within which the larvae feed, withers and dies. Larvae feed for a few weeks and, when fully grown, pupate in the soil. The adult stage is reached a few weeks later. Individuals, however, remain *in situ,* and do not emerge until the following spring. Adults are 2-3 mm long and black with a greenish-blue sheen; they are readily distinguished from those of *A. rubi* (p. 154) by the antennae, which lack a scape.

Family APIONIDAE

***Apion trifolii* (L.)**
Clover seed weevil

This weevil is an often common pest of clover, especially red clover. The adults make small rounded or elongate holes in the foliage and florets, and badly affected leaves are reduced to shreds of ragged tissue. Some larvae destroy the ovules (such larvae are termed 'ovuliferous'), whereas others attack the seeds, and heavy infestations will result in considerable yield loss. In the British Isles, this species is most abundant in southeastern England.

BIOLOGY
Adults emerge in the spring, from late April onwards. In common with other species of *Apion*, they may feed on the foliage of various non-fabaceous plants before migrating to clover where, later in the season, breeding takes place. The oviposition period is protracted, commencing in mid-May and lasting for about a month. Eggs are placed in the green florets, usually several per flower head. They hatch in about a week. The larvae feed within the developing florets and complete their development within 3 weeks, passing through three instars. They then pupate within the flower head. Adults emerge about a week later but their appearance may be delayed by very dry conditions. These adults usually initiate a second generation. However, on late-flowering crops there is just one generation. Young adults eventually hibernate under leaves and other debris in ditches, hedges and similar situations.

DESCRIPTION
Adult 1.8-2.2 mm long, distinctly pear-shaped and mainly black, with a long, narrow rostrum **(Fig. 225). Egg** 0.5 mm long, oval, pale greenish-yellow and shiny. **Larva** up to 2 mm long; *body* dirty white, plump and distinctly C-shaped; *head* reddish-brown.
NOTE Several other species of *Apion* are associated with clover crops. These include: *A. assimile* Kirby and *A. apricans* Herbst (both mainly on red clover) and *A. dichroum* Bedel (mainly on white clover). Larvae of these species are all ovuliferous.

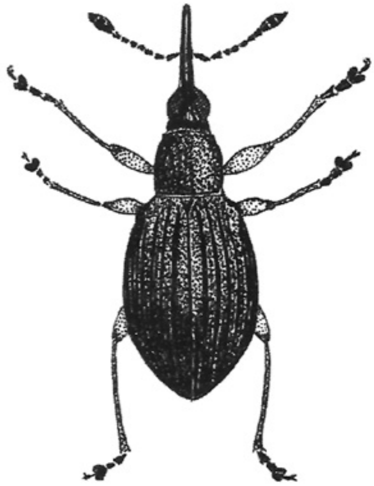


Fig. 225 Clover seed weevil, *Apion trifolii* (x25).

Apion vorax Herbst
Bean flower weevil

This weevil is a minor and usually sporadic pest of field bean. The adults form small, rounded holes (c. 1mm in diameter) or elongated punctures (c. 3 mm long) in the leaves but are of significance only as vectors of viruses such as broad bean stain virus (BBSV) and broad bean true mosaic virus (BBTMV); these viruses are also transmitted, but to a lesser extent, by pea & bean weevil, *Sitona lineatus* (p. 161). Damage to bean flowers by larvae is of no significance.

BIOLOGY
Adults overwinter in woodlands and become active in the early spring. They occur and often feed on plants such as *Galeobdolon luteum*, *Mercurialis perennis*, *Rubus fruticosus* and *Urtica*, before migrating to field bean (and other members of the family Fabaceae) upon which they are able to breed. Adults may be found in bean fields from late April or early May onwards, where they feed on the leaves and where eggs are eventually laid in the flowers and flower buds. The eggs hatch a few days later. Larvae feed on the pistils and styles for about 2 weeks before eventually pupating, usually amongst the shrivelled remains of the keel petal. Adults emerge shortly afterwards. Development from egg to adult takes about a month and there are up to two generations annually.

DESCRIPTION
Adult 2.5-3.5 mm long, mainly black; elytra bluish-black, with a metallic sheen. **Egg** 0.45 mm long, oval, yellowish. **Larva** up to 4 mm long; *body* translucent to creamish-white; *head* black. **Pupa** 3.0-3.5 mm long, whitish, translucent.

***Apion pomonae* (F.)**
Vetch seed weevil

Adults of this widely distributed weevil occur from late May onwards. They infest various kinds of Fabaceae, including vetch seed crops. Eggs are laid from mid-June onwards at the early flowering stage, each being inserted into a developing pod through the base of a flower or flower bud, often several eggs per pod. Larvae feed on the developing ovules and eventually pupate between two of the seeds. New adults appear from August onwards. Adults are 2.8-3.5 mm long, with a black or bluish-black head and thorax, blue or greenish-blue, somewhat downy, elytra and black legs.

Family CURCULIONIDAE (weevils)

***Anthonomus pomorum* (L.)**
Apple blossom weevil

The apple blossom weevil is a potentially important pest; in addition to apple, minor attacks may also occur on medlar, pear and quince. Larvae feed within the shelter of unopened blossoms, the petals of which turn brown to produce the characteristic 'capped blossom'. Minor infestations are of little or no significance but when attacks are heavy, considerable crop losses may be expected and all but the most advanced blossoms on the tree may be destroyed. Adults feeding on buds or foliage have little deleterious effect, except on pear where attack buds can become distorted and may shrivel and die.

BIOLOGY
Adult weevils emerge from hibernation in the early spring, usually from February onwards, to feed on the opening buds of apple trees. The weevils become sexually mature within a couple of weeks and mating then takes place. Soon afterwards, eggs are laid singly in the developing floral buds. The eggs hatch about 7-10 days later. Each larva feeds on the anthers and style, and also bites into the base of the petals to arrest their development. Larvae are fully grown in about a month. Each then pupates within the now empty shell of the capped blossom; the new adult emerges 2-3 weeks later, usually in June. Young adults feed on the foliage for a short time. They then seek suitable overwintering sites, under bark or leaf litter or in other sheltered situations such as piles of logs or fallen timber.

DESCRIPTION
Adult 3.5-6.0mm long, mainly black, with greyish and whitish hairs imparting a mottled pattern and a characteristic V-shaped mark over the elytra **(Fig. 226). Egg** 0.7 x 0.5mm, oval, white and translucent. **Larva** up to 8 mm long; *body* white to yellowish **(Fig. 227a);** *head* dark brown or blackish. **Pupa** 4-5 mm long, pale yellow, with a pair of prominent posterior spines, and distinct wing pads and other appendages **(Fig. 227b).**

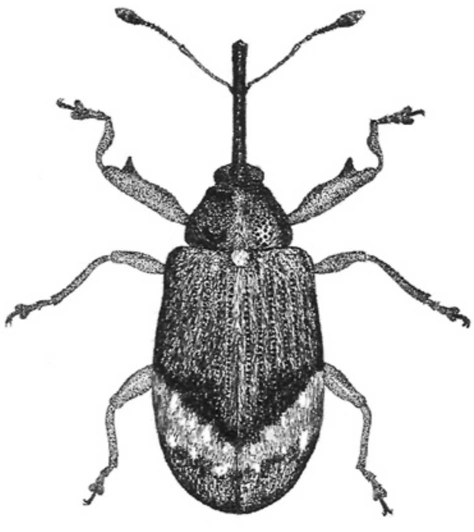


Fig. 226 Apple blossom weevil, *Anthonomus pomorum* (x!5).

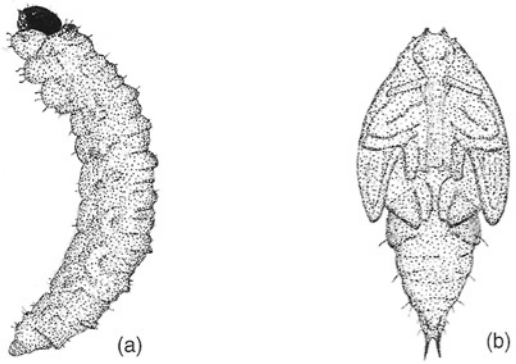


Fig. 227 Immature stages of apple blossom weevil, *Anthonomus pomorum:* (a) larva; (b) pupa (xlO).

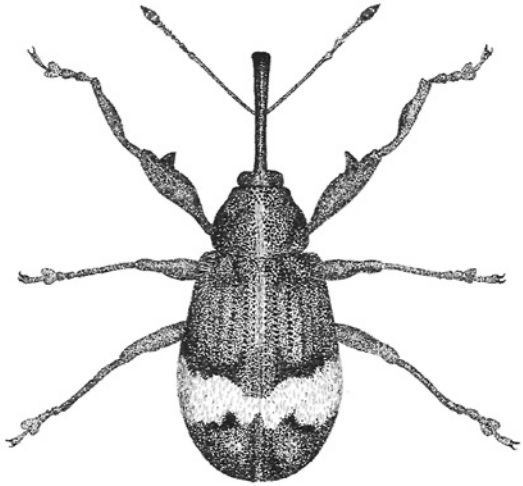


Fig. 228 Apple bud weevil, *Anthonomus piri* (x!2).

Anthonomus piri **Kollar**
Apple bud weevil

In continental Europe, this weevil is an important pest of pear. In the British Isles, it is restricted to apple but is found only rarely. Adults are on average slightly larger than those of *Anthonomus pomorum* (above) and are reddish-brown with a straight, rather than a V-shaped, elytral mark **(Fig. 228).** The yellowish-white larvae develop within unopened vegetative buds during the spring.

Anthonomus rubi **(Herbst)**
Strawberry blossom weevil

This mainly black (2-4 mm long) weevil is a locally important pest of strawberry. Infestations also occur on *Rubus,* including cultivated blackberry and raspberry. The adults, that are present in greatest numbers in late May or early June, cause minor damage by drilling small round holes through the leaves and flower petals. Eggs are deposited singly in unopened blossom buds. The egg-laying female also partially severs the blossom stalk (cf. damage caused by strawberry rhynchites, *Rhynchites germanicus,* p. 151). Eggs hatch within a week and the larvae feed for up to 2 weeks before pupating. Young adults emerge about 2 weeks later. They feed briefly on host plants and then hibernate, reappearing in the following spring. Damage to strawberry crops tends to be most significant on cultivars that produce few blossoms; more vigorous cultivars usually compensate for early loss of blossoms. Infestations on *Rubus* hosts occur somewhat later in the year than those on strawberry.

Ceutorhynchus assimilis (Paykull)
Cabbage seed weevil

This weevil is a generally common pest of brassica seed crops; economic damage also occurs on certain vegetable brassicas. **Brassica seed crops:** adult feeding is of no direct significance, although feeding punctures may allow female brassica pod midges, *Dasineura brassicae* (see p. 171) to deposit eggs into pods. Most damage is caused by the larvae, which feed within the pods on the developing seeds; each larva (typically one per infested pod) usually destroys several seeds. Attacks are particularly common on oilseed rape and brown mustard (white mustard is immune to attack) but crops are often able to fully compensate for any damage caused. **Vegetable brassicas:** most significant damage is caused in summer, from mid-July to mid-August, by adults reared on nearby rape crops. Such individuals may feed on the buttons of Brussels sprout, producing brown markings on the outer leaves, and on developing cauliflower curds, causing the tissue to turn pinkish; the weevils may also feed on the young leaves of other vegetable brassicas, and check the growth of recent seedlings or transplants.

BIOLOGY

Overwintered adults emerge in May. They are attracted to flowering brassicaceous weeds, such as *Sinapis arvensis,* and also to brassica seed crops, especially oilseed rape and white mustard. Here, they feed on the buds, flowers and developing pods. After mating, the females deposit eggs singly in the young pods, usually from late May onwards. The weevils make distinct egg-laying punctures in the pod walls and then mark the pod with a pheromone to deter other ovipositing females. The eggs hatch in 1-2 weeks and the larvae then attack the developing seeds. Larvae feed for 3-6 weeks, depending upon temperature. When fully fed, usually in late June or July, each larva bites its way out of the pod, leaving a pinhead-sized exit hole in the wall **(Plate 5a),** and drops to the ground. Individuals then pupate in earthen cells a few centimetres below the surface. Young adult weevils appear about 2 weeks later, usually from mid-July to August. These weevils feed on brassicaceous weeds, and may also attack vegetable brassicas, before eventually taking up their winter quarters amongst debris in nearby woodlands or hedgerows.

DESCRIPTION

Adult 2.2-3.0 mm long, lead-grey, unicolourous, with a long, slender rostrum **(Fig. 229). Egg** 0.6 x 0.4 mm, oval, creamish-white and translucent. **Larva** up to 5 mm long; *body* creamish-white and sac-like; *head* light brown.

NOTE Adults of *Ceutorhynchus floralis* (Paykull). a greyish-black weevil, appear to be increasing in numbers on oilseed rape crops. Although of no pest status (it breeds on weeds such as *Capsella bursa-pastoris* and *Erysimum cheirantholdes),* the adults are sometimes mistaken for *Ceutorhynchus assimdis* and can, therefore, contribute during pest monitoring to over-estimates of the number of seed weevils present in a crop. The weevils are most readily distinguished by their small size (1.5-1.8 mm long) and somewhat *Apion-like* appearance; the antennae of this species have just six funicular segments (there are seven in *C. assimdis).*

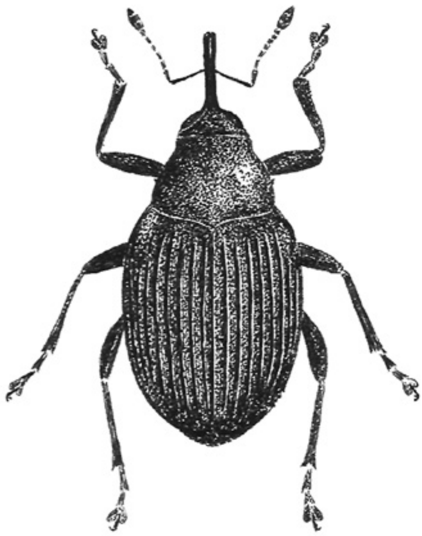


Fig. 229 Cabbage seed weevil, *Ceutorhynchus assimilis* (x20).

Ceutorhynchus napi Gyllenhal
Rape stem weevil

This weevil is a major pest of winter rape in France, Germany and Switzerland, and in other parts of continental Europe, but does not occur in the British Isles; infestations also occur on other crops, including cabbage and turnip. Most significant damage is caused by the process of egg laying within the elongating stems, rather than by larval feeding. Main stems typically twist and split open, especially following heavy rain or frosty conditions, and considerable distortion and disruption of growth results. Infested stems are often killed and plants then survive only by producing lateral shoots. Damaged plants are particularly liable to invasion by secondary organisms such as canker.

BIOLOGY

Adults appear in the early spring and then invade rape crops, eventually depositing eggs singly (cf. *Ceutorhynchus pallidactylus,* below) in the young, elongating stems, close to a terminal bud. The eggs hatch several weeks later and larvae feed within the pith of the stems for up to 6 weeks. They then vacate the host plant and enter the soil to pupate in an earthen cell. The adult stage is reached 3-4 weeks later but the weevils remain within their pupal cells throughout the winter (cf. *C. pallidactylus,* below).

DESCRIPTION

Adult 3.2-4.0 mm long, greyish, with distinct blackish longitudinal furrows on the elytra. **Larva** up to 7 mm long; *body* whitish at first but finally yellowish; *head* brownish-black in the first two instars, yellowish-brown in the third **(Plate 5b).**

Ceutorhynchus pallidactylus (Marsham)
Cabbage stem weevil

This widely distributed pest is common on Brassicaceae, and often a problem on spring-sown brassica crops. Larvae feed within the stems and petioles, reducing plant vigour; heavy infestations on spring-sown brassica seed crops may significantly reduce yields. Larvae that attack spring-sown Brussels sprout, cabbage and cauliflower seedlings can also cause serious damage, infested plants becoming stunted and deformed and the inner tissue spongy and brittle; also, the stems of infested seedlings often break when the seedlings are transplanted. Larval infestations on winter rape often occur in the lateral shoots but are of little or no significance. When numerous, young adults emerging in summer can cause considerable damage to vegetable brassicas, as they browse on the leaves and bite into the underside of the petioles, mid-ribs and other major veins, which then become scarred and, sometimes, distorted.

BIOLOGY

Adults emerge from hibernation from mid-April onwards and then feed on various brassicaceous hosts, including brassica seed crops and vegetable brassicas. Eggs are laid from mid-May onwards. They are placed in groups of five or six within the stems and petioles (cf. *Ceutorhynchus napi,* above), and this causes slight blistering. The eggs hatch 1-4 weeks later. Larvae feed during late May and June, tunnelling within the pith and often forming extensive galleries. When fully grown, 3-6 weeks later, they vacate the plants to pupate in the soil close to the surface. New adults appear in July or early August, and feed briefly on brassica plants before overwintering in the shelter of field margins and so on (cf. C. *napi,* above).

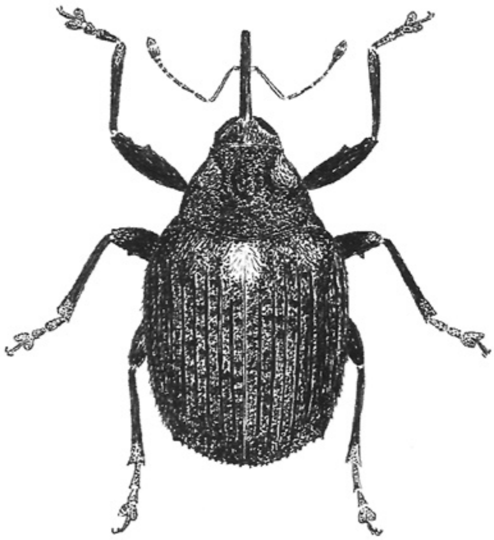


Fig. 230 Cabbage stem weevil, *Ceutorhynchus pallidactylulus* (x20).

DESCRIPTION

Adult 2.5-3.5 mm long, greyish-brown and with a whitish patch of scales on the back, just behind the thorax **(Fig. 230) (Plate 5c);** *body* noticeably larger and more quadrate than that of *Ceutorhynchus assimilis* (p. 154); *legs* reddish. **Egg** 0.7 x 0.6 mm, oval, translucent, smooth, shiny. **Larva** up to 6 mm long; *body* creamish-white and elongate **(Fig. 231);** *head* pale yellowish-brown.

Ceutorhynchus picitarsis Gyllenhal
Rape winter stem weevil

This weevil is a local and usually uncommon pest of winter brassica crops, including oilseed rape,

Fig. 231 Larva of cabbage stem weevil, *Ceutorhynchus pallidactylus* (x12).

swede and turnip. The larvae feed gregariously within the petioles, stems and crowns, and heavy infestations result in extensive hollowing and rotting of the tissue **(Plate 5d),** stunting, malformation and, sometimes, death of plants. Surviving plants often develop without terminal shoots, these being replaced by numerous weak lateral shoots that flower later than normal and yield poorly.

BIOLOGY
Adults occur in the autumn, eggs being laid mainly from mid-October to mid-November. The larvae feed inside host plants from October onwards. They pass through three instars and become fully grown in the following spring. Pupation takes place in the soil a few centimetres below the surface. New adults appear from mid-May to early June. They aestivate during the summer, in litter at the edges of woodlands and in hedgerows, and reappear in September or October.

DESCRIPTION
Adult 2.2-3.5 mm long, mainly shiny black, with a distinctive, pale yellowish mark on the 'shoulder' of each elytron; *legs* partly reddish. **Larva** up to 6mm long; *body* white; *head* brown.

Ceutorhynchus pleurostigma **(Marsham)**
Turnip gall weevil

This weevil is a common but local pest of brassica crops, especially culinary swede and turnip, and late-sown or late-planted cabbage and cauliflower. The larvae feed in galls on the roots, and damage of greatest significance is caused to young plants (seedlings or transplants) during the autumn and early winter; plant growth is checked severely if infestations are heavy. Well-established crops are rarely harmed but extensive galling on culinary swedes and turnips may be troublesome.

BIOLOGY
Adults are active throughout the late spring and summer. Eggs are deposited mainly in August and September, each in a small hole excavated by the egg-laying female in the roots of host plants. The eggs hatch 1-2 weeks later. As the larvae feed, they become enclosed in conspicuous marble-like galls **(Plate 5e).** These galls occur just below the soil surface and, unlike those caused on brassica roots by club-root disease, are partly hollow **(Plate 5f).** Larvae complete their development in the following spring, and emerge from the galls in March or April to pupae in the soil. Adults appear a few weeks later.

DESCRIPTION
Adult 2-3 mm long, mainly black with a distinct spur on each femur. **Egg** 0.4 x 0.3 mm, oval and translucent. **Larva** up to 6 mm long; *body* whitish; *head* brown. **Pupa** 2-3 mm long, white.

Ceutorhynchus contractus **(Marsham)**
Turnip stem weevil

This weevil is associated with *Sinapis arvensis* and various other wild related hosts. It is also reported, occasionally, as a minor pest of cultivated Brassicaceae, especially turnip. The larvae (which are creamish-white with a brown head) feed within the petioles, each forming a short, greenish gallery. Although some eggs are laid in the autumn, most are deposited in the early spring, soon after the adults emerge from hibernation. Larvae complete their development in May or early June, and the next generation of adults emerges from June onwards. Adults are 2 mm long and mainly bluish-black or greenish-black, with a coppery sheen; the rostrum is relatively short and broad.

***Hypera nigrirostris* (F.)**
A clover leaf weevil

This species is associated mainly with clover. The larvae typically form short slits in the stems or burrow into the buds; the heads of attacked plants may become distorted or young shoots killed, but damage caused is rarely significant.

BIOLOGY
Overwintered adults are active in April and May, and females deposit about 200 eggs over a period of about 4 weeks. Eggs hatch in 2-3 weeks and the larvae then burrow into the buds or stems. Larvae usually feed for 3-4 weeks and then pupate, each spinning a silken cocoon on the plant or on the soil surface. New adults appear 1-2 weeks later. These young adults feed for a short time and then seek sheltered sites in which to overwinter.

DESCRIPTION
Adult 3-4 mm long, mainly blackish, partly clothed in green, greenish-grey or brownish, hair-like scales; *legs* red with dark femora **(Fig. 232). Larva** up to 5mm long; *body* yellowish-green.

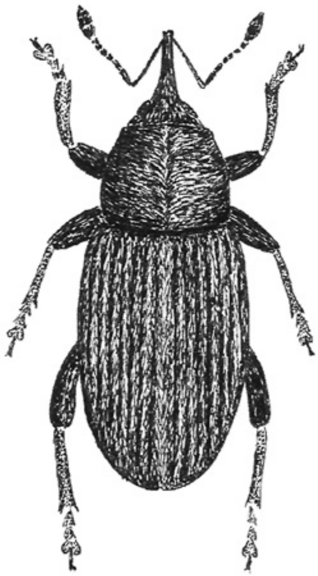


Fig. 232 A clover leaf weevil, *Hvpera nigrirostris* (x!8).

***Hypera postica* (Gyllenhal)**
A clover leaf weevil

Adults and larvae feed on the buds, leaves and seeds of various members of the Fabaceae, especially lucerne and trefoils. Young foliage becomes tattered and riddled with irregular holes, and flower buds are destroyed. The pest also causes distortion, discoloration and death of growing points. Attacks on seed crops are especially serious and usually most severe in dry seasons; in the British Isles they occur mainly in eastern England.

BIOLOGY
Adults hibernate in hedgerows and other sheltered situations, reappearing in March and April. After feeding for about 2 weeks, eggs are deposited singly or in batches in small holes bitten into the stems of plants. Each female deposits 600-800 eggs over a period of several weeks, and the eggs hatch 2-3 weeks after being laid. The larvae feed within the stem for a few days and then migrate to the shoot tips where they attack the buds. They feed externally (this is unusual for weevil larvae). Larvae are fully grown in 3 or more weeks, passing through four instars. They then pupate, each in a flimsy, yellowish-white, net-like cocoon formed on the host plant, usually on the underside of a leaf, or on the soil. Adults emerge about 2 weeks later; they feed briefly before seeking shelter in which to overwinter. In the British Isles, this species is univoltine; however, in southern Europe, and in other favourable regions, there may be two generations annually.

DESCRIPTION
Adult 4.5-5.5mm long and appear mainly greyish-brown, with paired, dark, longitudinal stripes extending dorsally down much of the body and narrowing posteriorly on the elytra; *rostrum* relatively broad and about half as long as the prothorax; *prothorax* often with a pale, narrow

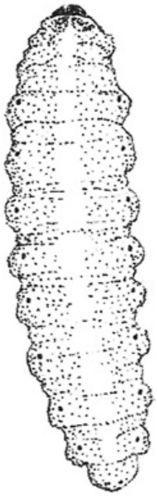


Fig. 233 Larva of a clover leaf weevil, *Hypera postica* (x15).

dorsal line and a pair of pale subdorsal bands. **Egg** 1.0 x 0.5 mm, oval, yellowish to brownish. **Larva** up to 6 mm long; *body* greenish with a white dorsal stripe **(Fig. 233);** *head* brownish-black.

Otiorhynchus singularis (L.)
Clay-coloured weevil

The clay-coloured weevil is an important horticultural pest. Adults remove bark from trees and shrubs; sometimes, they also ring-bark shoots or stems and cause the death of plants. Attacks are often of considerable importance on young trees or new grafts. Adult weevils also attack leaves and petioles, and kill the buds of plants. The form and timing of damage vary from host to host. On currant and raspberry, for example, the petioles are partially severed; the leaves then, characteristically, keel over. Larvae sometimes cause damage to the roots of cultivated plants but are relatively unimportant (cf. *Otiorhynchus sulcatus,* below).

BIOLOGY
Adults of this mainly parthenogenetic weevil are active at night from April onwards; by day, they hide beneath soil mulches, in soil crevices and so on. The weevils will feed on various plants and often ascend young trees to browse on the young bark, buds and foliage. Eggs are laid in the summer, and the larvae later feed on plant roots, including those of various weeds. Fully grown larvae pupate in the spring, and new adults appear shortly afterwards. Some adults survive for more than a year.

DESCRIPTION
Adult 6-7 mm long, strongly sculptured and shiny black but coated in dull, greyish-brown scales, giving an irregular, camouflage-like pattern; *body* often coated with mud. **Larva** up to 8 mm long; *body* plump and creamish-white; *head* brown.

Otiorhynchus sulcatus (F.)
Vine weevil

This insect is one of the most important pests of horticultural crops, both outdoors and under protection. The adults notch the edges of leaves, and often cause extensive damage in strawberry beds and in gardens and nurseries, especially on favoured plants such as camellia and rhododendron; the adults can also ring-bark young plants. The larvae are usually of even greater significance. They feed voraciously on the root system of a wide variety of cultivated plants, destroying the fine rootlets and larger roots; attacked plants often wilt and die. The larvae also burrow into crowns, corms and rhizomes. Larval damage is often severe on herbaceous plants, soft-fruit crops and containerized ornamentals.

BIOLOGY
This species is univoltine and parthenogenetic, adult females on outdoor crops usually appearing in May and June. They feed at night and rest during the daytime on host plants or hide amongst debris on the ground. Eggs are laid in the soil from late July onwards, each female depositing up to 800 or more in her lifetime. On low-growing plants, such as strawberry, eggs are sometimes placed in folds on the lower leaves.

The eggs hatch 1-2 weeks later. The first-instar larvae are very mobile and immediately migrate to the root system where they begin to feed. Individuals pass through several instars and become fully fed in the following spring. They then pupate, each in a small earthen cell. The adult stage is attained from mid-April onwards but individuals remain *in situ* for a period before finally emerging. Most adults die before the onset of winter but some may survive for one or more years. In heated glasshouses and other protected situations, the life-cycle is often accelerated and young adults may emerge in the autumn. Also, the period of egg laying is often protracted and, as a result, all stages of the pest may occur together.

DESCRIPTION

Adult 7-10mm long, mainly black and shiny; *prothorax and elytra* deeply sculptured, the latter often with several patches of yellowish hairs. **Egg** 0.7 mm in diameter, white and shiny when newly laid but soon becoming brownish if viable. **Larva** up to 10 mm long; *body* creamish to brownish-white; *head* reddish-brown **(Fig. 234).** **Pupa** 7-10 mm long, white with distinct wing pads and other appendages.

NOTE Several other species of *Otiorhynchus*, e.g. *O. clavipes* (Bonsdorff), *O. ovatus* (L.) and *O. rugosostriatus* (Goeze), are associated with fruit crops; weevils from related genera (e.g. *Barypeith.es* and *Sciaphilus)* are also of pest status, e.g. on strawberry.

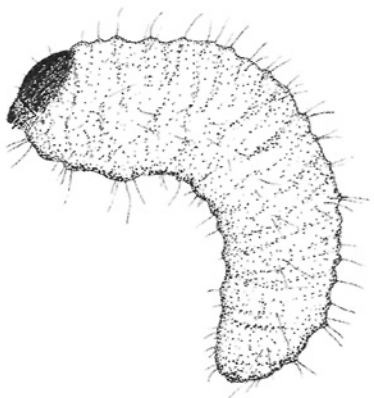


Fig. 234 Larva of vine weevil, *Otiorhynchus sulcatus* (x!5).

Philopedon plagiatus **(Schaller)**
Sand weevil

Adults of this widespread but locally distributed weevil are most numerous in sandy districts. They feed on the leaves of various plants and sometimes cause minor damage to sugar beet and other crops, biting out large semicircular notches in the margins of cotyledons and leaves. The weevils also sever the stems of young plants at or about soil level. Attacks, which may also occur on carrot and other crops, are of greatest significance when plants are at the early seedling stage. The larvae, which feed on plant roots, are of no economic importance. In the British Isles, attacks occur mainly in the Brecklands of Norfolk and Suffolk.

BIOLOGY

Adults overwinter in the soil. They emerge in April and immediately begin to feed on host plants. Eggs are deposited in the soil, usually from late May to mid-June. Larvae feed from June or July onwards, attacking the roots of *Carduus, Cirsium,* grasses and various other plants; development is slow and larvae become fully grown late in the following year.

DESCRIPTION

Adult 4-8 mm long, oval, stout-bodied, with protruding eyes and relatively thick legs; *body* black, but thickly clothed in brownish to brownish-grey scales; *elytra* with light and dark scales, which give a longitudinally striped pattern **(Plate 6a),** and clothed with short upright hairs; *antennae* reddish. **Larva** up to 8 mm long; *body* white; *head* light brown.

Phyllobius pyri **(L.)**
Common leaf weevil

This weevil is a generally abundant pest, especially in grassland areas. The adults feed on the leaves of various trees, including fruit trees, making irregular holes in the leaves and flower petals. The larvae feed on the roots of various plants but are most abundant on grasses. Larval damage to the root system often loosens the turf and infested areas often develop into brownish, unthrifty patches; larval damage to the roots of cereals is also reported.

BIOLOGY
Adults appear in the spring, from late April onwards. They often congregate in large numbers on trees and shrubs (Rosaceae), and on other plants, where they feed on the foliage and flowers. Eggs are laid in the soil during the early summer, usually in association with grasses, each female depositing up to 200 over a period of a few weeks. The eggs hatch in 2-3 weeks. The larvae feed on the roots of grasses and other plants, and usually become fully grown by the onset of winter. They then overwinter and pupate in the spring, shortly before the emergence of the adults.

DESCRIPTION
Adult 5-7 mm long, black, clothed in coppery, golden-brown or greenish-bronze scales; *rostrum* very short **(Fig. 235). Larva** up to 7 mm long; *body* creamish-white and translucent; *head* yellowish-brown **(Plate 6b).**

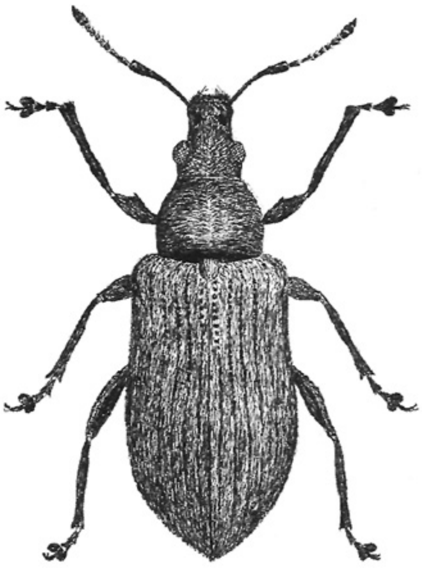


Fig. 235 Common leaf weevil, *Phyllobius pyri* (xlO).

NOTE Adults of various other species of *Phyllobius,* and members of the related genus *Polydrusus,* also cause damage to fruit trees and ornamental plants; most of these weevils are clothed in coppery-brown or metallic-green scales. Larvae of one species *(Phyllobius pomaceus* Gyllenhal) sometimes cause significant damage to the roots of strawberry plants (see also *Otiorhynchus* spp., p. 159 *et seq.).*

***Plinthus caliginosus* (F.)**
Hop root weevil

This generally uncommon weevil is most often found in hop gardens and vineyards but will also attack crops such as raspberry and strawberry. Most damage is done by the larvae; these attack the roots and are especially damaging to newly planted stock and in young plantations.

BIOLOGY
The adult weevils may be found throughout the year but are most common in the late summer and autumn. They are rather inactive and usually shelter during the daytime beneath moss, stones or pieces of wood. Eggs are laid mainly from September to November, each placed singly in a small puncture made in the rootstock or subterranean part of a newly planted set. The larvae feed within the host plants for up to 18 months; they then pupate within the feeding gallery and adults emerge 2-3 weeks later, usually in the late summer.

DESCRIPTION
Adult 5.5-9.0mm long, dark brown to black; *body* elongate, strongly punctured **(Fig. 236)** and often coated in mud; *rostrum* stout and finger-like. **Larva** up to 10mm long; creamish-white; *head* brown; *frons* with a characteristic median line **(Fig. 237).**

***Sitona lineatus* (L.)**
Pea & bean weevil

This generally abundant weevil is a pest of various members of the Fabaceae, including broad bean, field bean and pea. Adults form character-

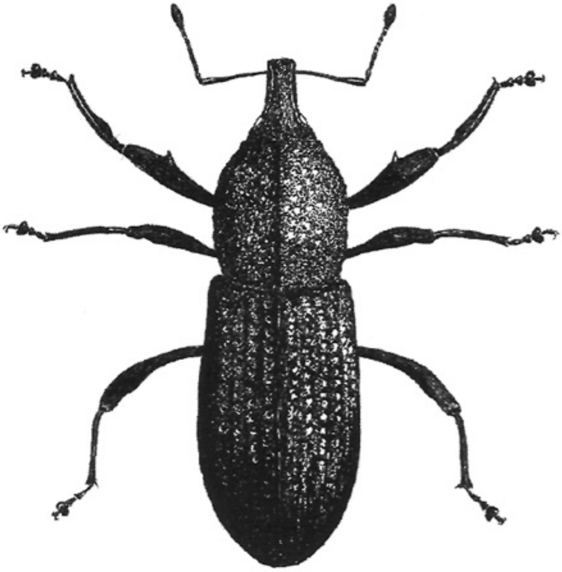


Fig. 236 Hop root weevil, *Plinthus caliginosus* (xlO).

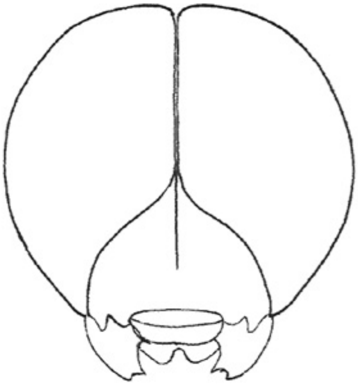


Fig. 237 Head of larva of hop root weevil, *Plinthus caliginosus.*

istic U-shaped notches in the leaf margins; young adults in autumn can also attack a wide variety of other plants, including strawberry and many ornamentals. Damage by adults is usually unimportant but can be of some significance if growing points of backward bean or pea plants are attacked at the establishment phase, especially when seedling growth is retarded by poor growing conditions. Larvae feeding on root nodules can cause yield reductions of beans, owing to the premature shedding of pods. The adult weevils are also implicated in the transmission of viruses, including broad bean stain virus (BBSV) and broad bean true mosaic virus (BBTMV); these viruses are also transmitted by the pea flower weevil, *Apion vorax* (p. 152).

BIOLOGY

Adults emerge from hibernation in the spring, from late March onwards. They often occur in large groups, attracted by an aggregation pheromone produced by the males. Mated females deposit large numbers of eggs (sometimes over 1000), either on the leaves of host plants or in the soil. The eggs hatch 2-3 weeks later. The larvae feed on the root nodules of Fabaceae. They pass through five instars and complete their development in about 6 weeks. They then pupate, each in an earthen cell formed a few centimetres below the soil surface. New adults emerge in the late summer, 2-3 weeks later. The young adults are very active and migrate from host fields, usually by walking. They may then be found feeding on many kinds of plant well into October before eventually hibernating.

DESCRIPTION

Adult 4-5 mm long, mainly black-bodied, clothed with greyish-brown scales; *prothorax* with three pale longitudinal bands; *elytra* often with pale longitudinal bands; *eyes* moderately prominent; *antennae* red and relatively narrow **(Fig. 238).** **Egg** 0.4mm long, oval, whitish but later becoming black. **Larva** up to 6 mm long; *body* creamish-white and distinctly wrinkled; *anal segment* with a fleshy pseudopod; *head* small, pale brown.

NOTE Various other species of *Sitona are* of agricultural significance, mainly as pests of clover, lucerne or other forage legumes. These include: *S. hispidulus* (F.) - a generally common, dark-scaled species with particularly prominent eyes **(Fig. 239),** that commences egg laying in the autumn and is associated mainly with clover; *S. humeralis* Stephens - a common but southerly distributed species associated with clovers, trefoils and vetches; and *S. puncticollis* Stephens - a relative large (4.5-6.0 mm long) black-bodied species clothed with brownish or yellowish-brown scales, also associated with clovers, trefoils and vetches.

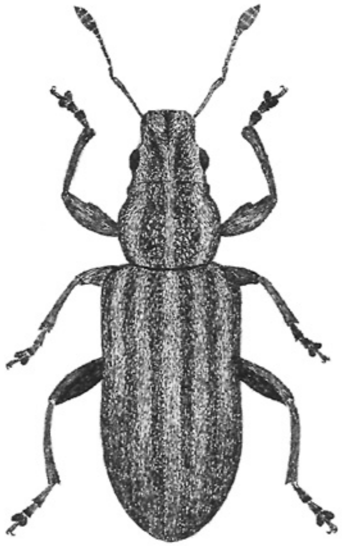


Fig. 238 Pea & bean weevil, *Sitona lineatus* (xl2).

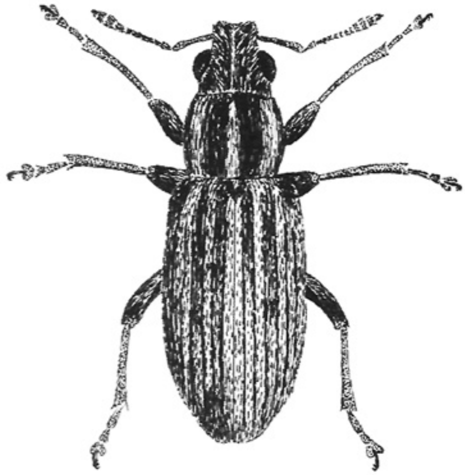


Fig. 239 A clover weevil, *Sitona hispidulus* (xl2).

***Tanymecus palliatus* (F.)**
Beet leaf weevil

This weevil is a minor pest of sugar beet. The adults notch the edges of the cotyledons and young leaves but damage is more often reported in eastern Europe than in the British Isles; attacks tend to be of greatest significance under dry conditions. The adults (8-12mm long) are reddish-brown, with a pale margin to the thorax and hind-most parts of the elytra. In outline, they are elongate with a relatively narrow thorax; also, the elytra taper noticeably posteriorly.

ORDER DIPTERA (TRUE FLIES)

Family TIPULIDAE (crane flies)

***Nephrotoma appendiculata* (Pierre)**
Spotted crane fly

This crane fly is a generally common but minor pest, and is usually of most significance in gardens and allotments. The larvae (known as 'leatherjackets') cause damage to the roots of grasses, especially in the early spring when patches of dead or dying plants may appear. The larvae also attack the roots, stolons and underground parts of stems of many other plants, including various ornamentals, soft-fruit crops and vegetables.

BIOLOGY
Adults of this often abundant crane fly are most numerous in May, and eggs are then deposited at random on the soil. The eggs hatch in the early autumn, after a period of summer diapause. The larvae then feed on the subterranean parts of various plants before overwintering. Larvae resume feeding in the early spring and most complete their development by the middle of April. Pupation takes place in the soil, and the pupa wriggles to the surface shortly before the adult emerges.

DESCRIPTION
Adult up to 20 mm long, mainly black, yellow and golden-yellow; *head* with a distinct black triangular mark; *prescutum* with three conspicuous black markings **(Fig. 240);** *wings* up to 15 mm long and clear, apart from a pale yellow or light brown stigma. **Egg** 0.8 x 0.4 mm, oval and black

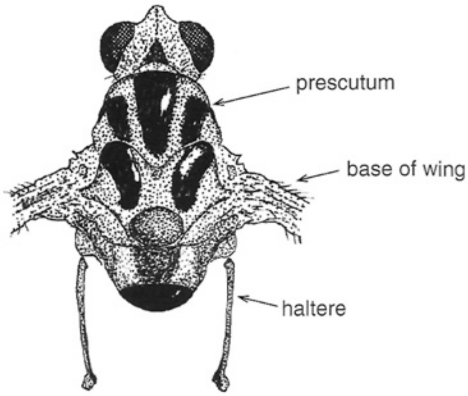


Fig. 240 Head and thorax of *Nephrotoma.*

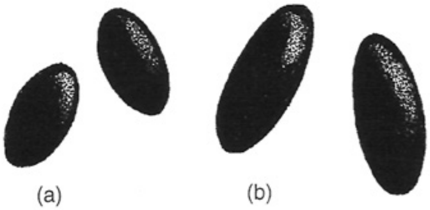


Fig. 241 Crane fly eggs: (a) *Nephrotoma appendiculata;* (b) *Tipula paludosa* (x20).

(Fig. 241a). Larva up to 30 mm long, greyish-brown; *prothoracic segment* with a pair of small humps dorsally; *posterior papillae* distinctive - the lateral pair on the spiracular disc longer than the dorsal pair and the anal lobes all rounded (cf. common crane fly, *Tipula paludosa,* below) **(Fig. 242a).**

Tipula paludosa Meigen
A common crane fly

This well-known pest is often abundant in wet grassland and pastures. The soil-inhabiting larvae (known as 'leatherjackets') often attack the roots and germinating seeds of cereals planted in recently ploughed-up grassland, and can cause considerable damage. At night, they also come to the surface and may then sever or otherwise damage the basal parts of stems; leaves in contact with the soil may also be holed or shredded. Damage is particularly severe in spring, when attacked plants turn yellow, wilt or die; dead or dying plants frequently occur in patches. Attacks

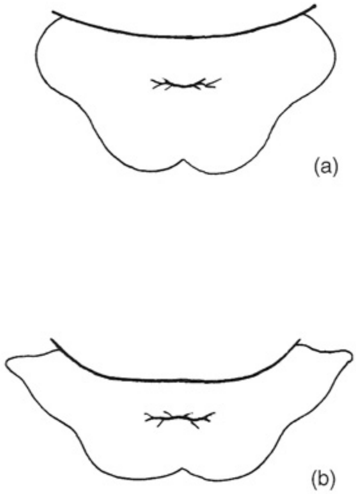


Fig. 242 Outline of the anal segment of leatherjackets: (a) *Nephrotoma appendiculata;* (b) *Tipula paludosa.*

are often reported on reseeded grassland and on cereal and vegetable crops which follow ploughed-up infested grassland; they also occur on strawberry, on various outdoor ornamentals (including bedding plants) and on containerized plants grown in plastic tunnels and under other protective structures.

BIOLOGY
Unlike the following species, *Tipula paludosa* is univoltine, most adults occurring in late August and September. Eggs are laid at random in the soil, each female depositing up to 300 or more. The eggs hatch in approximately 2 weeks but they are very susceptible to desiccation and require high humidity to survive. The larvae feed from autumn onwards and are usually fully grown by the following summer. They then pupate in the soil, and adults emerge about 3 weeks later. Gravid females do not fly, so that eggs tend to be laid close to where the adults emerged from the pupa and mated; consequently, populations of the pest can quickly build up in suitable sites (cf. *T. oleracea,* below).

DESCRIPTION
Adult 17-25 mm long, grey with a yellowish-red or brownish tinge and indistinct longitudinal

stripes on the thorax; *antennae* 14-segmented; *wings* up to 23 mm long, shorter than the abdomen (cf. *Tipula oleracea*, below); *legs* very long, narrow and fragile. **Egg** 1.1 x 0.4 mm, elongate-oval, shiny black **(Fig. 241b).** **Larva** up to 45 mm long, dull brownish-grey, plump with a soft but tough skin; *head* black but indistinct; *posterior papillae* fleshy and often tapered - the dorsal and lateral pair on the spiracular disc elongated and of similar length, the dorsal pair of anal papillae elongate and the ventral pair rounded **(Fig. 242b)** (cf. spotted crane fly, *Nephrotoma appendiculata*, p. 163).

Tipula oleracea L.
A common crane fly

Adults of this generally common species appear earlier in the year than those of *Tipula paludosa* (above). Larvae also occur somewhat earlier and, as a result, often cause noticeable damage to plants in the same year as eggs were laid. Unlike those of the previous species, gravid females are usually able to fly away from emergence sites, so there is less likelihood of populations in following crops escalating to damaging levels. It has been observed, however, that emerging adults can be 'trapped' beneath the canopy of post-flowering oilseed rape crops; this can result in the appearance of unusually large populations of larvae of this species in following winter wheat crops. Unlike *T. paludosa*, this species has two generations per year, adults occurring at various times from April to October. The antennae of adults are 13-segmented and the wings (wing length: 18-28mm) are at least as long as the body (cf. *T. paludosa*, above); larvae are distinguishable from those of *T. paludosa* by the two pairs of elongated, subtriangular anal papillae.

Family BIBIONIDAE (St. Mark's flies)

Bibio marci (L.)
St. Mark's fly

This generally abundant fly is a minor pest of cereals and grasses. The larvae graze on the roots and sometimes cause plants to wilt and die. Infestations typically occur in heavily manured sites. Although the larvae can be harmful, adult bibionids are often useful pollinators of fruit trees.

BIOLOGY

Adults are active from April to June, and the males typically hover in large swarms over the ground, hedges and other vegetation. Egg-laying females are attracted to decaying vegetable matter, where they then dig down into the soil for a few centimetres before depositing eggs in raft-like groups. Eggs hatch about 5 weeks later. The larvae, which feed gregariously, develop relatively slowly and do not reach the pupal stage until the late winter or early spring.

DESCRIPTION

Adult black-bodied, very hairy (especially male) and relatively large; *wings* 8-12 mm long. **Egg** 0.75 mm long, sausage-shaped, white when newly laid but soon becoming darker at each end. **Larva** up to 24mm long, dull greyish-brown, with distinctive fleshy papillae on the body - these, in common with other species of *Bibio* (see Fig. 85), are longer, more slender and more numerous than in the genus *Dilophus* (p. 166); *head* dark brown; *spiracles* on last body segment each with just two pores (typical of *Bibio)* **(Fig. 243a)** (cf. *Dilophus* p. 166). **Pupa** 12-14 mm long, the abdominal segments ornamented with several small spines; *head* with just one anterior process, that in the female being relatively small (typical of *Bibio;* cf. Dilophus, p. 166).

Bibio hortulanus (L.)
March fly

This is a relatively small species (wings 5.5-9.5mm long); males are black-bodied but females have the abdomen and part of the thorax orange-red; the legs are entirely black in both sexes (cf. *Bibio johannis*, below). Adults occur in May and June. The larvae occasionally cause damage in the late winter or early spring, particularly to crops of winter wheat.

Bibio johannis (L.)

Larvae of this species are sometimes damaging to cereals and other crops, infestations most

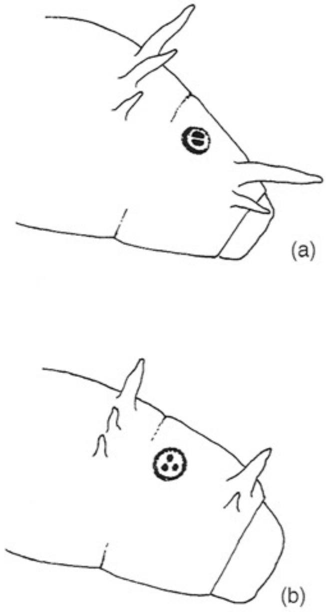


Fig. 243 Tip of the body of bibionid larvae: (a) *Bibio:* (b) *Dilophus.*

often being reported in fields of winter wheat in the late winter or early spring. Adults are small (wings 4.5-6.5mm long); both sexes are black-bodied but the legs of females are ochreous and those of males reddish with black femora. The flies occur from March to June and are often found resting on the leaves of cereal plants and grasses.

NOTE Morphological differences between larvae of the various species of *Bibio* are slight and specific determinations are not always reliable.

Dilophus febrilis **(L.)**
Fever fly

This species is a minor pest of various crops, including cereals (notably spring barley and maize), potato and sugar beet, and infestations tend to occur on damp, heavily manured sites; damage is also reported on grassland and on various horticultural crops, including hop and strawberry. The soil-inhabiting larvae feed on the roots, tubers and stolons, and attacked plants often collapse and die. On cereals, the larvae

Fig. 244 Foreleg of fever fly, *Dilophus febrilis.*

often hollow out the seed; they also destroy the roots and lowermost parts of the shoots. On potato, the larvae burrow into the flesh of the tubers to form extensive galleries and cavities. Adults are useful pollinators of fruit trees.

BIOLOGY

Adults emerge from April onwards. Large numbers of males often congregate on low vegetation, including the tips of grasses and cereal plants. The flies frequently visit open flowers and, in the spring, are of some benefit as pollinators of fruit trees and other plants. After mating, females burrow a few centimetres into the soil, especially in the presence of rotting vegetation or organic manure. Each then forms a small cell in which a cluster of 200-300 eggs is laid. Eggs hatch about a month later. The larvae feed gregariously on the subterranean parts of plants and, in favourable situations, there may be several thousand individuals per square metre. Larvae pass through four instars and then pupate; adults appear a few weeks later. There are usually two or three generations annually, and adults tend to be most numerous in the spring and autumn.

DESCRIPTION

Adult mainly shiny black; *pronotum* with two transverse rows of backwardly directed spines; *wings* 4-7 mm long; *fore tibiae* each with an apical circlet of seven to nine stout spines **(Fig. 244).** **Egg** 0.55 mm long, sausage-shaped, white

Fig. 245 Larva of fever fly, *Dilophus febrilis* (x6).

when newly laid, becoming slightly darker at each end. **Larva** up to 12mm long, dull, light brown, more or less cylindrical; each body segment with several relatively short papillae **(Fig. 245)** (cf. *Bibio,* Fig. 85); *head* prominent, blackish-brown (cf. leatherjackets, e.g. *Tipula* spp., p. 164); *posterior spiracles* each with three pores **(Fig. 243b).** **Pupa** 7.5 mm long, whitish, darkening to brownish-grey; *head* with one (female) or three (male) pointed anterior processes (cf. *Bibio,* p. 165).

Family SCIARIDAE (sciarid flies)

Bradysia paupera Toumikoski

This sciarid is a common and often important pest that can check the growth of glasshouse cuttings, seedlings and young pot plants, including cucumber, lettuce, melon and various ornamentals. Attacked plants may also wilt and die, especially in sunshine. Less frequently, when eggs are deposited on leaves, the larvae skeletonize the foliage.

BIOLOGY

Adult sciarids are very active, and are often seen flitting or scurrying about at the base of cuttings, seedlings or older plants. The egg-laying females are much attracted to dried blood fertilizer and to steam-sterilized soil; each will deposit 100 or more eggs in the soil close to host plants. Eggs hatch several days later, the incubation time varying considerably according to temperature. The larvae feed for 3-4 weeks and usually attack the root hairs; when fully fed, they construct silken cocoons within which to pupate, and adults emerge about a week later. More rarely, eggs may be placed directly onto plant tissue; the larvae then feed on the leaf tissue and may eventually pupate on the foliage. Under suitable conditions breeding is continuous.

DESCRIPTION

Adult 3.0-3.5 mm long, black, with a greyish-brown abdomen; *eye bridge* present (see Fig. 87) (cf. cucumber sciarid fly, *Pnyxia scabiei,* p. 168); *legs* yellowish; *antennae* relatively short and thick; *palps* 3-segmented (cf. cucumber sciarid fly, *P. scabiei,* p. 168). **Egg** 0.2 x 0.1 mm, oval, translucent-whitish. **Larva** up to 6 mm long, elongate, translucent-whitish; *head* shiny black.

Bradysia amoena (Winnertz)

This relatively small, dark-bodied species occurs commonly in association with pot plants. The adults are similar to those of *Bradysia paupera* (above) but have longer, thinner antennae; they are active at virtually any time of year and frequently attract attention in dwelling houses; the larvae can cause injury to seedlings and small plants but are rarely important.

Bradysia aprica (Winnertz)

Infestations of this small, widely distributed sciarid often occur in glasshouses, where the larvae cause minor damage to pot plants. Adults are dark-bodied with pale halteres, pale legs and clear wings.

Bradysia brunnipes (Meigen)

This species is often common in mushroom houses, and the adults are sometimes a nuisance to pickers. The larvae feed in the casing. Although implicated in the spread of diseases, they do not damage the mushrooms directly (cf. mushroom sciard fly, *Lycoriella auripila,* p. 168). Adults are blackish (females have a paler abdomen), with slightly smoky wings (wing length: 3.0-4.5 mm) and yellow halteres.

Lycoriella auripila **(Winnertz)**
A mushroom sciarid fly

This species is the main sciarid pest in mushroom houses. The larvae burrow into the sporophores and sometimes cause the death of the developing buttons; mushroom size is also affected. As larvae move through the mushroom compost they leave behind a characteristic slime trail.

BIOLOGY
Eggs are deposited mainly in the compost, although sometimes also on the developing mushrooms, either singly or in small groups. They hatch within a few days. Larvae develop rapidly and pass through four instars before pupating, each in a flimsy cocoon consisting of fragments of compost and strands of silk. There is a succession of generations, and development from egg to adult takes from 3 to 6 weeks, depending on temperature.

DESCRIPTION
Adult black-bodied; *eye bridge* present (see Fig. 87); *wings* 2.0-2.8mm long, with a reduced anal area (cf. *Lycoriella solani,* below); *palps* 3-segmented. Egg 0.7 x 0.3 mm, oval, translucent. **Larva** up to 8 mm long, translucent-whitish; *head* shiny black, with powerful mouthparts.

Lycoriella solani **(Winnertz)**
A mushroom sciarid fly

This sciarid is associated with rotting plant tissue and was once considered a serious pest of mushrooms. Nowadays, however, this species is recognized as primarily saprophytic and of secondary importance, as the larvae feed mainly on the compost and attack only unhealthy mushroom sporophores. Adults (wings 2.5-3.5mm long) are larger than those of *Lycoriella auripila* (above) and the wings include a large anal area.

Pnyxia scabiei **(Hopkins)**
Cucumber sciarid fly

Larvae of this generally common sciarid often damage cucumber plants, attacking the stems and tap roots at about soil level; infested plants wilt and finally collapse and die. The black-bodied adults are distinguished from *Bradysia* spp. (p. 167 *et seq.)* by their 1-jointed palps and by the absence of an eye bridge (see Fig. 87); females (body 1-2 mm long) are wingless; males (body up to 1.3 mm long) are either short-winged (brachypterous) or long-winged (macropterous).

Family CECIDOMYIIDAE (gall midges)

Contarinia pisi (Winnertz)
Pea midge

This midge is a locally important but sporadic pest of pea; occasionally, infestations also occur on *Vicia* bean. Larvae cause considerable distortion of growth. New shoots become discoloured and severely distorted; damaged flowers often abort or may produce small, malformed pods. Significant crop losses usually occur only when the first three flower trusses, which contribute most to harvested yields, are attacked. In the British Isles, this midge is most frequent in eastern England.

BIOLOGY
Adult midges first appear in June, but the time of their emergence depends largely on soil moisture and temperature. Mating takes place almost immediately; the mated females (that live for about 4 days) then disperse to seek new host plants. The midges are active in calm conditions, and most dispersal takes place after showers of rain or in the late evening and early morning. Eggs are deposited in batches of about 20-30 on the stipules and buds or beneath the bud scales, and crops remain susceptible to attack throughout the bud and flowering stages. Eggs hatch in about 4 days. The larvae feed on the young tissue for about 10 days. They then drop to the ground *(Contarinia* larvae typically 'jump' by flexing their bodies) and enter the soil to pupate in small, whitish cocoons. New adults emerge about 2 weeks later, and these eventually give rise to a second generation of larvae. Fully grown second-generation larvae, along with individuals of the first generation which did not pupate, overwinter

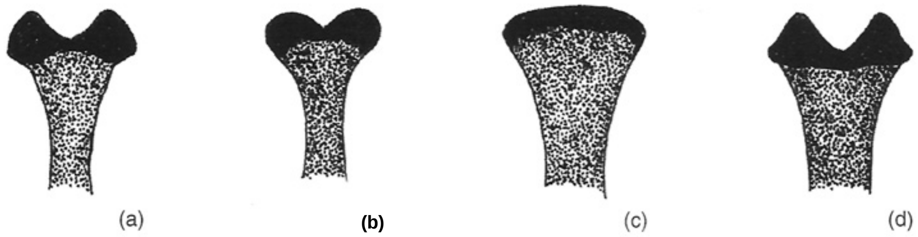


Fig. 246 Spatulas of various midge larvae: (a) pea midge, *Contarinia pisi;* (b) yellow wheat blossom midge, C. *tritici;* (c) saddle gall midge, *Haplodiplosis marginata;* (d) orange wheat blossom midge, *Sitodiplosis mosellana.*

in the soil and most of these pupate in May or June; some larvae, however, remain in their cocoons for several years before eventually pupating and producing adults.

DESCRIPTION
Adult greyish-brown with long legs and antennae; *wings* 2mm long. **Egg** 0.25mm long, translucent, elongate-oval with a pointed tip. **Larva** up to 3 mm long, dirty white; *sternal spatula* broadened anteriorly and strongly cleft **(Fig. 246a).**

Contarinia tritici (Kirby)
Yellow wheat blossom midge

Infestations of this widely distributed midge occur on wheat and, less frequently, barley and rye but are rarely of economic significance. The larvae attack the floral parts (stigma and styles) (cf. orange wheat blossom midge, *Sitodiplosis mosellana,* p. 176), and usually prevent pollination and, thus, grain development. Heavily infested ears have a flattened appearance.

BIOLOGY
Adult midges, although short-lived, sometimes appear in vast numbers over cereal crops in about mid-June. Eggs, typically in batches of up to 30, are laid in the developing but unhardened florets, as soon as the developing ear is exposed (i.e. when the leaf sheath has split: Growth Stage 51); the females do not deposit eggs in hardened florets. Eggs hatch 7-10 days later. The larvae then feed gregariously, sometimes several hundred in each infested ear, and complete their development in approximately 3 weeks. (The yellowish nymphs of cereal thrips, *Limothrips* spp., also occur in the ears of developing cereals, see p. 92 *et seq.*, and these are sometimes mistaken for midge larvae.) Fully grown larvae eventually 'jump' to the ground and enter the soil; they usually emerge from the ear ahead of those of *Sitodiplosis mosellana* (larvae of both species sometimes occur together). Under very dry conditions, the larvae can become trapped within the glumes but they often emerge in numbers following a shower of rain. A few larvae may pupate whilst still within the glumes; others which have succeeded in reaching the ground may also pupate (without forming cocoons). Such individuals give rise to a partial second generation of adults that deposit eggs on *Elytrigia repens.* The majority of larvae, however, spin cocoons in the soil and either pupate in the following May or early June (typically, first emerging from their cocoons and moving closer to the soil surface) or remain in diapause for up to three seasons before eventually pupating. Winter mortality of larvae is often considerable.

DESCRIPTION
Adult 2-3 mm long, lemon-yellow to dusky-yellow, with relatively large, black eyes and dusky wings. **Egg** minute, golden-yellow and translucent; sausage-shaped with a long stalk. **Larva** up to 3 mm long, yellow, tapered anteriorly and blunt posteriorly, the penultimate body segment with a pair of chitinized tubercles; *sternal spatula* with a rounded, bifid tip **(Fig. 246b).**

Contarinia dactylidis (Loew)
Cocksfoot midge

Infestations of this univoltine species occur on cocksfoot. The small (up to 2mm long), gregarious, lemon-yellow larvae (cf. *Contarinia geniculati*, below) feed on the seeds, sheltered within the glumes. Adult midges are active from late May onwards, eggs being deposited within the developing florets. The larvae feed during the summer for up to 4 weeks. Fully grown individuals then enter the soil to overwinter, each in a silken cocoon. Pupation takes place in the spring, shortly before the appearance of the adults. Although seed production is reduced, attacks are rarely of economic importance.

Contarinia geniculati (Reuter)

This generally common grass midge attacks the florets of both cocksfoot and meadow foxtail. The larvae feed singly within the florets (cf. *Contarinia merceri*, below) and there are up to two generations each year. In common with those of other species, they contribute to yield losses in seed crops. The fully grown larvae are pinkish-yellow and, unlike those of related species, lack a sternal spatula. In common with those of *Dasineura alopecuri* (p. 171), the larvae often remain within infested seeds after harvest.

Contarinia humuli (Theobald)
Hop strig midge

Infestations of this widely distributed but uncommon pest are sometimes reported in hop gardens; the whitish larvae (known as 'hop strig maggots') feed gregariously within the cones, usually from mid-August to mid-September. Infested strigs become riddled with tunnels and blackened, heavily infested cones turning brown. Attacks are most often reported on cultivars Fuggle and Tutsham. Adult midges occur in late July and August, and there is just one generation annually.

Contarinia medicaginis Kieffer
Lucerne flower midge

Infestations of this widely distributed midge occur on lucerne. The whitish larvae (up to 2mm long) feed gregariously within the flower buds, which become swollen basally and fail to open. Heavy infestations cause significant seed loss, damage often being of considerable importance in continental Europe but of little significance in the British Isles. The yellowish-grey adults occur from May onwards, and development from egg to adult takes approximately 5-6 weeks; there are two or three generations annually.

Contarinia merceri Barnes
A foxtail midge

This generally common midge is associated with meadow foxtail. Infestations sometimes cause economic damage to seed crops, especially those growing in sheltered sites. Adults occur in late May and early June, eggs being deposited within the florets. The golden-yellow larvae, up to 2.5 mm long, which have a small sternal spatula, feed gregariously within the florets (cf. *Contarinia geniculati*, above, and *Dasineura alopecuri*, p. 171); they destroy the seeds so that empty glumes are present at harvest. Individuals are fully grown within a month. They then enter the soil to spin cocoons. A few of the larvae may pupate in the summer to produce a partial second generation in the autumn; most, however, overwinter and pupate in the spring.

Contarinia nasturtii (Kieffer)
Swede midge

Infestations of this widely distributed midge occur on various members of the Brassicaceae, including cabbage, cauliflower and fodder brassicas; however, they are most important on swede, including fodder crops. The small, delicate, yellowish adults appear in May and June, and eggs are then deposited in the young tissue of host plants. The eggs hatch in about a week and the pale, yellowish-white larvae (up to 2.5 mm long) then feed gregariously. They cause a swelling of flowers, crinkling of leaves ('crumple leaf symptom) and, often and most significantly, death of the main growing point; the latter damage leads to the proliferation of secondary shoots ('many neck' symptom). Larval damage is often followed by bacterial rotting of tissue and tends to be most severe in June, particularly under dry conditions. Fully grown larvae 'jump' to the ground and eventually pupate in cocoons in the soil, the next generation of adults appearing shortly afterwards; some larvae, however, do not pupate but remain in a state of diapause for up to 1 or more years. There are usually from three to five generations each year, depending on temperature.

Contarinia pyrivora (Riley)
Pear midge

This univoltine midge is a damaging pest of pear but tends to occur mainly on garden trees rather than in commercial orchards. Adult midges are active in the spring, when they deposit eggs in the open blossoms. The relatively large, up to 5 mm long, yellowish-white larvae feed gregariously within the developing fruitlets and become fully grown in about 6 weeks. They cause severe distortion; affected fruitlets also turn black and, on reaching approximately 15-20 mm in diameter, usually crack open and decay. Fully fed larvae overwinter in the soil, and adults emerge in the spring.

Dasineura brassicae (Winnertz)
Brassica pod midge

Infestations of this potentially major pest occur on oilseed rape and other brassica seed crops but not on white mustard. The larvae feed within the developing pods and cause premature ripening and splitting, which may result in significant seed loss. Infested pods often swell (the so-called 'bladder pod' symptom) but this symptom is not expressed on all hosts. Midge damage is often concentrated on headlands and decreases markedly further into the crop.

BIOLOGY

Adult midges emerge in May. They are weak fliers, and the egg-laying females migrate downwind to seek host plants, usually within a few hundred metres of emergence sites. Eggs (up to 30 per female) are laid in batches in the pods of brassica plants in late May or early June. The adult females are unable to penetrate an unblemished pod wall and usually deposit their eggs through feeding or egg-laying punctures previously made by adults of the cabbage seed weevil, *Ceutorhynchus assimilis* (p. 154). Sites of other mechanical injury are also utilized; later in the season, for example, second-generation midges may deposit eggs through holes (exit holes) formed in pod walls by fully fed seed weevil larvae. Midge eggs hatch within a few days. The larvae then feed gregariously on the pod wall **(Plate 6c),** without damaging the central septum, causing premature ripening and splitting. (In prematurely split, bird-damaged pods, the septum is usually broken.) When fully grown, the larvae escape and fall to the ground. They then enter the soil and pupate, each in a small silken cocoon. A second generation of adults appears about 2 weeks later. Some larvae, however, do not pupate but remain in a state of diapause until the following or subsequent seasons. There are usually up to three or more generations per year, depending upon temperature, although any one crop is likely to sustain only two generations in a season.

DESCRIPTION

Adult 2 mm long, greyish-brown, with a pinkish (male) or red (female) abdomen. **Egg** minute, sausage-shaped and translucent. **Larva** up to 2 mm long, whitish; the younger stages are translucent.

Dasineura alopecuri (Reuter)
A foxtail midge

This widely distributed pest occurs on meadow foxtail throughout northern Europe and can have a very significant effect on seed crops. The larvae feed within the florets, affecting germination; they also cause direct damage to the seeds, which often develop a distinct lateral depression. Adult midges are red and appear in May. The females deposit reddish eggs singly in the florets, the long ovipositor readily penetrating beneath the glume. Eggs hatch about a week later and the larvae feed for up to 2 months. Fully grown individuals are 2.0-2.5 mm long, reddish-orange and distinctly oval-bodied; the anterior protuberances of the very broad sternal spatula are distinctly pointed (ear-like) (cf. *Contarinia geniculati*, p. 170, and *C. merceri*, p. 170). Larvae (in common with those of *C. geniculati)* remain within the dead florets, even after these have dropped to the ground. Pupation occurs in the spring. This pest is spread readily within infested seed, the latter failing to be removed by normal post-harvest cleaning processes.

Dasineura leguminicola (Lintner) Clover seed midge

This widely distributed and generally common, reddish to orange-coloured midge is associated with red clover. The larvae are capable of causing significant damage to seed crops; affected plants flower irregularly, buds fail to open properly and the heads turn brown prematurely. Affected seeds are often distorted and may be invaded by secondary fungal pathogens. Eggs are deposited singly, or in small batches, in the furled heads of clover plants, usually in June. They hatch a few days later. The neonate larvae immediately migrate into the floral parts, and down the corolla tube, to feed adjacent to the ovary. The pinkish larvae, each with a distinct, sharply cleft sternal spatula are fully fed in 4-6 weeks. They then vacate the flowers and drop to the ground to spin silken pupal cocoons within the soil. A second generation of adults emerges 2-3 weeks later. There are usually up to three generations annually; larvae of the final generation pupate in the following spring, shortly before the appearance of the adults.

Dasineura mali (Kieffer) Apple leaf midge

Infestations of this widely distributed midge occur on apple, eggs being deposited in the margins of young apple leaves. Infested leaves are tightly rolled longitudinally and distorted, the rolled edges often turning purplish-red. The leaf folds often afford protection to young larvae of summer fruit tortrix moth, *Adoxophyes orana* (p. 212). Damage is of particular significance on young trees but attacks on mature trees rarely prove of significance. Larvae (up to 3 mm long) vary from translucent-white or creamish-white to red or orange. They feed gregariously and are fully grown in about 2 weeks; most then pupate in the soil. There are usually three generations annually but up to five in parts of continental Europe.

Dasineura pyri (Bouche) Pear leaf midge

This pest occurs on pear, especially on young trees, where the larvae cause a distinctive longitudinal curling of the young leaves. The larvae, which are whitish and up to 2 mm long, feed gregariously on the upper epidermis, within the shelter of the tightly rolled leaf margins. Infested leaves are discoloured; they frequently turn red and, finally, black. There are usually three generations annually, and the pest tends to become more numerous later in the season. In dry summers, the number of generations may be restricted to two.

Dasineura tetensi (Riibsaamen) Black currant leaf midge

This midge is often a persistent pest of black currant. The larvae feed in the shelter of the young leaves. The infested leaves fail to develop properly and become crumpled and discoloured, affected tissue often turning black. Attacks are particularly significant on young bushes and cuttings. Adults are active from April onwards. Eggs are then deposited in small batches in the folds of the unfurling leaves, usually at the shoot tips. The translucent to whitish larvae feed gregariously for about 2 weeks and then drop to the ground to pupate in cocoons in the soil. New adults appear about 2 weeks later. There are normally three overlapping generations annually but sometimes a partial fourth.

***Haplodiplosis marginata* (von Roser)**
Saddle-gall midge

The saddle-gall midge is a sporadic and locally important pest of barley, oats and wheat, but causes most damage on heavy-land sites where cereals are grown intensively; infestations also occur on various grasses, including *Elytrigia repens.* The larvae form distinctive galls on the stems of infested plants. If numerous, the galls (which often occur in rows along the stem) have a direct effect on cropping, reducing grain size and plant yields by 10% or more. The galls also weaken stems, so that affected plants may lodge or break off in a strong wind. Damage tends to be concentrated around the edges of fields. In the British Isles, this pest has proved of most significance in central and eastern England.

BIOLOGY
Adults appear in late May and early June. Eggs are then deposited in chain-like groups, usually on the upper surface of the leaves of wheat and other hosts. In total, each female may deposit up to 200 eggs, in batches of about 25. The eggs hatch 1-2 weeks later. The larvae then move into the shelter of the leaf sheath and begin to feed on the stem, each forming a characteristic saddle-like depression or gall. Fully grown larvae eventually drop to the ground, usually in late July, to overwinter in the soil, each in a silken cocoon. Most surviving larvae pupate in the spring, after first vacating their cocoons and moving closer to the surface; a smaller number of larvae, however, remain in diapause for a further year or more. There is just one generation annually.

DESCRIPTION
Adult 4.0-5.5 mm long, blood-red. **Egg** 0.3 mm long, sausage-shaped, red and translucent. **Larva** up to 5 mm long, orange-red to red; *sternal spatula* broad, with a blunt tip **(Fig. 246c).**

***Heteropeza pygmaea* Winnertz**
Mushroom cecid

This midge is generally common and widespread in decaying vegetation and rotting wood, and has become an important pest of cultivated mushrooms. The larvae contaminate the sporophores; they also introduce a bacterium that produces brown longitudinal stripes on the stipes and tiny black globules of liquid on the gills. Crop losses, especially of the later flushes, are often heavy.

BIOLOGY
Breeding populations in mushroom beds consist of paedogenetic larvae, which feed on fungal mycelium and also invade the sporophores. The larvae become fully grown in about 5 days. The larval gut then opens to expel a faecal tube about 10 mm long (cf. mushroom midge, *Mycophila barnesi*, p. 175), after which the larvae (known as 'mother' larvae) moult into sedentary 'hemi-pupae' within which several embryos develop; new individuals emerge about 2 days later, each as a "daughter' larva, about 1mm long. Under ideal conditions. 14 'daughter' larvae are produced from each 'mother' larva in just under a week, and larval populations build up extremely rapidly; many thousands can occur in a mere handful of casing material. Under dry conditions, the larvae will clump together to form sticky seething masses, often measuring many millimetres across. These larvae are frequently transported to previously clean mushroom beds on workers' clothes, equipment and tools, and are a major source of new infestations; larvae may also be introduced into mushroom houses in contaminated peat. If breeding conditions become unfavourable, fewer than normal individuals are produced within the 'mother' larvae, and the embryos develop into thick-walled resting stages, capable of surviving for well over a year. Larval infestations in mushroom beds may continue to develop for many generations but, eventually, usually about 2 months after spawning, 'imago' larvae appear. These pupate after a single moult and, about 5 days later, adult midges emerge. The adults often occur in vast numbers but are harmless. Also, most are female and few become fertilized, so the risk of their initiating further infestations is slight.

DESCRIPTION
Adult female orange, weak-bodied, with sclerotized spermothecae visible towards the

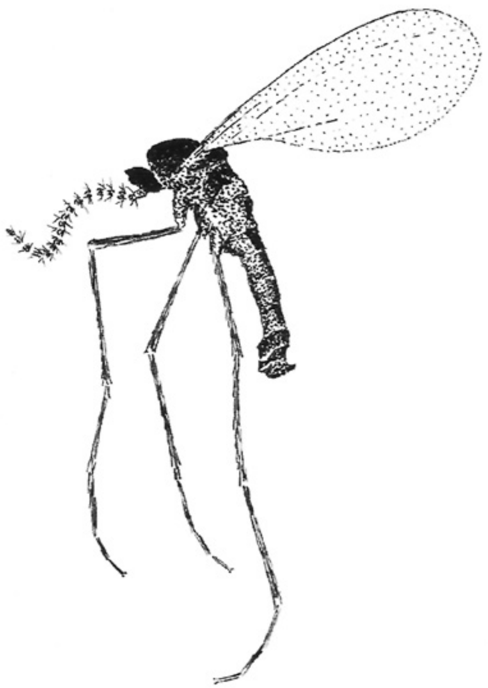


Fig. 247 Hessian fly, *Mayetiola destructor* (xl5).

tip of the abdomen; *wings* 0.8 mm long. **Paedogenetic larva** up to 3 mm long, white, tapered anteriorly, but somewhat rounded posteriorly, with a pair of anterior eye-spots meeting to form an 'X'. **'Imago' larva** similar in appearance to paedogenetic larva but with a sternal spatula and separated eye-spots.

***Mayetiola destructor* (Say)**
Hessian fly

The hessian fly is associated mainly with wheat but will attack barley and rye; *Elytrigia repens* is also a host. The larvae produce a noticeable swelling at the base of young plants; later, they also cause the leaf nodes to swell. The ears of infested plants may turn whitish and the grains often shrivel; infested plants may also lodge or break off in the wind, and this contributes to further yield loss. Although of relatively little importance in the British Isles, hessian fly is a major pest in many other wheat-growing countries, particularly North America.

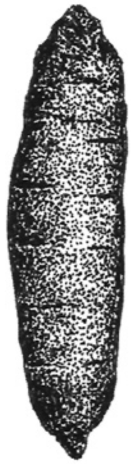


Fig. 248 Puparium of hessian fly, *Mayetiola destructor* (x!5).

BIOLOGY
Adults of the first generation appear in March or April. Eggs are deposited in batches on the leaves of host plants, and they hatch about a week later. The larvae feed within the shelter of leaf sheaths at the base of the plant and complete their development in approximately 3 weeks. They then pupate *in situ* to form a cluster of seed-like puparia (this is the so-called 'flax-seed' stage) **(Plate 6d).** Adult midges appear about 3 weeks later, but development times vary considerably according to temperature. There is usually at least one further generation, or partial generation; puparia form the overwintering stage.

DESCRIPTION
Adult black with a brownish or brownish-red abdomen **(Fig. 247).** **Egg** 0.5 mm long, sausage-shaped, red. **Larva** up to 4 mm long, whitish, translucent; *sternal spatula* robust, with a bifid tip. **Puparium** 4 mm long, dark brown, resembling a seed of flax **(Fig. 248).**

***Mayetiola avenae* (Marchal)**
Oat stem midge

This species is similar in habits and appearance to *Mayetiola destructor* (above) but is associated with oats. The larvae cause infested nodes to become swollen but damage is insignificant and the insect is not of economic importance.

Mayetiola dactylidis **Kieffer**
Cocksfoot stem midge

Infestations of this univoltine species occur on wild and cultivated cocksfoot, but are not considered of any great significance.

Mycophila barnesi **Edwards**
A mushroom midge

Larvae of this widely distributed midge are orange and occur commonly in cultivated mushroom beds, often in their thousands. Each 'mother' larva reaches about 2 mm in length and produces up to 20 'daughter' larvae in just over a week. Unlike larvae of the mushroom cecid, *Heteropeza pygmaea* (p. 176), the gut contents are voided at intervals throughout larval development, and breakdown of mushrooms through bacterial action does not occur; also, there is no clumping behaviour and no resting stage in the life-cycle, individuals dying if starved of food. Attacks by this species, which has a slower rate of development than either *H. pygmaea* or *Mycophila speyeri* (below), tend to be limited to the third and later flushes of mushrooms.

Mycophila speyeri **(Barnes)**
A mushroom midge

This species develops more rapidly than *Mycophila barnesi* (above), and the bright orange 'mother' larvae each produce about 20 'daughter' larvae in less than a week; the larvae often contaminate mushroom crops from the first flush onwards.

Resseliella theobaldi **(Barnes)**
Raspberry cane midge

The raspberry cane midge is a widespread and locally important pest of raspberry, particularly in the main raspberry-growing areas of England and Scotland. Occasionally, attacks also occur on loganberry. The larvae may be found beneath the rind of the new canes, immediately adjacent to growth splits. The feeding sites eventually turn brown or black but direct damage is usually of only minor importance. More significantly, midge-damaged canes are often infected by fungal pathogens; this results in a disease known as 'midge blight', and this may lead to the death of canes ('cane blight'). Midge damage is especially severe on cultivars with freely splitting canes (e.g. Glen Clova, Mailing Enterprise and Mailing Promise) and, where 'midge blight' develops, crop yields in the following season may be reduced considerably.

BIOLOGY
Adult midges appear from early May onwards but the time of appearance varies by several days to a few weeks, depending on local temperatures. Eggs are deposited in breaks in new raspberry canes and hatch in about a week. The larvae feed gregariously beneath the rind for up to 3 weeks and then drop to the ground to spin silken cocoons in the soil. Second-generation adults emerge 2-3 weeks later. There are usually three overlapping generations each year and larval populations tend to increase markedly as the season progresses; in late summer and autumn, there may be several hundred larvae feeding on any one infested cane. Fully grown larvae of the autumn generation overwinter in their cocoons and pupate in the spring.

DESCRIPTION
Adult 2.0 mm long, dark reddish-brown. **Egg** minute, sausage-shaped, translucent. **Larva** up to 3.5 mm long, translucent when young but soon becoming yellowish-orange to salmon-pink.

Resseliella oculiperda **(Riibsaamen)**
larva **= Red bud borer**

This widely distributed but local midge is a potentially important pest of rose. The larvae cause damage to budded stocks and grafts; a similarly damaging 'strain' also occurs on fruit trees (Rosaceae), particularly apple. Affected buds or grafts may wilt and die; damage caused by late summer and autumn larvae tends to be most significant. The minute, c. 2 mm long, dark reddish-brown adults occur from May onwards, and there are typically three generations each year. Eggs are inserted in the slits in the bark of newly budded or grafted stock. They hatch in about a week. The larvae then feed in small groups for up to 3 weeks. Fully grown larvae, which are salmon-pink to reddish-orange and up to c. 3 mm long, drop to the ground to pupate in small cocoons spun in the soil. Adults emerge 2-3 weeks later. Larvae of the final generation complete their development in the autumn, overwinter in their cocoons and pupate in the spring.

Resseliella sp.
Bean stem midge

This undescribed species of *Reselliella* is a minor pest of field bean and was first reported, in the early 1980s, in eastern England. First-generation adults appear in late May and June. Eggs are then laid in stem lesions, especially on winter-sown beans. The larvae, which gradually change in appearance from translucent whitish to deep orange-red, feed gregariously in rows immediately below the epidermis; they occur mainly from mid-June to mid-July, and their feeding sites typically appear as black patches running up the stem. Fully grown larvae drop to the ground, pupate in the soil and a second generation of midges emerges from mid-July to mid-August. The fungus *Fusarium* is associated with the larval feeding sites and, where significant fungal growth develops, infested plants may become lodged. First-brood larvae are associated mainly with winter beans, as spring-sown bean plants have relatively few stem lesions when egg-laying females of the first generation are active.

Sitodiplosis mosellana (Gehin)
Orange wheat blossom midge

This widespread and sporadically important pest occurs on barley, rye and wheat; second and subsequent winter wheat crops growing in sheltered sites are particularly liable to be attacked. The larvae feed deeply within the florets and 'attack' the developing grain (seed) producing tissue-dissolving enzymes. The larvae usually occur singly or in small numbers (cf. yellow wheat blossom midge, *Contarinia tritici*, p. 169). Affected grains are misshapen and discoloured; also, they do not enlarge fully and the loosened seed coat often splits. If three or more larvae are associated with a single grain, the inner tissue will be destroyed completely. Although heavy infestations cause yield reductions, the pest is of greatest significance for its overall effect on grain quality, especially as damaged grains may be invaded by secondary fungal pathogens.

BIOLOGY
Adult midges appear in June. After mating at emergence sites, the females migrate to new host crops to lay eggs. They rest by day, at the base of the crop, and are active mainly at dusk, especially in warm, calm conditions. The eggs are deposited in the florets, singly or in small batches; typically, the females select ears which are fully emerged from the enclosing flag-leaf sheath (Growth Stages 55 onwards) (cf. yellow wheat blossom midge, *Contarinia tritici*, p. 169). The eggs hatch within a few days at normal summer temperatures. Surviving larvae, often just one from each egg batch as mortality of eggs is often high, then feed for up to a month. Final-instar larvae retain the skin of the penultimate stage and such larvae, which appear superficially pupa-like, often remain within the ear up to harvest time, especially under dry conditions. Fully grown larvae (which, unlike those of *C. tritici*, do not jump) enter the soil, where they form cocoons and eventually overwinter. There is just one generation annually. Diapausing larvae are known to survive in the soil for many years before pupating and producing adults.

DESCRIPTION
Adult 1.5-2.5 mm long, reddish-orange to brick-red and relatively stout-bodied. **Egg** minute, reddish to orange-yellow, sausage-shaped. **Larva** up to 2.5 mm long, reddish to orange-yellow, tapering both anteriorly and posteriorly;

sternal spatula with an angular, distinctly bifid tip **(Fig. 246d).**

Family PHORIDAE (scuttle flies)

***Megaselia halterata* (Wood)**
Worthing phorid

This fly is often a serious pest of cultivated mushrooms, although the larvae feed only on fungal mycelium and do not tunnel into the developing mushrooms (cf. *Megaselia nigra,* below). Minor attacks are of little or no significance but heavy infestations can cause considerable yield loss. The adult flies are sometimes a nuisance to pickers; they may also inadvertently pick up spores of *Verticillium fungicola* on their bodies, and then spread them from infected to previously healthy mushroom beds.

BIOLOGY
Adults occur during the summer and autumn, and are sometimes very numerous in mushroom houses, especially close to doors and lights. They often gather in considerable numbers and make characteristic jerky runs over the surface of walls, trays and boxes. In mushroom houses, most eggs are deposited in the casing material, close to the tips of the rapidly developing fungal hyphae, during the short period of mycelial growth. Under normal casing conditions, the eggs hatch in about 2 days and the larvae feed for 4-5 days before pupating; adults emerge 7-8 days later. In the lower temperatures associated with spawn-running rooms, where eggs are also deposited, development from egg to adult may take about 2 months. The adult flies often emerge in vast numbers from dumped mushroom compost and sometimes invade nearby dwellings; they may then cause considerable concern to local residents.

DESCRIPTION
Adult brownish-yellow to reddish-brown, with a hump-backed appearance; *antennae* short and inconspicuous, with a distinctly swollen third segment; *wings* 1.5-2.5 mm long, without cross-veins (see Fig. 96). **Egg** 0.5 x 0.2mm, oval, white. **Larva** up to 4 mm long, creamish-white and translucent, pointed anteriorly but blunt posteriorly; *anal segment* with a pair of prominent spiracles and distinct papillae. **Puparium** 2.5 mm long, brown; *anterior spiracles* horn-like.

Megaselia nigra (Meigen)
A mushroom scuttle fly

Larvae of this generally abundant species tunnel within the stipe and cap of wild mushrooms during the late summer and autumn. Damage is often extensive **(Plate 6e)** and may be followed by bacterial breakdown of the tissue. The larvae also infest cultivated mushroom crops and, prior to the introduction of modern cultural methods, were often serious pests. The females deposit eggs on the gills of mushrooms or on the casing but, unlike the previous species, they will oviposit only in daylight; attacks do not occur, therefore, in blacked-out mushroom houses or culture chambers, and this has led to a significant decline in the importance of this insect. Adults occur from June to December; they are mainly black and slightly larger than those of *Megaselia halterata* (above).

Family SYRPHIDAE (hover flies)

Eumerus strigatus **Fallen**
A small narcissus fly

Infestations of this generally common species occur on narcissus and onion bulbs; roots of various other crops, including cabbage, carrot, parsnip and potato, are also attacked. The larvae feed gregariously and break down the invaded tissue into a wet, greyish or blackish mass. The pest is usually of secondary importance and typically invades unhealthy or previously damaged plant material.

BIOLOGY
Adult flies occur in the early spring and are attracted to rotting vegetative tissue. Eggs are then laid, in batches, in suitable situations. The larvae feed gregariously, hollowing out bulbs, tubers

Fig. 249 Larva of a small narcissus fly, *Eumerus strigatus* (x7).

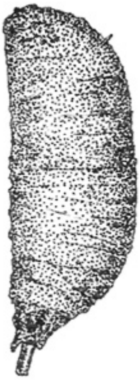


Fig. 250 Puparium of a small narcissus fly, *Eumerus strigatus* (x7).

and other suitable underground parts of host plants. Fully fed larvae usually pupate in the neck region of infested bulbs, and adults of a second generation appear in mid-summer. Larvae of the second generation become fully grown by the autumn. They then enter the surrounding soil where they overwinter; pupation occurs in the spring.

DESCRIPTION

Adult 5-6 mm long, mainly black with a golden sheen on the head and thorax; *thorax* with whitish longitudinal lines; *abdomen* with three pairs of white, crescent-shaped marks; *pterostigma of forewing* yellow or light brown. **Egg** 0.7 mm long, elongate, white. **Larva** up to 9 mm long; dirty yellowish-white; *posterior respiratory cone* reddish-brown and elongated **(Fig. 249). Puparium** 6-7 mm long, dirty yellowish-white; *posterior respiratory cone* reddish-brown and elongated **(Fig. 250).**

Eumerus tuberculatus Rondani
A small narcissus fly

This species is associated mainly with diseased or decaying narcissus bulbs. The larvae cause considerable damage and often completely destroy attacked bulbs. However, since infestations rarely if ever occur on healthy bulbs, the insect is of only secondary importance. Adults are distinguishable from those of *Eumerus strigatus* (above) by the dark brown or blackish pterostigma.

Merodon equestris (F.)
Large narcissus fly

The large narcissus fly is mainly a pest of daffodil and narcissus; various other ornamental bulbs, but not tulip, are also attacked. The inner tissue of larva-infested bulbs is destroyed and the resulting cavity becomes filled with rotting tissue and blackish frass. Infested bulbs feel soft, especially in the neck region. If planted, damaged bulbs give rise to weak, discoloured and distorted foliage and poor-quality flowers; sometimes, growth is limited merely to the emergence of a ring of narrow, grass-like leaves. Although widely distributed, in the British Isles this pest is of most significance in southwestern England.

BIOLOGY

Unlike species of *Eumerus* (p. 177 *et seq.),* the large narcissus fly is univoltine, and adults are active in calm, sunny weather at any time from late April to July. Eggs are laid singly on the neck of a bulb or in the soil, especially where the egg-laying female can gain access through a soil crevice; the eggs may also be laid low down upon withering foliage of host plants. Eggs hatch in approximately 2 weeks, and each neonate larva immediately crawls down the bulb and bites its way in through the base plate. Further development occurs within the bulb. Larvae are usually fully grown by the winter. They pupate in the spring, usually in the neck of the infested bulbs. In forcing houses, development of the pest may be accelerated and adults often emerge as early as February.

DESCRIPTION
Adult 2-14 mm long; *body* bumblebee-like, clothed mainly in gingery-brown hairs but hairs often forming black, grey or reddish crossbands **(Plate 6f).** Egg 1.6mm long, elongate-oval, pearly-white. **Larva** up to 18 mm long, stout-bodied, dirty yellowish-white; *posterior respiratory cone* dark brown.

Family TEPHRITIDAE (large fruit flies)

***Ceratitis capitata* (Wiedemann)**
Mediterranean fruit fly

This insect is a notorious pest, capable of causing destruction of citrus fruits, peaches and various other fruits. Although established in many warmer parts of the world, including areas surrounding the Mediterranean, parts of Africa, Central and South America, its occurrence in cooler areas, such as northwestern Europe, is usually dependent upon the initial accidental importation of live larvae in consignments of harvested fruits. Many countries operate rigorous quarantine or eradication measures to prevent this pest from becoming established. Larvae feed within the flesh of infested fruits and cause extensive damage; attacked fruits may drop prematurely and are often invaded by secondary bacterial and fungal pathogens. Fruits damaged only by adult oviposition 'strikes' are also unmarketable.

BIOLOGY
This species overwinters in the pupal stage, adults emerging in the spring. When laying eggs, adult females make a distinctive hole (up to 5 mm deep) in the surface of a fruit, into which one or several eggs are laid; this oviposition puncture later becomes surrounded by a sunken area of rotting tissue. Larvae feed within the flesh of the infested fruit and, when fully grown, emerge to pupate in the soil. There are several generations in a season, the rate of development (and, hence, number of generations) depending considerably on temperature. At optimum temperatures of 32°C, development is very rapid, the life-cycle then being completed in approximately 2 weeks.

DESCRIPTION
Adult 4-5 mm long; *head* yellowish; *eyes* colourful and iridescent; *thorax* black, marked with greyish-brown; *wings* clear, with black veins and dark spots and orange markings; *legs* yellowish; *abdomen* stubby, orange-yellow and with two silvery-white crossbands, the female with a distinct oviscapt. Egg 1mm long, white, elongate and somewhat banana-shaped. **Larva** up to 8 mm long; yellowish-white, subcylindrical, tapering anteriorly; *mouth-hooks* distinctly curved and claw-like, with the tip directed downwards (cf. European cherry fruit fly, *Rhagoletis cerasi*, p. 180). **Puparium** 4-5 mm long, reddish-brown.

***Euleia heraclei* (L.)**
Celery fly

The celery fly is a pest of celery and parsnip; infestations also occur on parsley, various wild Umbelliferae and on ornamentals such as giant hogweed. The larvae (known as "celery leaf miners') form expansive, brown, blister-like blotches on the leaves **(Plate 7a),** which affect both the appearance and vigour of host plants. Blotched leaves curl, turn yellow and eventually become brown; heavily infested plants appear scorched, plant growth is checked and crop quality is reduced. Damage is particularly severe on young celery plants; that on parsnip (cf. mines caused by larvae of the moth *Epermenia chaerophyllella*, p. 208) tends to be less so.

BIOLOGY
Adults appear in late April and early May. Eggs are deposited in or on the underside of celery

leaves and other hosts during May; they hatch about a week later. The larvae then feed within the leaf tissue to form expansive blotches in which black frass and moisture accumulate. Unlike mines formed by larvae of *Epermenia chaerophyllella* (p. 208), there are no associated strands of silk. Several larvae often occur within the same blotch, and development takes from 2 to 3 weeks. Larvae then pupate within the blotch or in the soil, and adults emerge 3^1 weeks later. A second generation of adults occurs in late July and August. Second-brood larvae complete their development in the autumn and then overwinter within their puparia. Under favourable conditions, there may be three generations annually.

DESCRIPTION
Adult 5 mm long, light brown to black, with green eyes; *thorax* shiny; *legs* yellow; *wings* iridescent, distinctly mottled **(Fig. 251). Egg** 0.5 mm long, elongate-oval, white, smooth-shelled. **Larva** up to 7 mm long, shiny white, greenish-tinged; *posterior spiracles* relatively close-set and each with three elongate pores; *mouth-hooks* triangular and with numerous small teeth. **Puparium** 5 mm long, pale yellow, wrinkled, oval and slightly flattened.

***Rhagoletis cerasi* (L.)**
European cherry fruit fly

In continental Europe, this insect is a potentially important pest of cherry; a distinct race is associated with *Lonicera.* Larvae feed on the flesh of maturing fruits, and losses of cherries at harvest are sometimes of considerable significance. The pest does not occur in the British Isles, although the larvae are often found in imported cherries.

Fig. 251 Wing of celery fly, *Euleia heraclei* (x!2).

BIOLOGY
Adults occur from late May to early July and are particularly active in warm, sunny weather. Females deposit eggs singly in the developing fruits of cherry, the eggs hatching 1-2 weeks later. Larvae feed for about a month before vacating the fruit and dropping to the ground. Each then pupates in the soil and overwinters. There is just one generation annually.

DESCRIPTION
Adult 4-5 mm long; *head and thorax* black, marked with yellow; *abdomen* black; *wings* transparent, mottled with blue-black. **Larva** up to 6 mm long, whitish; *mouth-hooks* not stongly curved and with a small projection behind the apical tooth (cf. Mediterranean fruit fly, *Ceratitis capitata,* p. 179).

***Platyparea poeciloptera* (Schrank)**
Asparagus fly

This insect is an important pest in the main asparagus-growing areas of continental Europe. Heavy infestations weaken the crowns of plants and reduce crop yields. Larval damage in early summer causes asparagus heads to become dwarfed and distorted. Later in the season, infested shoots are girdled. This leads to the premature death of foliage and stems. Although formerly recorded in the British Isles as a minor pest, this insect is probably now extinct in these islands.

BIOLOGY
Eggs are laid in young asparagus shoots during May and June. Larvae burrow within the stems throughout the summer; when fully grown, they pupate in the stem at about soil level. In the autumn, infested stems frequently rot and break open, and the puparia often then fall out. Adults emerge from the puparia in the spring.

DESCRIPTION
Adult 6-7 mm long, greyish to blackish; *head* yellow; *eyes* red; *wings* mottled with brownish-black. **Larva** up to 10 mm long, white;

mouth-hooks with their main axis more or less in line with the rest of the mouthparts (cf. asparagus miner, *Ophiomyia simplex*, p. 191). **Puparium** 6-8mm long, light brown.

Family PSILIDAE

Psila rosae (F.)
Carrot fly

The carrot fly is a widespread and important pest of carrot, celeriac, celery, parsley and parsnip; several wild species of Umbelliferae (but not all) are also hosts. **Carrot:** roots of plants of all ages are affected. Seedlings are often killed; this causes noticeable gaps in crop rows and increases the likely severity of attacks on surviving plants later in the season. Infestations on young plants cause the foliage to turn reddish, wilt and die; superficial damage by larvae can cause root fanging and stunting of plants. On older plants, larvae mine the outer tissue of the tap root; the cortex then becomes riddled with brown or rusty-red tunnels (cf. damage caused by carrot miner, *Napomyza carotae*, p. 189); the extent of damage increases throughout the late summer and autumn, and will also continue in clamps throughout the winter. Mined roots are susceptible to canker and subsequent rotting. **Celery:** damage to fibrous roots causes the outer leaves to wilt; more seriously, mining in the base of leaf stalks, crown and main roots results in poor top growth and yellowing of the foliage. Early-season transplants are particularly liable to be attacked, and damage affects the size and overall quality of plants. **Parsley:** larvae mine the outer tissue of the tap root and also destroy the fibrous roots; this affects plant vigour and quality. **Parsnip:** the main roots of young plants are often severed, and the larvae also burrow within the petioles; on older plants, mining is restricted mainly to the region of the tap root in the top 15 cm of soil.

BIOLOGY

Adults of the first generation appear in May or June, and eggs are deposited singly or in small groups in the soil close to host plants. They hatch in about a week. The larvae then attack the fibrous roots and also graze on the surface of the tap root. Some second-instar larvae mine within the tap root but most internal feeding occurs during the third (= final) instar. When fully grown, the larvae return to the soil to pupate, and adults of the second generation emerge from late July or early August onwards. Second-generation larvae usually complete their development in the autumn, but many will continue to feed well into the winter before eventually pupating. Under favourable conditions a third or partial third generation of adults appears in the autumn; thus, adults may occur at any time from May to October or November. Depending on temperature, the precise timing of adult appearance and the duration of the immature stages vary considerably from site to site and from year to year.

DESCRIPTION

Adult 5-7 mm long, shiny black; *head* reddish-brown; *legs* yellowish **(Fig. 252);** *antennae* with the bulbous third segment half yellow and half black **(Fig. 253a)** (cf. *Psila nigricornis*, 182); *wings* 5.5 mm long, large and iridescent. **Egg** 1.0 x 0.4 mm, white, ribbed longitudinally. **Larva** up to 10 mm long, shiny creamish-white, slender-bodied **(Plate 7b);** *mouth-hooks* with their long axis more or less continuous with the rest of the mouthparts, and each with one

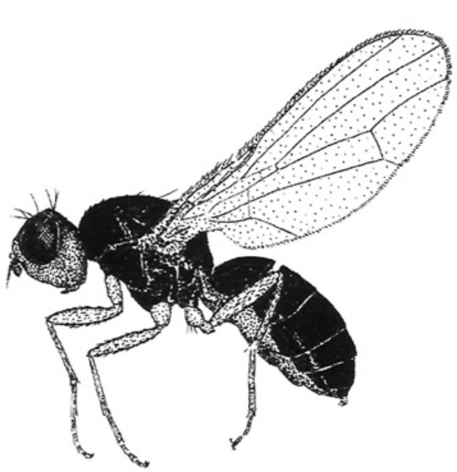
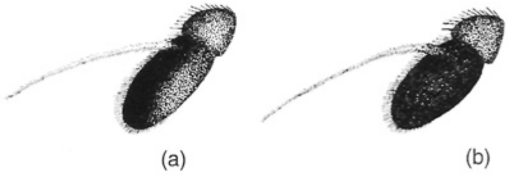


Fig. **252** Carrot fly, *Psila rosae* (x10).



(a) **(b)**

Fig. 253 Antennae of psilid flies: (a) *Psila rosae;* (b) *P. nigricornis.*

tooth; *posterior spiracles* distinctly pigmented and 3-pored (cf. *Napomyza carotae,* p. 189). **Puparium** 5-7 mm long; elongate, yellowish-brown.

Psila nigricornis **Meigen**
larva **= Chrysanthemum stool miner**

This insect is associated with chrysanthemum stools and was formerly an important pest. Nowadays, however, owing to changes in cultural techniques and better hygiene procedures, infestations are infrequent. Chrysanthemum cuttings and lettuces planted in infested chrysanthemum stool beds are also attacked. Adults are normally active in May and June. Eggs are then deposited in the soil close to chrysanthemum plants. The eggs hatch about 2 weeks later. The creamish-white, shiny larvae mine within the stools to form long, but superficial, galleries. Pupation takes place in the soil 1-2 months later, and a second generation of adults appears in the late summer or autumn. Second-generation larvae feed throughout the winter and, under glasshouse conditions, usually give rise to adults by March. Adult flies are bluish-black, with the head and legs brownish-yellow and the bulbous third antennal segment mainly black **(Fig. 253b)** (cf. *Psila rosae,* p. 181).

Family SPHAEROCERIDAE (lesser dung flies)

Pullimosina heteroneura **(Haliday)**

This common fly breeds in manure and may also occur in poor mushroom-house compost where bacterial decomposition is underway. Its presence in mushroom houses, therefore, is an indication of unsuitable growing conditions. Although the larvae are saprophytic and entirely harmless, the adult flies may inadvertently transfer harmful organisms to healthy mushroom beds. The small, black-bodied adults are often mistaken for scuttle flies (especially as they scurry over the compost surface in a phorid-like manner, see p. 177) but are readily distinguished by the presence of cross-veins in the wings, by other details of the wing venation and by their very short, swollen hind metatarsi.

Family OPOMYZIDAE

Geomyza tripunctata **Fallen**
Grass & cereal fly

This widely distributed fly is associated mainly with rye-grass and certain other grasses but will also attack wheat. The larvae feed within the central shoots that then turn yellow and die ('dead-heart' symptom). Infestations, however, do not reach economic levels.

BIOLOGY

Adults occur at any time from early March to November, but are usually most numerous in April and again from July to October. Eggs are deposited singly on the stems of host plants, usually at or just below soil level. After egg hatch, the larva bores into the base of a leaf and then burrows spirally downwards to enter the base of the central shoot, within which further development takes place. Larvae eventually pupate in the soil and adults emerge 17-30 days later. There are normally two generations annually. The winter is usually passed in the final (third) larval instar, such individuals then pupating in February or March.

DESCRIPTION

Adult 2.5-3.5 mm long, greyish-black. **Egg** 1mm long, spindle-shaped, shiny white, with numerous irregular longitudinal furrows and ridges. **Larva** up to 6.5 mm long; *body* plump, greyish-white and opaque **(Plate 7c);** *anterior spiracles* elongate, each with up to 16 lobes;

Fig. 254 Puparium of grass & cereal fly, *Geomyza tripunctata* (x1O).

posterior spiracles 3-pored and borne on short tubercles. **Puparium** 4 mm long, dark reddish-brown, elongate and obliquely truncated anteriorly **(Plate 7d);** *anterior spiracles* very prominent **(Fig. 254).**

***Meromyza saltatrix* (L.)**
Grass fly

Infestations of this minor pest occur on various grasses, especially fodder grasses. The larvae cause the central shoots of young plants to turn yellow and die. Infestations also occur on wheat, typically in crops following a grass ley. On older plants, the larvae cause damage to the developing inflorescences. As a result, the flower heads may not emerge properly from the enclosing leaf sheath; the larvae have also been implicated in the development of 'white' ears. Larvae are pale green to pale bluish-green and up to 10 mm long, with a minute pair of posterior spiracles. They are, therefore, readily distinguished from other ley pests such as gout fly, *Chloropspumilionis* (p. 194), yellow cereal fly, *Opomyza florum* (below) and frit fly, *Oscinella frit* (p. 195). Larvae that develop from eggs laid in summer feed within the shoots of host plants and eventually pupate in the spring. Although in the British Isles there is probably just one generation annually, in continental Europe this species (unlike other members of the genus) is bivoltine.

***Opomyza florum* (F.)**
Yellow cereal fly

This pest is associated with cereals and grasses, and is often common. The larvae feed singly within the centre shoots. Infested shoots turn yellow and die; this typical 'dead-heart' symptom appears in the early spring at about the same time as damage caused by the larvae of wheat bulb fly, *Delia coarctata* (p. 197). If an infested shoot is removed from the leaf sheath, a characteristic spiral mark may be seen running down towards the base **(Plate 7e).** Early-sown winter wheat (i.e. crops drilled before mid-October) are most at risk but the larvae do not move from tiller to tiller; at least in the British Isles, this pest rarely causes significant damage.

BIOLOGY
Adults are active from mid-June onwards. Oviposition, however, does not take place until the autumn, when eggs are laid on the soil close to host plants. The eggs do not begin to hatch until late January or early February. Host plants are then invaded, a single larva feeding within the centre shoot and destroying the growing point. Larvae are fully grown in 5-6 weeks, usually by the end of May, and pupation occurs within the damaged shoots. Adults emerge about 3 weeks later. There is just one generation each year.

DESCRIPTION
Adult 2-4 mm long, yellow; *wings* clear, spotted with black. **Egg** 0.6 mm long, shiny white, spindle-shaped, with several longitudinal ridges and furrows. **Larva** up to 8 mm long, elongate and creamish-white **(Plate** 7f); no posterior papillae (cf. wheat bulb fly, *Delia coarctata,* p. 197); *mandibles* each with two large and three small pointed projections; *anterior spiracles* prominent, rosette-like but relatively small, usually 10-lobed (cf. frit fly, *Oscinella frit,* p. 195); *posterior spiracles* 3-pored and separated by a more or less distinct U-shaped depression **(Fig. 255).** **Puparium** 4 mm long, yellowish-brown, abruptly tapered anteriorly.

Fig. 255 Tip of abdomen of larva of yellow cereal fly, *Opomyza florum:* (a) posterior spiracle (further enlarged).

Opomyza germinationis **(L.)**
Dusky-winged cereal fly

This generally abundant species is associated with grasses such as cocksfoot, meadow-grass and rye-grass; infestations on cereals are uncommon. The centre shoots of infested plants wither and die but the extent of damage is rarely of significance. Adults occur from mid-June to mid-November. Eggs are usually deposited on host plants towards the end of the season and typically hatch within a few weeks (cf. *Opomyza florum,* p. 183). The larvae feed slowly throughout the winter and finally pupate in the spring; adults appear in June. Larvae are slightly smaller, thinner and more pointed anteriorly than those of *O. florum;* also, the anterior spiracles are usually 8-lobed and the posterior spiracles separated by just a shallow depression.

Family EPHYDRIDAE (shore flies)

Hydrellia griseola **(Fallen)**
larva **= A cereal leaf miner**

Larvae of this species mine within the leaves of cereals and grasses. Infested leaves often turn yellow, commencing at the tip that then withers.

BIOLOGY
Adults of the first generation appear in the spring. Eggs are then laid near the base of leaves and hatch within a few hours. The larvae feed singly within the leaves. At first the larva mines towards the ligule and, later, towards the leaf tip. Pupation occurs within the larval gallery. Adults of a summer generation appear in August and September. Their larvae feed throughout the autumn and winter. They pupate in April and early May, and adults emerge shortly afterwards.

DESCRIPTION
Adult 2.0-2.5 mm long and dull grey; *antennae* black, the arista bearing five or six bristles; *palps* club-like, yellow; *wings* large, hyaline and distinctly oval. **Larva** up to 6 mm long, whitish and elongate; *anterior spiracles* absent; *posterior spiracles* borne on short, pointed, posteriorly directed processes; *mouth-hooks* with just one tooth.

Hydrellia nasturtii **Collin**
larva **= Watercress stem miner**

Larvae of this species mine within the main stems of watercress plants but usually do not enter the pith or attack the growing points. The effect on plant growth, therefore, is of little or no significance. Larvae (up to 5 mm long) are whitish and elongate, with distinct ventral swellings intersegmentally, and with numerous short black spines on the posterior segments; the body terminates in a pair of short, distinctly pointed, posteriorly directed respiratory processes. The larvae feed throughout the winter and complete their development in the spring. Pupation occurs in the larval mine, and adults emerge in the spring.

Scatella stagnalis **(Fallen);**
S. *tenuicosta* **Collin**
Glasshouse wing-spot flies

These small, black-bodied flies are often numerous in glasshouses and other protected sites and sometimes reach pest status. The larvae feed on algae growing on potting composts and rockwool growing-media, and on algae developing in nutrient-film troughs. Development from egg to adult takes approximately 2 weeks at normal glasshouse temperatures. Although not directly damaging to crop plants, the larvae may act as vectors of fungal diseases. The adult flies may

Fig. 256 A glasshouse wing-spot fly, *Scatella* sp. (x15).

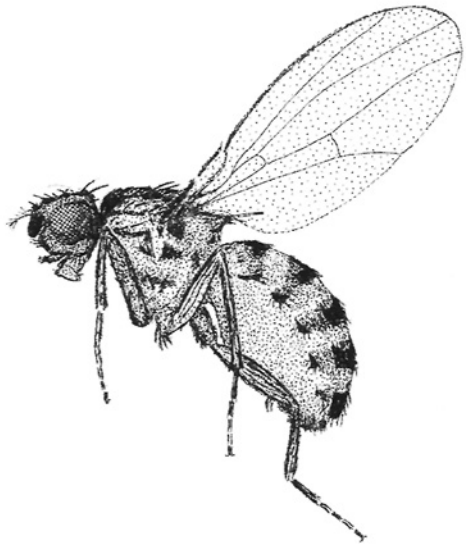


Fig. 257 A small fruit fly, *Drosophila* sp. (x15).

also cause concern and can be a nuisance, particularly when they contaminate pre-packed, plastic-wrapped food crops such as lettuce; the flies also soil glasshouse plants with specks of faecal material. Adults of *Scatella* are often mistaken for scuttle flies (see p. 177) or sciarid flies (see p. 167), but they are readily distinguishable by the twice-broken costal veins and by the slightly dusky wings which have several small, clear patches visible in the membrane **(Fig. 256).** Larvae of *Scatella* are dirty yellowish to dirty greenish, with a pair of conspicuous, dark-tipped posterior respiratory tubules (see Fig. 103).

Family DROSOPHILIDAE (small fruit flies)

Drosophila melanogaster Meigen
A small fruit fly

This generally abundant fly (best known for its universal use in cytological, genetical and other laboratory studies) is sometimes a minor problem in soft-fruit plantations, orchards and vineyards. Most frequently, the flies are merely of nuisance value, as they are often attracted in vast numbers to overripe, fermenting fruit and fruit juices, both indoors and outside. In vineyards, the larvae sometimes feed on damaged grapes and may also invade adjacent sound fruit, removing the flesh to leave only the skins; larvae may also act as disease vectors. Adults are c. 3 mm long and mainly yellowish or yellowish-brown, with bright red eyes; the abdomen is marked dorsally with dark brown cross-bands **(Fig. 257).** Larvae are up to 4.5 mm long and whitish, with laterally protruding anterior spiracles, tube-like posterior spiracles and distinct black mouth-hooks. Breeding takes place in various kinds of rotting vegetable matter. There are several generations annually and development from egg to adult takes about 3 weeks.

Scaptomyza flava (Fallen)

Whitish, usually blotch-like, leaf mines formed by larvae of this often abundant species occur on various members of the Brassicaceae, including oilseed rape and vegetable crops such as broccoli, Brussels sprout, cauliflower and radish. In severe cases, infested leaves are killed but any effect on plant growth is usually of little or no significance.

BIOLOGY

Adults occur from April onwards and there are several overlapping generations each year. The larvae feed within the lamina of expanded leaves to form blotch mines or irregular, often branched galleries, which frequently follow the major veins **(Plate 8a).** The frass deposited by this species is frequently placed within side galleries; this keeps the main feeding area frass-free. Fully fed larvae pupate externally within the mine **(Plate 8b)** or on the ground and adults emerge shortly afterwards.

DESCRIPTION
Adult 2.5-3.0mm long, pale yellow, with grey markings and bright red eyes. **Larva** up to 4mm long, white, translucent and elongate; *anterior spiracles* prominent; *posterior spiracles* borne on short but prominent, pointed processes (cf. cabbage leaf miner, *Phytomyza rufipes,* p. 192). **Puparium** 3.0-3.5 mm long, elongate, reddish-brown; *anterior spiracles* horn-like **(Fig. 258).**

NOTE In continental Europe, infestations on crops are more frequently attributed to *Scaptomyza pallida* (Zetterstedt).

Family AGROMYZIDAE

Agromyza megalopsis **Hering**

In parts of continental Europe (e.g. southern and western Germany), this species is a potentially serious pest of barley; extensive damage to spring crops has occurred and yield reductions have been reported. The yellowish-brown mines can occupy much, if not all, of the leaf tissue; this leads to extensive discoloration and death of foliage. This pest does not occur in the British Isles.

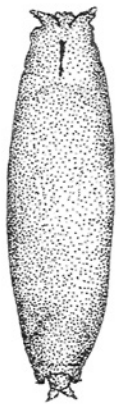


Fig. 258 Puparium of *Scaptomyza flava* (x15).

BIOLOGY
Adults occur mainly in May. Eggs are then deposited in the leaves of host plants, often up to 40 within each infested leaf. At first, larvae form narrow galleries, directed towards the leaf apex; they then turn downwards and continue feeding towards the base, the mines uniting so that the larvae eventually feed gregariously. Occupied mines occur mainly in June and July but there may be a partial second generation in the autumn. Pupation usually occurs on the ground but puparia are sometimes found within the mines.

DESCRIPTION
Adult 2 mm long, mainly black; *wings* hyaline, 2.5-2.7 mm long. **Larva** up to 3 mm long, whitish-yellow; *cephalopharyngeal skeleton* with dorsal elements (dorsal cornu) (see Fig. 107) divided into two; *posteror spiracles* 3-pored and abutting. **Puparium** brown.

Agromyza nigrella Rondani

This insect is a potentially important pest of winter wheat; attacks also occur on barley, oats, rye and various grasses. Heavy infestations have occurred on winter wheat in southeastern England and in Scotland, where consequent yield reductions have been reported. Mined leaves are conspicuously blanched and frequently shrivel and die: infestations on cereal flag leaves are common and of particular significance.

BIOLOGY
Adults occur in June, and eggs are then deposited in the leaves of various members of the Poaceae. Larvae feed in June and July. Each forms an extensive mine up to 20 cm long. At first the larva excavates a narrow gallery, directed towards the leaf tip. Later, it mines towards the leaf base; the gallery then develops into a broad blotch. Fully fed larvae pupate externally on the

ground. At least in some areas, there may be a second generation in the autumn.

DESCRIPTION
Adult mainly brownish to black, with pale squamae; *wings* 2.5-3.1 mm long. **Larva** up to 3 mm long, whitish-yellow; *cephalopharyngeal skeleton* with dorsal elements (dorsal cornu) (see Fig. 107) divided into two; *posterior spiracles* 3-pored and located on relatively large, widely spaced processes.

Agromyza nigrociliata Hendel

This widely distributed but minor pest of cereals and grasses has, on occasions, reached pest status on rye and wheat. The larval mines appear from early June onwards. They resemble those of *Agromyza nigrella* (above) but are usually broader and typically contain several larvae. Mined leaves become discoloured; heavy infestations of flag leaves on cereals are of most significance. Adults (wings 2.9-3.5 mm long) are mainly black with dark squamae. Larvae are whitish-yellow and the puparia dark reddish-brown.

Agromyza potentillae (Kaltenbach)
larva = Strawberry leaf miner

Minor infestations of this common and widely distributed leaf miner often occur on cultivated raspberry, strawberry and other Rosaceae, including ornamentals such as cinquefoil. The leaf mines commence as linear galleries. Each then develops into an irregular, pale blotch, visible from above. The mines are relatively small and there are often several in each infested leaf or leaflet. Although usually unimportant, heavy infestations on young strawberry plants can have a detrimental effect on growth. Adults occur in May or June and again in August; the larvae feed from June to July and from September to October. Pupation occurs amongst rubbish on the ground. Adults (c. 2 mm long) are black to greyish-black. The larvae are whitish and up to 3 mm long, with c. 9-pored anterior spiracles and 3-pored posterior spiracles.

Cerodontha incisa (Meigen)

This generally common leaf miner is a minor pest of cereals and grasses. The larvae form relatively large, whitish to yellowish galleries which extend back from the tips of expanded leaves and eventually turn brown **(Plate 8c).** Infestations are often noted on maize or sweet corn but tend to occur on mature plants and are not important.

BIOLOGY
Adults occur from spring onwards, and there are two or more generations each year. Larvae feed gregariously and pupate within the communal mine, each puparium attached to the leaf tissue by a few strands of silk.

DESCRIPTION
Adult mainly black; *wings* 2.3-2.8mm long. **Larva** up to 4 mm long, whitish; *mouth-hooks* with several small teeth; *posterior spiracles* borne on a prominent cylindrical projection, and each with three pores. **Puparium** 2 mm long, metallic-black; *posterior spiracles* located on a characteristic projection **(Fig. 259).**

Liriomyza bryoniae (Kaltenbach)
larva = Tomato leaf miner

This leaf miner is a locally important pest of glasshouse-grown tomato. Attacks also occur on

Fig. 259 Puparium of *Cerodontha incisa* (x20).

various other protected crops, including cucumber, lettuce and certain ornamentals. Infestations on seedlings and young plants check growth and will weaken or kill them; mines in the cotyledons are particularly damaging. Larvae within cotyledons may also burrow into the growing points or terminal shoots and frequently cause the death of plants. Attacks on established plants are less significant, although hosts may be weakened if outbreaks are severe. Adult feeding punctures on leaves (see below) are disfiguring. In Europe, this pest occurs mainly in the Channel Islands, Denmark, southern England, France, Germany and the Netherlands.

BIOLOGY
At first, adult females feed on exudates from the foliage, having first formed prominent punctures in the leaf surface with their ovipositors. Later, eggs are deposited in the upper surface of the leaves. These hatch in 4-8 days. Larvae then burrow beneath the upper epidermis to form long, irregular, whitish mines. Each mine contains a narrow trail of frass that may change from one side of the gallery to the other. The larvae are fully fed in approximately 7-12 days; they then vacate their mines, usually cutting their way out through the upper epidermis, and fall to the ground. They then enter the soil to pupate. Adults appear 2-3 weeks later, although emergence will be greatly delayed by cool conditions. There are normally three or four generations annually; puparia overwinter in the soil.

DESCRIPTION
Adult mainly pale yellow; *head, thorax and abdomen* partly shiny black dorsally; *scutellum* bright yellow; *antennae* mainly yellow; *legs* blackish with yellow femora; *wings* 1.8-2.1 mm long, the costal vein extending to vein M_{1+2} (see **Fig. 260a).** **Egg** 0.25 x 0.15 mm, white. **Larva** up to 3 mm long, yellowish-white; *mouth-hooks* with several prominent teeth; *posterior spiracles* mushroom-like, each with an arc of 7-12 pores. **Puparium** 2mm long, brownish-yellow.

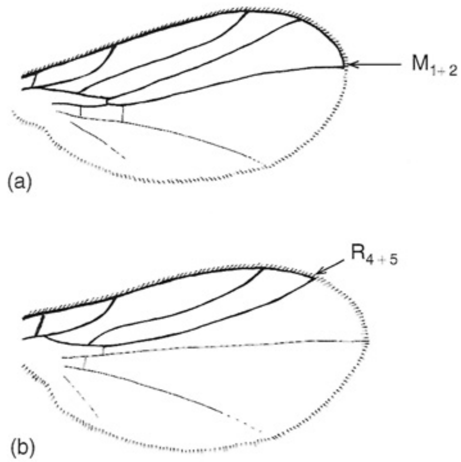


Fig. 260 Wing venation: (a) *Liriomyza;* (b) *Phytomyza.*

Liriomyza congesta **(Becker)**
larva **- A pea leaf miner**

Mines of this widely distributed and polyphagous species are often found on the upper side of leaves of labiate crops such as pea and *Vicia* bean (cf. *Liriomyzapisivora,* p. 189). Adults are relatively small (wings 1.3-1.7 mm long) and mainly greyish-black to yellow. They appear in the spring and eventually deposit eggs in the leaves, usually no more than one per leaf. The larval mines are linear and narrow, with the black frass dispersed along either side of a green central band. Each mine terminates in an expanded blotch, and fully fed larvae eventually pupate on the ground. There are two or more generations annually. The mines cause little or no distortion of the leaves and are usually insufficiently numerous to have any adverse effect on the growth of host plants. Larvae are whitish and up to 3 mm long; they are distinguished from those of *L. pisivora* (p. 189) by the 3-pored posterior spiracles.

Liriomyza huidobrensis **(Blanchard)**
larva = **South American leaf miner**

Infestations of this polyphagous leaf miner have occurred recently in various European countries, including England and the Netherlands, the pest having been introduced into glasshouses from abroad, usually on chrysanthemum plants. In parts of southern Europe, this pest is also now established on outdoor plants. The characteristic leaf mines arise from close to the mid-rib or major veins; each then progresses as a tortuous gallery that often turns tightly back upon itself, and thus appears broad and blotch-like. Pupation occurs in the mine or in the soil, in a yellowish-brown or reddish-brown puparium. There are several generations annually. Feeding punctures formed in leaves by adult females are often very numerous. Larvae are up to 3.3 mm long; each posterior spiracle bears an arc of six to nine small pores (cf. *Liriomyza trifolii,* below).

Liriomyza orbona **(Meigen)**

This widely distributed species is associated with *Bellis perennis* (Asteraceae) but also breeds on certain members of the Poaceae, including winter barley. The larvae form rather broad, whitish leaf mines. Adults (wings 1.7-2.6 mm long) are black, with the scutellum, halteres and knees yellow. They occur in May and June; the yellow-coloured larvae feed in June and July.

Liriomyza pisivora **Hering**
larva **= A pea leaf miner**

This species is very similar to *Liriomyza congesta* (p. 188) but adults are darker, the yellow coloration on the abdomen being far less extensive. Infestations also occur on the leaves of pea and *Vicia* bean but the mines are usually restricted to the lower surface, with the frass deposited in greenish-black bands. Also, the feeding galleries are relatively superficial and of little or no significance. Unlike *L. congesta,* with which this species was once confused, the posterior spiracles of the larvae are each 7-8-pored. Mines of *Phytomyza horticola* (p. 193) may also occur on the lower surface of pea leaves but they are lighter in colour and much broader.

Liriomyza strigata **(Meigen)**

Larvae of this very polyphagous species often mine the leaves of beet, lettuce and pea, usually on relatively mature plants; attacks also occur on various ornamentals. The mines often follow the major veins of the leaves and are usually much branched, with short lateral galleries extending into the lamina; mines are rarely numerous and damage caused is of little or no importance. The posterior spiracles of the larvae each have 10-12 pores.

Liriomyza trifolii **(Burgess)**
larva **- American serpentine leaf miner**

This mainly North American species is frequently introduced into Europe, especially on chrysanthemum cuttings; infestations may then develop on glasshouse-grown crops such as celery, cucumber, lettuce, tomato and various ornamentals. Growth of heavily infested plants is checked, affecting both crop yields and quality; host plants are also disfigured by adult feeding and egg-laying punctures. Larval mines are long, contorted and whitish, and each contains an irregular line of dark frass. Pupation occurs in the soil (cf. chrysanthemum leaf miner, *Phytomyza syngenesiae,* p. 192). Infestations build up rapidly and the pest breeds continuously whilst conditions remain favourable. During the summer, infestations may spread to outdoor plants, including *Vicia* bean and weeds such as *Senecio jacobaea* and *Solanum dulcamara.* Adults (wings 1.2-1.5 mm long) are greyish-black with a mainly yellow head and bright yellow scutellum and antennae. Larvae are 2 mm long, yellow to orange-yellow, and the posterior spiracles each 3-pored (cf. *Liriomyza huidobrensis,* p. 188; cf. *Phytomyza* spp., p. 191 *et seq.).*

Napomyza carotae **Spencer**
larva **- Carrot miner**

This species is a minor pest of carrot, the larvae feeding in the leaves and the roots. Leaf mines are of little or no consequence. However, mined tap roots may become malformed; attacks are of greatest importance on early crops. Although larval damage tends to be restricted to the uppermost part of the root and is relatively superficial, the overlying tissue eventually collapses to produce obvious, irregular scars which open out as the root grows (cf. carrot fly, *Psila rosae*, p. 181). Such damage tends to predispose the roots to invasion by pathogens, especially in wet conditions, and is a particular problem on crops in store. Although well established in parts of continental Europe, including Germany, the Netherlands and Switzerland, in the British Isles, where it was first reported (in East Anglia) in 1974, it is rare and not of pest status.

BIOLOGY
Eggs are laid in the leaves or stems of carrot plants. The adult females also make pale, rounded feeding punctures in the foliage, each *c.* 0.5 mm in diameter. After eggs have hatched, the larvae mine downwards within the mid-rib, petiole and stem; except in mature plants, the larvae also invade the roots. Pupation takes place within the mine. Adults occur from May to June, and from August to September; in some situations, there may be a partial third generation in October. The winter is passed in the pupal stage.

DESCRIPTION
Adult mainly grey or black; *wings* 2.7-3.1 mm long, the genus differing from *Phytomyza* (q.v.) by the addition of another cross-vein; *legs* black with yellow knees. **Larva** up to 6 mm long, white; *mouth-hooks* with main axis set more or less at right-angles to rest of mouthparts, and each with several small teeth; *posterior spiracles* borne on distinct projections and each with a double row of about 20 minute pores (cf. carrot fly, *Psila rosae*, p. 181). **Puparium** 4.5-5.5 mm long, white, slender; *posterior spiracles* brownish-black, each borne on a short projection.

Napomyza cichorii **Spencer**

This species is restricted to parts of continental Europe, including Belgium, France, Italy and the Netherlands, where it is a locally important pest of chicory and endive. Larval mines in leaves and blanched chicory heads cause similar damage to those formed by the black chicory fly, *Ophiomyia pinguis* (below). In addition, mines in the roots, and within the blanched heads, lead to distortion, stunting and weakening of host plants. Heavy infestations result in considerable crop losses.

BIOLOGY
Adults of the first generation occur in May and June. Eggs are laid in the mid-rib of chicory or endive. The larvae form mines which extend deeply into the plant tissue, including the roots. At summer temperatures, development is relatively rapid, and pupation takes place within about a month. A second generation of adults appears in August, and these produce the generation of larvae that invade winter-forced crops. Although normally bivoltine, there may be a partial third generation if conditions are favourable.

DESCRIPTION
Adult greyish to blackish, with parts of the thorax yellow; *legs* black with yellow knees; *wings* 2.7-3.5 mm long. **Larva** 5 mm long, whitish; *posterior spiracles* each with a double row of minute pores; *mouth-hooks* with main axis set more or less at right-angles to rest of mouthparts; *posterior spiracles* each with a double row of about 22 minute pores (cf. black chicory fly, *Ophiomyia pinguis*, below). **Puparium** 4-5 mm long, slender, whitish; *posterior spiracles* blackish-brown.

Ophiomyia pinguis **(Fallen)**
Black chicory fly

This insect is an important pest of chicory in continental Europe, and is particularly numerous in the chicory-growing regions of Belgium, France, the Netherlands and Switzerland; although not an established pest, it is introduced occasionally into the British Isles. The larval mines, which are often reddish tinged, spoil the appearance of harvested white chicory heads and, if infestations are heavy, the crop may be unmarketable. Attacks also occur on endive and lettuce.

BIOLOGY
Adults appear in the spring and eggs are then deposited in the upper surface of leaves of host plants, usually close to the mid-rib. Each larva burrows within the leaf tissue and eventually pupates at the end of the mine; feeding may also extend into the stems but never into the roots. In northern Europe, there is normally just one generation annually and larvae complete their feeding and pupate in the spring. In warmer regions and in forcing sheds, however, feeding is completed more rapidly and there may be several generations annually. When chicory plants are lifted in the autumn and cut for forcing, larvae in the bases of the plants transfer to the developing blanched heads, where they will continue to feed throughout the winter.

DESCRIPTION
Adult 2.5-3.0mm long, black, stout-bodied; *abdomen* distinctly shiny; *antennae* separated by a prominent facial keel; *wings* 1.9-2.3 mm long. **Larva** up to 6 mm long, whitish-yellow; *posterior spiracles* each borne on a distinct stalk and with about 10 large pores; *cephalopharyngeal skeleton* with dorsal elements (dorsal cornu) (see Fig. 107) divided into two; *mouth-hooks* each with a single prominent tooth (cf. *Napomyza cichorii*, p. 190). **Puparium** 3.5mm long, pale yellow; *posterior spiracles* each borne on a stalk.

Ophiomyia simplex (Loew)
larva = Asparagus miner

This fly is well established in the main asparagus-growing areas of continental Europe, where it is sometimes considered an important pest; however, observations in America and elsewhere suggest that this pest actually has little or no detrimental effect on crop yields. Larval feeding causes the outer tissue of stems to split; also, infested plants often turn yellow and wilt. Larval-damaged tissue may be invaded by pathogenic organisms, so that affected stems rot and eventually break off.

BIOLOGY
Adults appear from early June to mid-July, with a partial second generation emerging in the late summer. Eggs are laid in the base of the stems of host plants. After egg hatch, the larvae mine just below the epidermis. At first, they bore upwards for several centimetres; later, they burrow downwards, each forming an irregular feeding gallery. The mines, usually several in each infested plant, often extend below soil level. Pupation occurs in the mine, immediately below the epidermis.

DESCRIPTION
Adult shiny black; *wings* 2.2-3.0mm long. **Larva** up to 5 mm long, creamish-white; *cephalopharyngeal skeleton* with dorsal elements (dorsal cornu) (see Fig. 107) divided into two; *mouth-hooks* with long axis set more or less obliquely to rest of mouthparts (cf. asparagus fly, *Platyparea poeciloptera*, p. 190); *posterior spiracles* each with about 16 pores and borne on broad, raised processes. **Puparium** 4 mm long, brown, somewhat flattened; *posterior spiracles* borne on broad, raised processes.

Phytomyza nigra Meigen

This widespread and generally common leaf miner is a minor pest of barley, oats, rye and wheat; it is also associated with various grasses. Damage is usually insignificant and restricted to the loss of photosynthetic tissue.

BIOLOGY
Larvae feed within the leaves of various cereals and grasses to form long, narrow, whitish mines. Pupation occurs in the mine, with the anterior spiracles of the puparium protruding through the upper epidermis. There are several generations annually, and larvae occur from early spring to late autumn.

DESCRIPTION
Adult mainly greyish to black; *legs* black with yellow knees; *squamae* yellowish-grey; *wings* 2.3-2.6 mm long, the costal vein extending to vein R_{4+5} (see **Fig. 260b). Larva** whitish-yellow; *anterior spiracles* each with up to 18 pores and borne on a relatively long, outwardly curved stalk (cf. *Phytomyza fuscula*, p. 193); *posterior spiracles* each with 10-13 pores and borne on a

short stalk. **Puparium** yellowish-brown; *anterior spiracles* borne on a pair of prominent, diverging stalks.

Phytomyza rufipes Meigen
larva = Cabbage leaf miner

This generally abundant species is a minor pest of brassica crops, including broccoli, cauliflower, mustard and oilseed rape. Attacked seedlings may become malformed, especially if the larval mines extend into the stems, but damage caused to established plants is usually of little or no significance. Infestations on autumn-sprouting broccoli (= calabrese) can be troublesome, and the presence of larvae in crops sent for processing sometimes leads to the rejection of consignments. In the autumn, the pest is sometimes abundant on oilseed rape, but the larvae tend to occur in the senescing outer leaves and damage caused is unimportant.

BIOLOGY
Adults occur from May or June to September. Eggs are laid in leaves of suitable hosts, each placed close to a major vein. Larvae commence feeding by burrowing into nearby veins that they then follow into the mid-rib. Most feeding occurs within the mid-rib or petiole with, often, several larvae attacking the same leaf. Larvae in young plants may also enter the stem. Pupation usually occurs in the soil and adults appear approximately 6-8 weeks after eggs were laid. There are two generations annually and, under favourable conditions, a partial third.

DESCRIPTION
Adult mainly grey with sides of thorax yellow; *wings* 2.5-3.5 mm long. **Larva** up to 6 mm long, shiny white and maggot-like **(Plate 8d);** *mouth-hooks* set more or less at right-angles to rest of mouthparts; *anterior spiracles* short but prominent and many-lobed; *posterior spiracles* with up to 30 minute pores and directed more or less downwards (cf. *Scaptomyza flava*, p. 185). **Puparium** 3 mm long, pale brownish-yellow.

Phytomyza syngenesiae (Hardy)
larva = A chrysanthemum leaf miner

Infestations of this leaf miner (widely known in older literature as '*Phytomyza atricornis*'\ see also under *P. horticola*, p. 193) are often established on various members of the Asteraceae, especially glasshouse crops such as chrysanthemum; severe infestations are also reported on lettuce. The whitish to brownish larval mines are disfiguring and, if several occur on the same leaf, infested leaves may wilt, turn brown and die. Adult leaf-feeding punctures, which sometimes develop from small, whitish spots to brownish warts, are also disfiguring. Although usually regarded as a pest, the insect has been tested in New Zealand as a potential biological control agent for use against the weed *Senecio jacobaea.*

BIOLOGY
Adult females deposit eggs singly through punctures made in the upper surface of leaves. The eggs hatch a few days later. The larvae then mine within the leaves to form long, winding, narrow, wavy-edged (cf. American serpentine leaf miner, *Liriomyza trifolii*, p. 189) galleries, clearly visible from above. Black pellets of frass are deposited irregularly to one side along the length of the mine. Larvae as usually fully fed after 7-10 days. Each then burrows to the lower surface of **the** leaf to pupate in a small chamber, with the anterior spiracles of the puparium protruding through the lower epidermis (cf. *Phytomyza horticola*, p. 193, and *Liriomyza trifolii*, **p.** 189). Adult flies emerge one or more weeks later. The duration of the various stages depends on temperature, and breeding in glasshouses is continuous if conditions remain favourable, e.g. where all-year-round (AYR) chrysanthemums are grown. On outdoor hosts, there are usually two generations annually.

DESCRIPTION
Adult greyish-black, faintly marked with pale yellow on the head and sides; *legs* mainly black, with pale yellow knees; *wings* 2.2-2.6 mm long. **Larva** up to 3.5 mm long, greenish-white; *mouth-hooks* set more or less at right-angles to

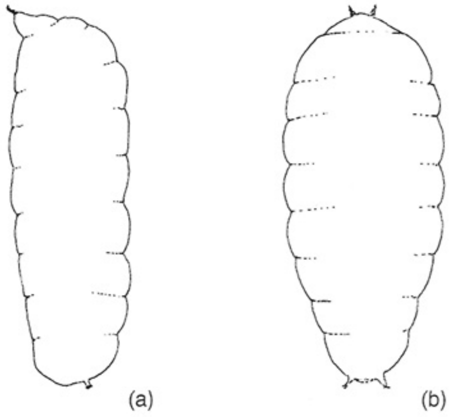


Fig. 261 Puparium of *Phytomyza syngenesiae:* (a) lateral view; (b) dorsal view (x15).

Fig. 262 Adult of *Phytomyza hordeola* (x20).

rest of mouthparts, and each with two prominent teeth; *posterior spiracles* each with 8-10 pores (cf. American serpentine leaf miner, *Liriomyza trifolii*, p. 189). **Puparium** 3 mm long, yellowish-brown to dark brown, slightly flattened **(Fig. 261).**

Phytomyza fuscula Zetterstedt

This species is essentially similar to *Phytomyza nigra* (p. 191) but is absent from the British Isles. In continental Europe, it is a minor pest of cereals, especially in more northerly areas; in Germany, important attacks on false oat are reported. *Phytomza fuscula* is best distinguished from *P. nigra* by examining the anterior spiracles of larvae or puparia, those of *P. fuscula* (each with eight pores) being borne on a pair of short, broad stalks arranged in the form of a prominent V.

Phytomyza hordeola Goureau
larva = A chrysanthemum leaf miner

Adults of this widely distributed and generally common leaf miner **(Fig. 262)** are similar in appearance to those of *Phytomyza syngenesiae* (p. 192) and, mistakenly, both species have been referred to in older literature as *'P. atricornis* The larvae are very polyphagous and form whitish mines in the leaves of various weeds and ornamental plants, and in certain field crops such as flax, linseed and pea **(Plate 8e);** mines may occur on either the upper or the lower side of leaves. In common with *P. syngenesiae*, pupation takes place at the end of the larval mine, but the puparium is formed immediately below the epidermis on the same side of the leaf as the rest of the mine. Larvae of this species are similar in appearance to those of *P. syngenesiae.*

Phytomyza ramosa Hendel
Teasel fly[9]

This widespread, relatively large species is associated with *Dipsacus* and, less frequently, other members of the Dipsacaceae. The white larva forms an elongate mine confined mainly to the mid-rib of a leaf, but (at least on small leaves) with short lateral galleries extending into the leaf lamina; mines may also extend into the main stem. Pupation occurs within the main gallery in a whitish puparium (3.5 mm long). Adults are mainly black (wing length: 2.2-3.2mm). Al-

[9] The name "teasel fly' is most frequently applied by commercial teasel growers to the pest *Endothenia gentianaeana*, a small moth (family Tortricidae) whose larvae damage the seed heads of teasel and cause them to disintegrate (see p. 220).

though attacks occur on cultivated teasel plants, grown commercially to produce seed heads suitable for teasing fine cloth (such as that used as billiard-table baize), they are not of significance and generally pass unnoticed.

***Phytomyza spondylii* Robineau-Desvoidy**

This common species is associated with various umbelliferous plants, including cultivated parsnip. The larvae are yellowish and form linear leaf mines. They pupate on the ground after escaping through a slit made in the lower surface of the leaf. Adults (wing length: 2.1-2.4mm) are blackish, with the sides of the thorax pale; the legs are black with just the knees of the forelegs yellow.

***Pseudonapomyza atra* (Meigen)**
***larva* = A cereal leaf miner**

This widely distributed but local leaf miner is a minor pest of barley; it is also associated with oats, wheat and various grasses. The tips of infested leaves become discoloured by the relatively narrow, pale yellow leaf mines. Damage sometimes attracts attention, but infestations are rarely, if ever, of economic significance.

BIOLOGY
Adults appear in May, and those of a partial second generation emerge in the summer. From one to five eggs are deposited about 10 cm from the tip of a leaf, each separately within the tissue between two of the leaf veins. On hatching, each larva forms a narrow but gradually widening gallery, directed towards the leaf tip; the mine eventually turns abruptly towards the leaf base to form an elongated, linear blotch within which larval development is completed. Fully fed first-generation larvae emerge in June and pupate in the soil.

DESCRIPTION
Adult minute (c. 2 mm long) and mainly black; *wings* 1.3-1.7mm long. **Larva** up to 4mm long, whitish-yellow and plump, with segmentally arranged rows of minute papillae; *anterior spiracles* prominent, each with about 11 lobes and borne on a relatively long stalk; *posterior spiracles* 7-pored, each borne on a short stalk. **Puparium** reddish-brown, with distinct horn-like anterior and posterior respiratory processes.

Family CHLOROPIDAE

***Cetema elongata* (Meigen)**

This species is associated with wild and cultivated grasses, including *Elytrigia repens* and *Poa annua.* The central shoots of attacked plants turn yellow but damage caused is of little or no economic importance.

BIOLOGY
Adults appear over an extended period in May and June. Eggs are then deposited singly on the leaves of host plants. Larvae feed singly within the central shoots from June or July onwards. Development is slow, and individuals do not pupate until the following spring, shortly before the appearance of the adults.

DESCRIPTION
Adult 3.0-3.5 mm long, mainly black to brownish-black and distinctly shiny; *face and scutellum* yellow; *legs* mainly pale, with the anterior tarsi and extreme tips of the hind tarsi black. **Larva** up to 6 mm long; *body* elongated, white with a greenish tinge; *antennae* prominent; *anterior spiracles* with five or six lobes; *posterior spiracles* borne on broad, distinctly separated tubercles.

***Chlorops pumilionis* (Bjerkander)**
Gout fly

Although locally common, this pest is not of major significance. Barley, rye, wheat and cultivated grasses such as meadow foxtail and timothy are attacked but infestations do not occur on oats; wild grasses, including *Elytrigia repens,* are also hosts. Larvae of the overwintering generation cause a characteristic swelling of the basal parts of infested shoots and tillers (the so-called 'gouty' symptom). Although sometimes locally extensive on barley and wheat crops sown before mid-October, effects on overall yield are insignificant. Larvae of the summer generation cause most damage to late-sown spring cereals; affected plants remain stunted and gouty. Where eggs are laid on more advanced plants, the ear may fail to emerge from its sheath; in such situations grain yields are reduced. In the British Isles, this pest is most abundant in southern and southwestern England.

BIOLOGY
Adults of the first generation occur in May and June. Eggs are then deposited singly on the upper surface of cereal leaves, usually no more than one per plant. The eggs hatch in approximately 10 days. The larvae bore into the centre of the main shoot to feed, and individuals become fully grown in about a month. Each then pupates *in situ,* and the adult fly emerges from the puparium a month or so later. Adults of the autumn generation occur from late July to early October. Their eggs are deposited on early-sown winter cereals, cereal volunteers and grasses, but usually not until September at the earliest. Larvae of the autumn generation feed slowly throughout the winter months and usually complete their development in March or April.

DESCRIPTION
Adult 4-5 mm long, mainly yellow, marked with dark brown dorsally; *thorax* with three dark, broad, longitudinal bars; *scutellum* bright yellow **(Plate 8f).** **Egg** 1 mm long, elongate-oval, white **(Fig. 263);** *chorion* with a distinctive hexagonal sculpturing. **Larva** up to 8 mm long, translucent, hyaline-whitish to creamish-white, broadly sausage-shaped **(Plate 9a);** *sternal spatula* black, clearly visible; *posterior spiracles* inconspicuous. **Puparium** 5-7 mm long, yellowish-brown, elongate, flattened **(Plate 9b);** *posterior spiracles* inconspicuous **(Fig. 264).**

Oscinella frit (L.)
Frit fly

Frit fly is a major pest of oats but will also cause significant damage to barley, maize (including sweet corn), rye, wheat and various cultivated grasses, especially Italian and perennial rye-grass. Damage in the British Isles is most significant on grassland and oats, although economically important attacks on sweet corn are also frequent. Infestations are usually most severe on lowland pastures and on crops direct-drilled into grass swards or on crops following a grass ley, as the larvae transfer readily from the old sward or the ploughed grass to recently germinated crops. **First-generation (spring) and third-generation (autumn/winter) larvae:** these attack young plants to feed on the growing points of the central shoots, which then wither and die ('dead-heart' symptom); each larva is capable of attacking several shoots and damage is particularly severe if crops have not begun to tiller. The most important damage to cereals occurs in plants up to the fourth-leaf stage, with 'dead-heart' symptoms on winter wheat evident from

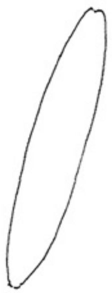


Fig. 263 Egg of gout fly, *Chlorops pumilionis* (x40).

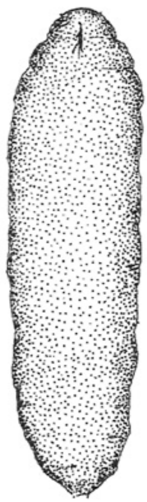


Fig. 264 Puparium of gout fly, *Chlorops pumilionis* (xfO).

November to mid-February - earlier than damage caused by wheat bulb fly, *Delia coarctata* (p. 197) and yellow cereal fly, *Opomyza florum* (p. 183). On maize and sweet corn, young plants usually survive attacks but emerging leaves or shoots are twisted and ragged, and cobs will be of poor quality. **Second-generation (summer) larvae:** these occur mainly on the ears of oats and cause the developing grains to become shrivelled ('fritted grain'); attacks launched before ear emergence may result in 'blind' shoots; very severe crop losses are reported.

BIOLOGY

Adults appear in the spring, usually from late April onwards. Eggs are then laid at the base of host plants, especially spring oats. They hatch 3^4 days later. Larvae feed within the shoots and take about 2 weeks to develop. They then pupate *in situ* and adults of the second generation appear about 2 weeks later (usually in June and July). Their eggs are usually deposited on the heads of flowering oat plants, in the shelter of the glumes. Eggs may also be deposited on the ears of wheat plants. Second-generation larvae eventually pupate within the grain and third-generation adults appear in the autumn (usually from August to October). Eggs of the autumn generation are laid on young grasses (especially rye-grass) and on volunteer cereals. The resulting larvae feed throughout the autumn and into the winter, and eventually pupate in the spring. Larvae transfer readily from plant to plant, so that attacks may appear on later-drilled crops, but they will not do so at soil temperatures below 8°C.

DESCRIPTION

Adult 1.5 mm long, stout-bodied, shiny black **(Fig. 265);** *legs* mainly, if not entirely, black (cf. *Oscinella vastator,* below). **Egg** 0.7 mm long, broadly elongate, white, ridged longitudinally. **Larva** up to 4 mm long, narrow-bodied, creamish-white and translucent; no posterior papillae **(Plate 9c)** (cf. wheat bulb fly, *Delia coarctata*, p. 197); *anterior spiracles* fan-like and inconspicuous, each with four to seven lobes (cf. yellow cereal fly, *Opomyza florum*, p. 183); *posterior spiracles* borne on small tubercles.

Fig. 265 Frit fly, *Oscinella frit* (x25).

Oscinella vastator **(Curtis)**

This species, along with various other close relatives, is associated with grasses such as fescues, rye-grasses and timothy. The larvae may, on occasions, transfer from grasses to cereals (apart from spring oats) and cause death of the central shoots but economically important attacks are rare. Adults of *Oscinella vastator* often require separation from those of *O. frit* in water-trap collections used to monitor frit fly numbers; *O. vastator* is distinguishable by, for example, its noticeably short, stubby, more brownish and more strongly veined wings, the longer antennal filament and usually more obviously banded (black and yellow) legs.

Family SCATHOPHAGIDAE

Nanna armillata **(Zetterstedt);**
N. flavipes **(Fallen)**
Timothy flies

Infestations of these generally common flies occur on timothy grass. The larvae graze on the developing inflorescences within the shelter of the leaf sheaths. Symptoms of attack show clearly after the ear emerges, as sections of spikelets are either partly or totally grazed away; these damaged areas are often arranged spirally. Severe seed loss is reported mainly from the northern parts of continental Europe, especially France, Germany and Scandinavia (where the range of these pests extends into the Arctic Circle).

BIOLOGY

Adults are active in late April or early May. They occur in association with timothy grass, upon which pairs of mating adults may be found; they also rest on the leaf tips, characteristically head downwards. Eggs are deposited close to the stem on the upper surface of the uppermost leaves, parallel to the veins. They hatch 5-7 days later. The larvae then bore into the grass stem to feed on the developing, but still enclosed, inflorescence. After 2-3 weeks, when fully grown, they reappear and usually drop to the ground before pupating in the soil. There is just one generation annually.

DESCRIPTION

Adult 5.0-5.5mm long, mainly dark grey; *legs* partly pale and reddish-brown. **Egg** 1 mm long, pale yellow, elongate, seed-like with four longitudinal ridges. **Larva** up to 8 mm long, lemon-yellow, maggot-like; *anterior spiracles* prominent and bifid, with several lobes; *posterior spiracles* slightly sclerotized and 3-pored. **Puparium** 5 mm long, dark brown.

Family ANTHOMYIIDAE

Delia antiqua **(Meigen)**
Onion fly

The onion fly is a widely distributed and often serious pest of onion; leek and shallot are also attacked. Most important damage occurs in June and July, with seedlings and salad crops most at risk. Infested seedlings soon wilt, and the leaves appear flaccid and may turn brown; such symptoms often occur in patches within crops and may be followed by the complete collapse of plants. On older plants, the larvae (maggots) may burrow within and destroy the inner tissue of the actual bulbs; there may be as many as 30 larvae inside a heavily infested bulb. The oldest leaves protruding from infested bulbs may wilt, turn yellow and then whitish; such leaves are readily detached. In the British Isles, this pest is most important in central and eastern England.

BIOLOGY

Adult flies appear in May. Eggs are deposited on the neck or young leaves of onion plants or placed in the soil immediately adjacent to host plants, each female fly depositing up to 200 eggs in her life-time. The eggs hatch within a few days, and the larvae then attack their hosts. Larvae may move from one bulb or plant to another in order to complete their development, passing through three instars and becoming fully grown in approximately 3 weeks. Pupation occurs in the soil, a few centimetres from the surface, and a second generation of adults emerges 2-3 weeks later. In favourable situations, there may be three generations annually. The pest overwinters in the pupal stage.

DESCRIPTION

Adult 5-7 mm long; mainly grey, with numerous long black hairs; *thorax* yellowish-grey with four brownish, longitudinal stripes; *abdomen* grey with a dark stripe down the mid-line; *wings* yellowish. **Egg** 1.0-1.3 mm long, white, elongate-oval and ridged longitudinally. **Larva** up to 10 mm long, dirty white, tapered anteriorly and blunt posteriorly **(Plate 9d);** *posterior papillae* relatively prominent, the small hind-most (median) pair distinctly separated **(Fig. 266a)** (cf. bean seed fly, *Delia platura*, p. 199). **Puparium** 6-7 mm long, oval, dark brown.

Delia coarctata **(Fallen)**
Wheat bulb fly

Wheat bulb fly is a local and sporadically important pest of winter wheat; infestations also occur on winter barley and on early-drilled crops of

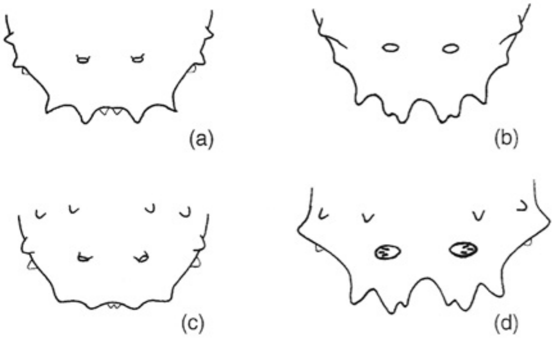


Fig. 266 Tubercles on the anal segment of *Delia* larvae: (a) onion fly, *D. antiqua;* (b) wheat bulb fly, *D. coarctata;* (c) bean seed fly, *D. platura;* (d) cabbage root fly, *D. radicum.*

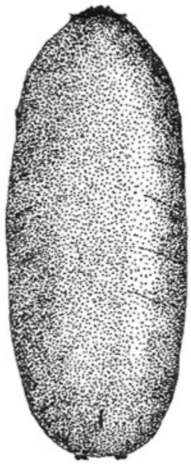


Fig. 267 Puparium of wheat bulb fly, *Delia coarctata* (xlO).

spring barley or spring wheat (usually crops sown before early March), but not on oats; *Elytrigia repens* is a wild host. Larvae cause the yellowing and death of central shoots ('dead-heart' symptom). Individual larvae typically move from one shoot to another, and overall effects on yield may be considerable, especially on untillered crops. On heavy land, attacks are usually most severe on crops which follow fallows or bastard fallows (leys ploughed-up in July); on lighter-land sites, the risk of attack is greatest when host crops follow pea, potato and root crops such as sugar beet. In the British Isles, infestations occur mainly in the midland and eastern counties of England (including Yorkshire).

BIOLOGY

Adults occur from June onwards. Eggs are laid on bare soil in July or August. The females select either fallow land, recently cultivated fields or bare soil beneath the leaf canopy of existing crops such as potato or sugar beet. Sites with well-structured soils are preferred. The eggs hatch in the following January or February. Larvae die within a few days in the absence of suitable host plants. On sites where cereals have been drilled, each larva bites its way into the base of a plant, just below soil level, and enters the central shoot to begin feeding. Larvae develop through three instars, and older larvae move from tiller to tiller, or from plant to plant, and thereby increase the extent of crop damage. The base of each infested shoot bears a ragged hole, surrounded by discoloured tissue. Larvae are usually fully grown by mid-May. They then enter the soil to pupate, and adults emerge a few weeks later. There is just one generation annually.

DESCRIPTION

Adult female 6-8 mm long, dull yellowish-grey; *legs* partly brown. **Adult male** 6-8 mm long, dark brown; *legs* black **(Plate 9e).** Egg 1.8 x 0.3 mm, elongate-oval, white and ribbed longitudinally. Larva up to 12 mm long, whitish to creamish-white, pointed anteriorly and blunt posteriorly **(Plate 9f);** *head* retracted into prothorax; *anterior spiracles* fan-like, with seven to eight lobes; *posterior spiracles* prominent; *posterior papillae* prominent **(Fig. 266b)** (cf. yellow cereal fly, *Opomyza florum,* p. 183; late-wheat shoot fly, *Phorbia securis,* p. 201). **Puparium** 6-8 mm long, brown and barrel-like; *posterior papillae and spiracles* prominent **(Fig. 267).**

Delia echinata (Seguy)
Spinach stem fly

This species is a locally important pest of spinach. Infested foliage becomes distorted, the petioles and mid-ribs split open, and shoots become blackened. Larvae may also occur as contaminants in crops sent for processing. In the British Isles, attacks occur most frequently in southern and southeastern England.

BIOLOGY
Adults first appear in the spring, and eggs are then deposited singly along the veins on the upper surface of young leaves. The eggs hatch within a few days. Larvae immediately burrow into the leaf tissue to feed within expansive blotch mines; fully fed individuals eventually pupate in the soil. Occupied mines occur from May to late September or early October, and there are three or four generations annually.

DESCRIPTION
Adult 4-5 mm long, yellowish-grey with a slightly darker median stripe on the thorax and abdomen; *legs* black; *wings* hyaline, iridescent, with yellow veins. **Larva** up to 7 mm long, white, with plant sap often congealed on the body to form distinctive black rings; *head* deeply retracted into prothorax; *anterior spiracles* 8-lobed and fan-like; *posterior spiracles* relatively large and prominent (cf. mangold fly, *Pegomya hyoscyami,* p. 200).

Delia platura **(Meigen)**
A bean seed fly

This fly is an increasingly important pest of French bean and runner bean, and various other vegetable crops, including Brussels sprout, cabbage, cauliflower, lettuce, onion, pea, potato and radish; infestations also occur on sunflower and certain ornamentals. The larvae often hollow out the seeds, which then fail to germinate; they also cause death or severe stunting of seedlings. Damage is particularly severe when germination is slow. In trashy conditions (especially following crops such as mustard, oilseed rape, parsnip and sugar beet), larvae may attack germinating cereal plants. On potato, the larvae will also act as vectors of the bacterial disease known as 'black leg'.

BIOLOGY
Adults are active from May onwards. Eggs are deposited in the soil, usually in the presence of decaying organic matter. The eggs hatch within a few days, and the larvae then tunnel inside germinating bean seeds, young bean stems and other suitable hosts. They feed for approximately 1-3 weeks and then pupate in the surrounding soil. New adults appear 2-3 weeks later and, after mating, females initiate a further generation; each fly deposits about 50 eggs. There are usually three to five generations each year.

DESCRIPTION
Adult 6 mm long, greyish-brown; *wings* 5 mm long. **Egg** 1.0 x 0.3 mm, elongate-oval, white. **Larva** up to 8mm long, white, relatively robust; *head* only partly retracted into the prothorax; *posterior papillae* relatively prominent, the very small hind-most (median) pair contiguous and inconspicuous **(Fig. 266c)** (cf. onion fly, *Delia antiqua*, p. 197). **Puparium** 4-5 mm long, oval, reddish-brown.

Delia radicum **(L.)**
Cabbage root fly

The cabbage root fly is a major pest of brassica crops (Brassicaceae) and causes considerable damage to summer cabbage and autumn cauliflower; infestations are also of significance on Brussels sprout, calabrese, Chinese leaf, radish, swede, turnip and ornamentals such as wallflower. Most damage results from eggs laid by first-generation flies in late April and May. Seedlings or recent transplants wilt and die, as the fibrous roots are eaten away and much of the tap root destroyed; damaged root systems are also liable to subsequent attack by fungal pathogens. Older or less heavily infested plants survive, but are usually stunted, and the outer leaves frequently become discoloured (often blue-green or reddish) and may wilt. **Brussels sprout:** larvae often feed within the buttons to cause extensive damage, and much of the inner tissue turns brown. Such larvae, and the damage they have caused, often remain undetected until after harvest; this is a particular problem on crops sent for freezing where only a small proportion of affected buttons may be sufficient for consignments to be rejected. **Cauliflower:** light attacks are sufficient to reduce curd size and, hence, yield of autumn cauliflowers but winter crops are rarely affected. **Chinese leaf, swede and turnip:** larvae cause minor damage to roots but may also feed within the growing points to produce multiheaded plants. **Radish:** fibrous roots are destroyed, weakening host plants, and the bulbous tap root may become riddled with tunnels **(Plate 10a),** rendering the crop unmarketable; superficial root damage may be sufficient to make crops unsuitable for human consumption. **Wallflower and other ornamentals:** attacked plants wilt in warm, dry weather and make poor growth; small plants may collapse and die.

BIOLOGY

Individuals overwinter as pupae within puparia. Adults emerge in the spring, from mid-April onwards, but the precise timing of their appearance depends upon temperature. Eggs are deposited in the soil close to the stems of host plants; the period of egg laying often coincides with the commencement of flowering of the common field-side weed *Anthriscus sylvestris.* Eggs hatch 3-7 days later, and the larvae immediately attack the roots of nearby host plants. They feed for 3-4 weeks and then, when fully grown, move away through the soil for a few centimetres before pupating. Adults of the second generation appear in late June and July, and those of the third from mid-August onwards. However, the two generations tend to overlap so that subsequent egg laying can occur at virtually any time from July to September. Although most eggs are laid in the soil, a few may be placed on the lower leaves of host plants. Larvae emerging from the latter may attack the stems and growing points or feed in the major leaf veins. Eggs are also deposited between the outer leaflets of developing Brussels sprout buttons, usually on those close to the base of the stems of early-maturing cultivars.

DESCRIPTION

Adult 6-7 mm long, mainly grey to blackish. **Egg** 1mm long, elongate-oval, white and ribbed longitudinally. **Larva** up to 10 mm long, creamish-white; *head* deeply retracted into prothorax; *posterior papillae* prominent, the middle pair beyond the spiracles distinctly bifid **(Fig. 266d)** (cf. *Delia platura,* p. 199, etc.). **Puparium** 6-7 mm long, elongate-oval, reddish-brown.

***Delia floralis* (Fallen)**
Turnip root fly

This northerly distributed species occurs in many parts of continental Europe and in northern England and Scotland. The larvae attack various vegetable brassicas and oilseed rape but are most often associated with swede and turnip crops. They feed deeply within the hearts of host plants from September onwards, and there is usually just one extended generation annually. Adults (6-8 mm long) are essentially similar in appearance to those of *Delia radicum* (above); the larvae are distinguished from those of *D. radicum* by slight differences in the papillae surrounding the posterior spiracles, none being bifid.

***Delia florilega* (Zetterstedt)**
A bean seed fly

This pest attacks French bean, runner bean, bulb and salad onions, and causes the same kind of damage as *Delia platura* (q.v.). The larvae are relatively slender-bodied, with a thin, semi-transparent body wall, through which the pinkish gut contents are clearly visible; the mouthparts (cephalopharyngeal skeleton) are prominent and the head only partly retracted into the prothorax (cf. onion fly, *D. antiqua,* p. 197); the posterior papillae are also particularly prominent (cf. *D. platura,* p. 199).

***Pegomya hyoscyami* (Panzer)**
Mangold fly

This is a widespread and common but usually minor pest of mangold and sugar beet; infestations also occur on red beet and spinach. The larvae (known as 'beet leaf miners') feed within large blotch mines. Mined leaves appear scorched and may eventually decay; this affects the marketable quality of spinach plants. Growth of plants, however, is rarely affected significantly unless heavy infestations occur on young plants. Crops are usually at greatest risk from first-generation attacks; sugar beet crops are more likely to suffer significant damage where crops are drilled to a stand.

BIOLOGY

Adults appear in early spring and deposit their eggs in small batches on the underside of host leaves. The eggs hatch in about 5 days. The larvae then burrow directly into the leaf tissue. They feed gregariously for about 2 weeks and form large, brown blotch mines, each of which commences as a linear gallery. Fully grown larvae enter the soil to pupate, and a second generation of adults emerges in July. In favourable areas and seasons, a third generation of adults appears from late August to early September.

DESCRIPTION

Adult 5-6 mm long; *thorax* mainly greyish-brown; *abdomen* reddish-brown; *legs* yellow with black tarsi. **Egg** 0.8 mm long, broadly elongate, white; *chorion* reticulate. **Larva** up to 8 mm long, greenish-white to yellowish-white **(Plate 10b);** *anterior spiracles* 8-lobed, fan-like; *posterior spiracles* relatively small, surrounded by numerous prominent papillae (cf. spinach stem fly, *Delia echinata,* p. 198). **Puparium** 6-7mm long, dark reddish-brown, barrel-shaped; *posterior spiracles* prominent **(Fig. 268).**

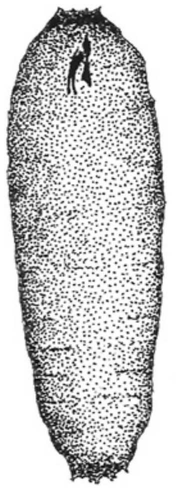


Fig. 268 Puparium of manold fly, *Pegomya hyoscyami* (xfO).

Pegomya rubivora **(Coquillett)**
Loganberry cane fly

Infestations of this locally distributed pest occur on blackberry, loganberry, raspberry and Tayberry. Adult flies are active in the spring, eggs then being deposited on newly emerging canes. The larvae feed gregariously. They burrow downwards to the base of the new canes, which are often girdled; this causes the canes to wilt and die. Pupation occurs in the soil, and there is just one generation annually.

Phorbia securis **Tiensuu**
Late-wheat shoot fly

This minor pest is associated mainly with spring and winter wheat, but will also breed on grasses. The larvae feed singly inside young plants, each causing yellowing, wilting and death of the centre shoot. Damage is rarely of significance and usually most evident on backward crops. In the British Isles, attacks are most often found in eastern England.

BIOLOGY

Adults are active in March and April. Eggs are then deposited singly beneath the outer edges of the leaf sheaths of young wheat plants. The eggs hatch a few days later. Each larva then burrows downwards into a leaf sheath, to form a spiral channel, before entering the central shoot. The larvae continue to feed within the shoots for 2-4 weeks. They then enter the soil to pupate, usually in late May or early June. Larvae are present, therefore, later in the season than those of the wheat bulb fly *(Delia coarctata,* p. 197). Individuals usually remain within the puparium until the following spring, although in favourable districts a second or at least a partial second generation may occur on wild grasses.

DESCRIPTION
Adult up to 5 mm long, dark grey; *legs* black. **Larva** up to 7 mm long, yellowish-white; *anterior spiracles* prominent, frilly-edged, with up to 20 lobes; *posterior spiracles* borne on distinct tubercles; *posterior papillae* very small or absent (cf. wheat bulb fly, *Delia coarctata*, p. 197).

ORDER LEPIDOPTERA (BUTTERFLIES AND MOTHS)

Family HEPIALIDAE (swift moths)

Hepialus humuli (L.) Ghost swift moth

This widely distributed, polyphagous pest is associated mainly with permanent grassland and lawns but can also damage a wide range of agricultural and horticultural crops planted in recently broken-up grassland or pasture. The soil-inhabiting larvae attack the subterranean parts of plants; particularly severe damage is caused in the second year of larval development.

BIOLOGY
Adults are active at dusk, mainly in June and July. The females lay many hundreds of eggs, which they drop at random whilst skimming over grassland. The eggs hatch in approximately 3 weeks. The larvae feed from late summer or early autumn onwards, constructing silken tunnels in the soil, into which they often retreat when disturbed. Larval development is slow and is usually not completed until after the second winter. Individuals then pupate in silken cocoons. Adults emerge about 3 weeks later, the pupae first working their way to the soil surface.

DESCRIPTION
Adult female 50-70 mm wingspan; *forewings* parchment-like, yellowish-ochreous, marked with orange **(Plate 10c);** *hindwings* greyish-brown. **Adult male** 45-50 mm wingspan; *wings* silvery-white. **Egg** 0.7 x 0.5 mm; white when laid but soon turning black. **Larva** up to 50 mm long; *body* whitish, robust and relatively opaque; *pinacula* dark brown and prominent; *head and prothoracic plate* reddish-brown **(Plate lOd)** (cf. *Hepialus lupulinus,* below).

Hepialus lupulinus (L.) Garden swift moth

This pest is widespread and common on a wide range of crops, particularly those grown in recently ploughed grassland and those in weedy sites. The larvae attack the roots and also bore into bulbs, corms and tubers. Infestations are often noted on carrot, hop, lettuce, potato and strawberry, and on many ornamental plants; bean, beet, cereals, parsnip and various other crops are also attacked. Damage occurs mainly from autumn to early spring.

BIOLOGY
Adults occur mainly in May and June. They are active at dusk and may then be seen flying low over fields and gardens. Eggs are broadcast randomly by the females whilst in flight, each depositing about 300. The eggs hatch approximately 2-3 weeks later. Larvae feed indiscriminately on the subterranean parts of plants. Each larva forms a silk-lined burrow in the soil, down which it retreats when disturbed. Larvae develop relatively slowly and usually do not become fully grown until the following spring. Pupation occurs in a flimsy cocoon several centimetres below the surface. The adult usually emerges about 6 weeks later, after the pupa has wriggled out of its cocoon and made its way to the surface of the ground.

DESCRIPTION
Adult 25-40 mm wingspan, female usually larger and stouter-bodied than male; *thorax* with a fin-like tuft of hairs; *forewings* yellowish-brown, more or less marked with white; *hindwings* yellowish-grey. **Egg** 0.5-0.6 mm across, white when laid but soon turning black and

shiny. **Larva** up to 35 mm long; *body* white and translucent, with the gut contents often clearly visible; *pinacula* pale brown and inconspicuous (cf. *Hepialus hamuli,* above); *head and prothoracic plate* light brown **(Plate lOe). Pupa** 20 mm long, reddish-brown; *abdominal segments* with projections ventrally and dentate ridges dorsally.

Family NEPTICULIDAE

***Stigmella malella* (Stainton)**
Apple pygmy moth

This leaf miner attacks apple and, although usually of no importance in orchards, can be a problem on nursery trees (including ornamental crab apple). This pest is of greater significance in continental Europe, where significant damage in established orchards can occur.

BIOLOGY
Adults are active in two main generations, flying in May and in August. Eggs are laid on the underside of apple leaves. However, the larvae mine just below the upper surface, each forming sinuous galleries within which a dark central line of frass is clearly visible. Occupied mines occur from June to July and from September to October. Pupation occurs outside the mine in a small, yellowish-orange, parchment-like cocoon, usually attached to the base of a leaf.

DESCRIPTION
Adult 4-5 mm wingspan; *head* dark ochreous; *forewings* blackish with a whitish cross-band; *hindwings* grey. **Larva** up to 4 mm long; *body* pale yellow and translucent; *head* brown.

Family INCURVARIIDAE

***Lampronia rubiella* (Bjerkander)**
Raspberry moth

This moth is a locally important pest of loganberry and raspberry. Larvae destroy the buds and lateral shoot and, if infestations are heavy, fruit yields are reduced significantly.

BIOLOGY
Moths are active in May, June or July, and eggs are laid singly in the open flowers of host plants. After egg hatch, each larva feeds on the surface of the developing fruit before tunnelling into the receptacle. When approximately 3 weeks old, the larvae drop to the ground and enter the soil. Here they remain until the following spring. At bud burst, the larvae reappear and invade the buds or young shoots; several are attacked during the course of larval development. Fully fed larvae pupate within silken cocoons spun on the host plant or on posts and other surfaces. Adults emerge about 3 weeks later.

DESCRIPTION
Adult 9-12 mm wingspan; *head* yellowish; *forewings* dark purplish-brown to golden-brown, speckled with creamish-yellow; *hindwings* purplish-grey **(Fig. 269). Larva** up to 8 mm long; *body* red; *head, prothoracic plate and anal plate* black.

Family COSSIDAE

***Zeuzera pyrina* (L.)**
Leopard moth

This southerly distributed pest occurs on various trees and shrubs and is sometimes a problem in young orchards, particularly in years following hot summers. The larvae bore within the shoots; they also tunnel within stems and branches of less than 10 cm in diameter. Damage is particu-

Fig. **269** Raspberry moth, *Lampronia rubiella* (x7).

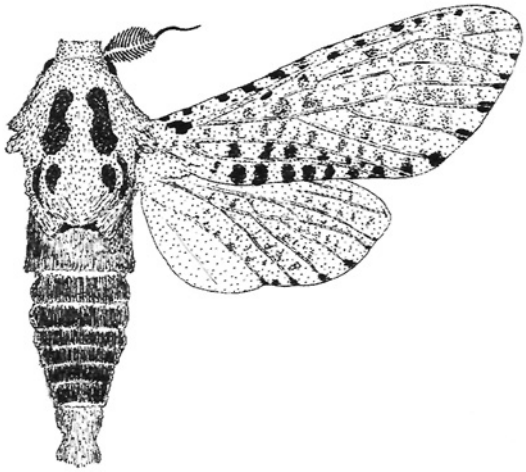


Fig. 270 Male leopard moth, *Zeuzera pyrina* (x2.5).

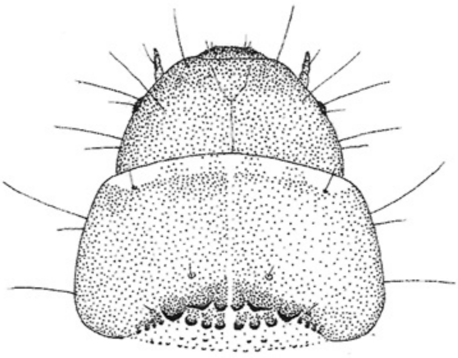


Fig. 271 Head and prothoracic plate of young larva of leopard moth, *Zeuzera pyrina.*

larly serious on young trees, some of which may be killed.

BIOLOGY
Adults occur in June and July, and eggs are laid in cracks or wounds in the bark of host trees. Larvae may at first attack the leaves but eventually they bore into the shoots and branches where they form long tunnels in the heart wood. Frass and particles of wood are expelled from the feeding galleries and these often accumulate on the ground beneath infested trees. Larval development is protracted and lasts for up to 2 or 3 years. Fully fed larvae pupate within their feeding galleries, each in a silken cocoon within which particles of wood are incorporated. Moths emerge about a month later.

DESCRIPTION
Adult 45-65 mm wingspan; *body* white marked with blue-black; *wings* white with blue-black spots, but thinly scaled and translucent **(Fig. 270). Larva** up to 60mm long; *body* yellow; *pinacula* black; *head* dark brown; *prothoracic plate* blackish-brown and very large; *anal plate* blackish-brown **(Plate lOf). Young larva** pinkish; *prothoracic plate* distinctively sculptured posteriorly **(Fig. 271).**

Family LYONETIIDAE

***Lyonetia clerkella* (L.)**
***larva* = Apple leaf miner**

Infestations of this generally abundant species occur on various trees and shrubs, including *&p-/* pie and cherry. The larvae mine the foliage, and heavy infestations can cause leaves to turn brown and die.

BIOLOGY
This species overwinters in the adult stage. The moths appear in April and then deposit eggs on the underside of leaves. Following egg hatch, each larva tunnels within the leaf to form a very long, brown or whitish gallery, visible from above. Fully fed larvae emerge 3-4 weeks later to spin cocoons on leaves, branches or trunks of trees, each suspended in a hammock-like fashion by threads of silk. Adults appear about 2 weeks later. This species usually completes three generations annually.

DESCRIPTION
Adult 8-9 mm wingspan; *forewings* brilliant white (but sometimes brownish), with a dark spot and several streaks apically; *hindwings* dark grey. **Larva** up to 8 mm long; *body* green and translucent; *head* brown.

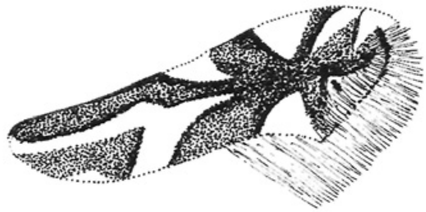


Fig. 272 Forewing of *Phyllonorycter blancardella* (xl5).

Family GRACILLARIIDAE

***Phyllonorycter blancardella* (F.)**

This generally abundant moth is a minor pest of apple. The larvae form blotch mines in the leaves, and these distort the lamina. This species is a particularly damaging orchard pest in continental Europe and North America.

BIOLOGY
First-generation adults of this bivoltine species emerge in May. Eggs are laid on the underside of leaves and hatch 2-3 weeks later. Larvae mine singly within the leaves for 5-6 weeks. Each larva then pupates within its mine. A second flight of adults appears in August but sometimes earlier. Their progeny overwinter as pupae within mines on fallen leaves.

DESCRIPTION
Adult 8-9 mm wingspan; *forewings* dark copper-brown with brilliant white, dark-edged markings **(Fig. 272);** *hindwings* dark grey. **Larva** up to 5 mm long; *body* yellow and translucent; *head* pale brown.

Family SESIIDAE (clearwing moths)

***Synanthedon tipuliformis* (Clerck)**
Currant clearwing moth

Infestations of this pest occur mainly on black currant; other closely related hosts, including gooseberry, are also attacked. The larvae bore within the pith of branches. Damaged branches often break off, especially in strong winds and if weighed down with ice (e.g. that formed on bushes during early-spring frost protection measures) or with maturing fruit.

BIOLOGY
Moths are active in sunny weather in June and July. They fly rapidly within black currant plantations and often visit nearby flowers to feed on nectar. Eggs are laid singly on the stems of host plants and hatch in approximately 10 days. The larvae then bore into the central pith to feed. They complete their development in the following spring and then pupate just beneath the bark.

DESCRIPTION
Adult 17-21 mm wingspan; *body* mainly metallic bluish-black, with narrow yellow cross-bands on the abdomen; *wings* mainly hyaline and scaleless, but venation and borders brownish-black (see Fig. 117). **Larva** up to 15mm long; *body* creamish-white; *head* light brown.

***Synanthedon myopaeformis* (Borkhausen)**
Apple clearwing moth

This species is a pest of fruit trees, especially apple. The larvae tunnel within the bark and are usually to be found on already debilitated or dying trees. Adults (20-25 mm wingspan) are mainly black with a conspicuous red band on the abdomen. They occur in July and are sometimes observed flying during sunshine, when they also visit flowers to imbibe nectar. Larvae (up to 17 mm long) are mainly creamish-white, with a brown head; they feed for almost 2 years before eventually pupating.

Family CHOREUTIDAE

***Choreutis pariana* (Clerck)**
***larva* - Apple leaf skeletonizer**

This species is a potentially damaging pest of fruit trees, especially apple and pear. The larvae graze away extensive areas of leaf tissue, damaged tissue turning brown.

BIOLOGY
Moths overwinter in various sheltered situations and emerge in April. Larvae feed singly on the upper surface of leaves, beneath a silken web. They also feed within folded leaves. Pupation occurs in dense, white cocoons formed on the underside of a leaf or on dead leaves on the ground. Adults emerge in July or early August. A second generation of larvae feed in late summer and these produce adults in the autumn.

DESCRIPTION
Adult 11-13 mm wingspan; *forewings* brown to greyish-brown with dark, wavy markings; *hindwings* greyish-brown. **Larva** up to 14 mm long; *body* yellow to pale green, translucent; *pinacula* black and very obvious; *head* yellowish-brown.

Family GLYPHIPTERIGIDAE

***Glyphipterix simpliciella* (Stephens)**
Cocksfoot moth

This generally common species occurs on wild *Dactylis glomerata;* it is also capable of damaging seed crops of cultivated cocksfoot. The larvae hollow out the seeds but infestations are of little or no importance.

BIOLOGY
Adults occur in late May and June. They often swarm, in groups of 10 or more, over the flowerheads of host plants. Eggs are laid at the base of the seeds and hatch about 2 weeks later. Larvae, which feed throughout July, at first attack the stamens of the florets; later, they bore inside the developing seeds. Individuals are fully grown in about a month. Each then overwinters in a cocoon spun inside a grass stem. Pupation occurs in the spring and adults emerge 3-4 weeks later.

DESCRIPTION
Adult 7-8mm wingspan; *forewings* mainly dark brownish-bronze, ornamented with silvery markings, five white strigulae on the apical half of the costa, an oblique white streak and a black apical spot **(Fig. 273);** *hindwings* dark grey. **Larva** up to 6 mm long; *body* whitish-green; *head and prothoracic plate* black.

Fig. 273 Forewing of cocksfoot moth, *Glyphipterix simpliciella* (x!5).

Family YPONOMEUTIDAE (e.g. small ermine moths)

Acrolepiopsis assectella **(Zeller)**
Leek moth

This insect is a local pest of leek; garlic, onion and shallot are also attacked. The young larvae form small holes in the furled leaves; older individuals cause distortion and also graze away considerable areas of photosynthetic tissue. Infestations induce secondary rotting of the leaves and bulbs, and this may result in plant death. In the British Isles, attacks are usually limited to the coastal parts of eastern, southern and south-western England but they are more widespread in continental Europe, where they extend from Denmark southwards.

BIOLOGY
Adults overwinter amongst shelter on the ground and reappear in the spring. Eggs are then deposited on the leaves of host plants, usually towards the base. The eggs hatch about a week later. The larvae then bore through the leaf sheath into the heart of the plant. They feed for 3-4 weeks, and often mine within the hollow leaves down to the base of the stem. Fully grown larvae pupate in loose, net-like cocoons (8-9 mm long) **(Plate 11a)** which they spin on the host plant, in the soil or amongst debris on the ground. There are several generations annually; these range from two or three in northerly parts

of the pest's range to five or six in more southerly regions, where pupae may also overwinter.

DESCRIPTION

Adult 16 mm wingspan; *forewings* mainly greyish-brown, marked irregularly with brown and white **(Plate lib). Egg** 0.5-0.6 mm long, creamish-white, suboval, flattened and with a reticulated surface. **Larva** up to 11mm long; *body* greenish-white; *head* brown. **Pupa** 6-7 mm long, brown.

***Plutella xylostella* (L.)**
Diamond-back moth

This species is a notorious and cosmopolitan pest of vegetable brassicas. Less-significant infestations also occur on brassica seed crops, including oilseed rape. Larvae, when numerous, cause significant leaf damage. Attacked leaves become riddled with holes and the remaining tissue often turns brown; infestations are of particular importance on cabbage and cauliflower, where the larvae often invade the heart leaves. Seed heads of swede and turnip are also liable to be destroyed. In the British Isles, attacks tend to be sporadic and are of greatest significance in hot, dry summers when large numbers of adults invade the country from continental Europe.

BIOLOGY

Pupae overwinter, and adults emerge in the following year, from May onwards. There are usually two main flight periods, from May to June and from August to September. Adults are most active at night but are readily disturbed during the daytime. Females lay large numbers of eggs, typically in groups of two or three. The eggs hatch about 10 days later. At first, the larvae mine within the leaf tissue but they then feed externally on the underside of the expanded leaves, sheltered by flimsy silken webs. Development, which includes four larval instars, takes approximately 3-4 weeks. Each larva then pupates in an open, net-like cocoon (7-10 mm long) spun on the foodplant. Adults emerge about 2 weeks later. Although in the British Isles there

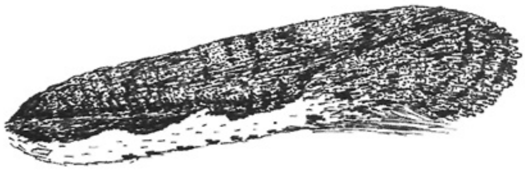


Fig. 274 Forewing of diamond-back moth, *Plutella xylostella* (xlO).

tend to be two (occasionally three) main generations, the arrival of immigrants from continental Europe (where there may be six or more generations annually) may result in overlapping broods of larvae.

DESCRIPTION

Adult 11-16 mm wingspan; *head and thorax* ivory-white; *forewings* light brown to dark brown, with an irregular creamish to ivory-white band on the hind margin **(Fig. 274)** (forming a characteristic series of three diamond-shaped marks when both forewings are held over the back in repose); *hindwings* grey, with a long fringe of hairs. **Egg** 0.5 x 0.25 mm, elliptical and pale lemon-yellow. **Larva** up to 12 mm long; *body* pale yellowish-green; *head* pale brown with darker markings; *pinacula* large and pale; *body hairs* black and prominent; *prothoracic plate* inconspicuous, with scattered blackish markings; *anal claspers* elongate and clearly visible from above. **Pupa** 6-8 mm long, at first pale green but soon turning brown.

***Yponomeuta malinellus* Zeller**
Apple small ermine moth

This species is a minor pest of apple. The larvae feed gregariously, often coating the foodplant with masses of characteristic webbing. Heavy infestations may lead to considerable defoliation and significant fruit loss. Attacks occur most frequently on unsprayed trees, such as those in mature private gardens and old, neglected orchards. This and other closely related species (the latter associated with plants such as *Crataegus monogyna, Euonymus europaeus, Primus avium,* *P. padus, P. spinosa* and *Salix alba)* are collectively known as 'small ermine moths'.

BIOLOGY

Moths are active in July and August. Eggs are laid on shoots and spurs in long, oval or elongate, raft-like batches of up to 80 or more and then coated with a protective secretion that hardens soon afterwards. The eggs hatch in the autumn. The larvae then congregate and overwinter between the remains of the egg raft and the underlying bark. In the early spring, the larvae invade the opening buds; later, they mine gregariously within the expanded leaves to form large blotches. Second-instar larvae vacate the mines to feed externally in communal webs, attacking both leaves and blossom trusses. Infested shoots and branches may become coated in webbing. The larvae are fully fed in June. They then pupate in white, opaque cocoons spun in groups within the web. Adults appear about 2 weeks later.

DESCRIPTION

Adult 18-22 mm wingspan; *forewings* white with a characteristic pattern of small white spots; *hindwings* grey **(Fig. 275). Egg** flat, dark purplish-grey and laid in a large batch. **Larva** up to 20 mm long; body dirty yellowish-grey; *head, pinacula and dorsal plates* black **(Fig. 276). Young larva** mainly yellowish-white; *head and prothoracic plate* brown. **Pupa** 10 mm long; mainly yellow but head, thorax, wing cases and tip of abdomen darker; *penultimate segment* with a distinct ventral hump; *cremaster* with six long filaments.

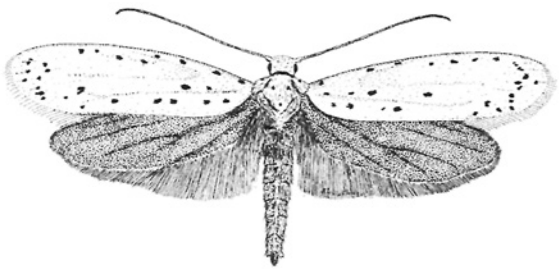


Fig. 275 Apple small ermine moth, *Yponomeuta malinellus* (x4).

Family EPERMENIIDAE

Epermenia chaerophyllella (Goeze)

This moth is a widespread but usually minor pest of garden-grown or allotment-grown parsnip; infestations also occur on carrot. Leaves are grazed from below; the upper surface remains intact but turns brown to give the appearance of an extended blotch; attacks commence close to the petiole and, particularly on lower leaflets, may spread over most if not all of the lamina. Heavy infestations reduce the vigour of plants (cf. infestations of celery fly, *Euleia heraclei,* p. 179).

BIOLOGY

Adults appear in April or early May. They deposit eggs on the leaves of host plants, and first-generation larvae occur from June onwards. The larvae usually commence feeding by mining the leaves but they soon occur externally, to feed gregariously amongst strands of silk; they expel large quantities of black frass **(Plate lie).** Fully/grown individuals pupate on the ground amongst debris, each in a flimsy, net-like cocoon. A second generation of adults appears in July and August. Larvae of this generation complete their development in September or early October.

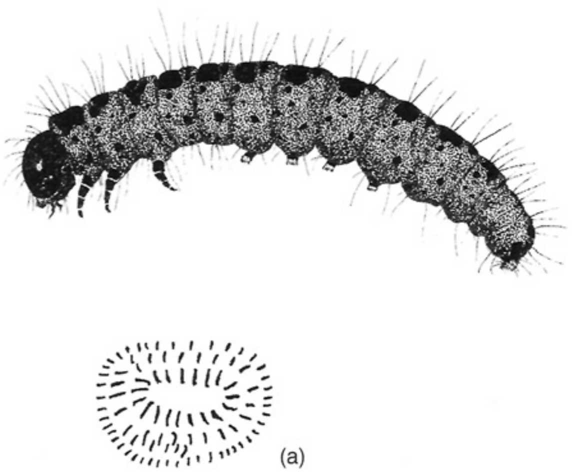


Fig. 276 Larva of apple small ermine moth, *Yponomeuta malinellus* (x4): (a) arrangement of crochets on an abdominal proleg (further enlarged).

They pupate to produce adults that emerge in the autumn but then hibernate.

DESCRIPTION

Adult 12-13 mm wingspan; *forewings* brown to blackish, marked with a pair of white spots (usually separated by black scales), and with two yellowish-brown and two black dorsal patches of scales ('scale teeth') **(Plate lid) (Fig. 277). Larva** up to 10mm long; *body* pale yellowish-white and transparent; *pinacula* large, black and each bearing a short, black seta; *head, prothoracic plate and anal plate* brown **(Fig. 278). Pupa** 5-6mm long, light brown; *cremaster* dome-like and terminating in a spine.

***Epermenia aequidentellus* (Hofmann)**

This relatively uncommon, locally distributed species is associated mainly with carrot. The larvae at first form brownish blotch mines in the leaflets but, later, they feed externally. Damage caused to cultivated plants is insignificant, although foliage of individual plants, especially in gardens and allotments, may be destroyed. Adults occur from June to July and from September to October, and larvae from May to June and from August to September. Larvae are distinguished from those of *Epermenia chaerophyllella* (above) by their darker dorsal line, black head, black prothoracic plate and black pinacula.

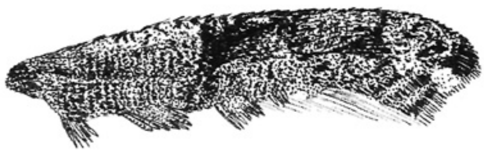


Fig. 277 Forewing of *Epermenia chaerophyllella* (xlO).

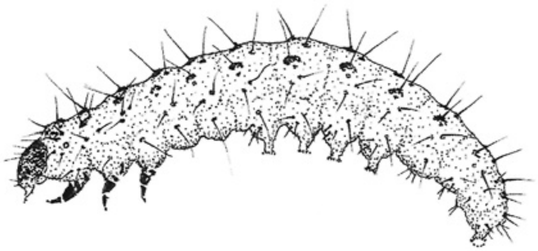


Fig. 278 Larva of *Epermenia chaerophyllella* (x!2).

Family COLEOPHORIDAE (casebearer moths)

***Coleophora spinella* (Schrank)**
Apple & plum casebearer moth

This insect is a minor pest of fruit trees. The case-bearing larvae form blotch mines in the leaves; they also remove sections of leaf when constructing their cases. However, damage caused is rarely significant.

BIOLOGY

Adults fly in June and July, when eggs are laid singly on the underside of leaves. Following egg hatch, the larvae at first mine within the leaves. Later, they feed externally but remain sheltered within a fragment of leaf that forms a characteristic case. Larvae overwinter within their cases and complete their development in the spring. Pupation takes place within the larval case, and the adult moth emerges about 2 weeks later.

DESCRIPTION

Adult 10-12 mm wingspan; *forewings* dark brownish-grey; *hindwings* dark grey. **Larva** up to 5 mm long; *body* brown; *head, prothoracic plate & anal plate* dark brown. **Case of young larva:** brown and pistol-shaped **(Fig. 279a). Case of older larva** 5-6 mm long, light brown, cylindrical and cigar-like **(Fig. 279b).**

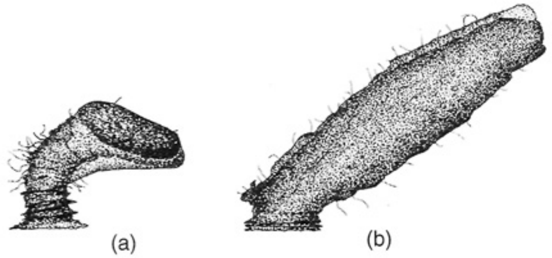


Fig. 279 Apple & plum casebearer, *Coleophora spinella:* (a) case of young larva; (b) case of older larva (x8).

Family OECOPHORIDAE

Agonopterix nervosa **(Haworth)**
Carrot & parsnip flat-body moth

Infestations of this generally common species occur on various umbelliferous plants including, occasionally, cultivated carrot and parsnip. Damage caused is of little or no importance.

BIOLOGY
Adults occur in August and then hibernate. They reappear in the following spring and deposit eggs on the leaves of host plants. Larvae feed on the flower heads in June and July, surrounded by silken webbing; they also bore into the stems and petioles. Pupation occurs in the pith of plant stems.

DESCRIPTION
Adult 21-24 mm wingspan; *forewings* mainly brown with slightly dusky veins; *hindwings* pale but darkened apically. **Larva** up to 20 mm long; *body* blue-black, marked with orange laterally and intersegmentally; *pinacula* distinct black and white-edged; *head and prothoracic plate* black. **Pupa** 10-12 mm long, brown and shiny.

Depressaria pastinacella **(Duponchel)**
Parsnip moth

This moth is a widespread and often common, but minor, pest of cultivated parsnip. The larvae also feed on certain wild umbelliferous plants, including *Heracleum sphondylium* and *Pastinaca sativa.* The larvae, which damage the stalks and flower heads, weaken host plants and reduce crop yields and quality.

BIOLOGY
Larvae, often known as 'parsnip webworms', feed from June onwards. At first, they attack the aerial parts of host plants, including the flower heads and seed capsules, and produce tough strands of silk amongst which they shelter. Later, the larvae bore into the plant stems, usually towards the base of the leaves. Fully fed larvae pupate in the stalks of host plants. Adults appear in the autumn and then hibernate. They reappear in the following March or April, and eggs are then laid on the leaves of parsnip and other hosts.

DESCRIPTION
Adult 25-27 mm wingspan; *thorax* pale brown with three short black longitudinal lines anteriorly; *forewings* mainly pale brown, suffused with black and ochreous-white, and patterned with black streaks **(Plate He);** *hindwings* ochreous-white to greyish. **Larva** up to 25 mm long; *body* dark bluish-grey above and ochreous to brownish-yellow laterally and below; *pinacula* black, shiny and prominent; *head and prothoracic plate* black and shiny **(Plate llf).**

Family GELECHIIDAE

Phthorimaea operculella **(Zeller)**
Potato moth

This insect is mainly a pest of the subtropics. However, infestations also occur in temperate regions. The larvae burrow into potato leaves, stems and tubers and are particularly damaging to tubers in store. Damaged potato tubers are often invaded by fungi and mites, and the remaining tissue then rapidly decomposes. Damage is also recorded on other members of the Solanaceae, including aubergine and tomato. On tomato, significant damage may result when the larvae bore within the leaves, stems and developing fruits. This pest is not established in the British Isles, although it is known to occur occasionally in association with imported produce.

BIOLOGY
Adults tend to be active from April to October. Under suitable conditions, there may be six if not more overlapping generations annually (10°C being the threshold for larval development). Adults usually lay their eggs in cracks or crevices on potato tubers, tomato stems and so on. The eggs usually hatch within a few days. Larvae then bore into the plant tissue to form silk-lined galleries from which, as development proceeds, frass is ejected. Larvae are usually fully fed in

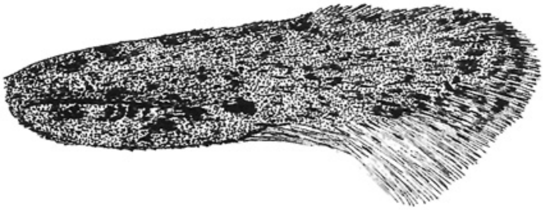


Fig. 280 Forewing of potato moth, *Phthorimaea operculella* (xl5).

Fig. **281** Pith moth. *Spuleria atra* (x6).

2-3 weeks. They then emerge to pupate in narrow, whitish cocoons formed on potato sacks and other available surfaces. New adults appear within 2-4 weeks, depending on temperature.

DESCRIPTION
Adult 10-12 mm wingspan; *forewings* mainly yellowish-grey, peppered with black spots **(Fig. 280);** *hindwings* grey, with long hair fringes. **Egg** oval and pearly-white. **Larva** up to 10mm long; *body* white, suffused with pinkish dorsally on each segment; *head, prothoraclc plate and anal plate* brownish-black.

Family MOMPHIDAE

Spuleria atra **(Haworth)**
Pith moth

This local pest is occasionally troublesome on young, unsprayed apple trees. The larvae bore within the new shoots and cause the leaves to wilt and die. Damage is of greatest significance on young trees.

BIOLOGY
The moths fly in July and August, and deposit their eggs singly close to the buds or leaf bases. The eggs hatch in about 2 weeks, and the larvae enter the bark to burrow inside a shoot or spur throughout the autumn and winter. In spring, frass deposits are expelled from the feeding galleries through surface cracks. Larvae complete their development in June and then pupate close to the surface. Adults emerge a few weeks later.

DESCRIPTION
Adult 10-14 mm wingspan; *forewings* brownish-grey with two prominent black tufts of scales; *hindwings* grey **(Fig. 281). Larva** up to 10mm long; *body* brownish-pink; *head, prothoraclc plate and caudal plates* dark brown (see Fig. 127).

Family COCHYLIDAE

Eupoecilia ambiguella **(Hiibner)**
Vine moth

In continental Europe, this species is a pest of grape vines. Larvae of the first generation damage the flowers; those of the second generation feed directly on the developing grapes. This species occurs on various wild hosts in the British Isles, where it is univoltine and not recorded as a pest.

BIOLOGY
Adults occur in the spring, the period of activity varying from region to region. Eggs are laid on the buds of grape vines and hatch 1-2 weeks later. Larvae then spin several buds together and commence feeding, the shelters becoming more dense and larger as larval development progresses. Larvae eventually pupate in folded leaves, usually after feeding for up to a month, and adults appear about 2 weeks later. Second-generation larvae feed on immature fruits and complete their development in the autumn. They then spin overwintering cocoons, hidden in or beneath the bark of older vine stems, or in cracks on supporting posts.

DESCRIPTION

Adult 12-15 mm wingspan; *forewings* whitish-ochreous, marked with yellow-ochreous and with a conspicuous, brownish median fascia; *hindwings* grey. **Larva** up to 11mm long; *body* reddish-brown or yellowish-brown to olive-green; *pinacula* large, brown and moderately conspicuous; *head and prothoracic plate* dark brown or black; *anal plate* brownish to yellowish.

Family TORTRICIDAE (tortrix moths)

Acleris comariana (Lienig & Zeller) Strawberry tortrix moth

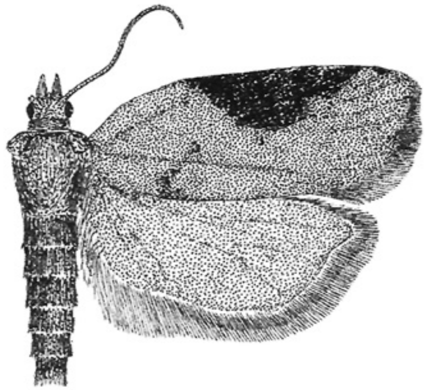


Fig. 282 Strawberry tortrix moth, *Acleris comariana* (x6).

This species is a locally common pest of strawberry, especially in fenland areas. The larvae, when numerous, cause considerable defoliation. They sometimes also attack the developing fruit, causing malformation.

BIOLOGY

Unlike other strawberry-infesting tortricids, this species overwinters in the egg stage. The eggs hatch in spring and the larvae feed in folded leaves from April onwards, sometimes webbing the foliage to adjacent blossoms. Fully fed larvae pupate in June, and adults occur from mid-June to July. Their eggs hatch in approximately 2 weeks, and the larvae feed rapidly to pupate by the autumn. A second flight of adults occurs from September to late October or early November; these moths deposit the winter eggs on the leaves of strawberry plants.

DESCRIPTION

Adult 13-18 mm wingspan; *forewings* extremely variable, but often brown with a prominent red or blackish costal blotch; *hindwings* grey **(Fig. 282). Egg** 0.8 x 0.6mm, flat, pale yellow to reddish. **Larva** up to 15 mm long; *body* green, darker dorsally; *pinacula* brown; *head* yellowish-brown; *prothoracic plate* yellowish-brown with a dark hind margin; *anal plate* green. **Young larva** whitish to brownish; *head* brown or black. **Pupa** 6.0-7.5 mm long, light brown; *cremaster* broad and short, with short lateral horns **(Fig. 283a).**

Acleris variegana (Haworth) Garden rose tortrix moth

Larvae of this polyphagous species feed on the foliage of various fruit crops (Rosaceae); they are also a pest of cultivated rose. Adults, that have much of the basal part of the forewings marked with white **(Fig. 284),** occur from July to September. The mainly green to yellowish-green larvae feed from May to early July.

Adoxophyes orana (Fischer von Roslerstamm) Summer fruit tortrix moth

This species is an important orchard pest in continental Europe. Locally important infestations also occur on apple and pear in southeastern England, especially in Kent. The larvae damage the leaves but, more significantly, graze upon the maturing fruits from which they remove large areas of skin.

BIOLOGY

Adults occur in June and again, usually in larger numbers, in August and September. Eggs are laid in yellow, scale-like batches on the leaves and hatch about 10 days later. Larvae inhabit

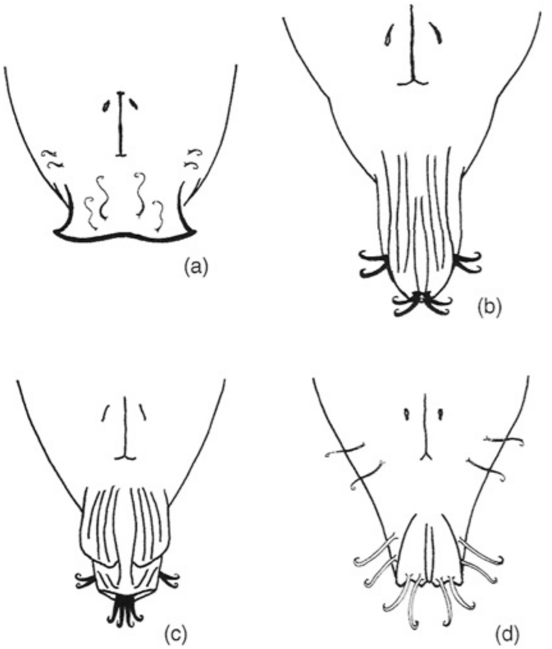


Fig. 283 Pupal cremasters: (a) strawberry tortrix moth, *Acleris comariana;* (b) carnation tortrix moth, *Cacoecimorpha pronubana;* (c) straw-coloured tortrix moth, *Clepsis spectrana;* (d) dark strawberry tortrix moth, *Olethreutes lacunana.*

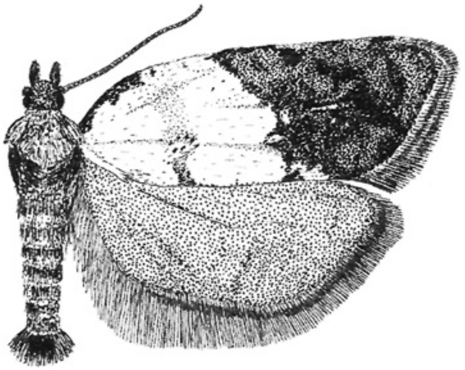


Fig. 284 Garden rose tortrix moth, *Acleris variegana* (x6).

spun leaves, attacking the foliage and developing fruits. Summer larvae pupate in August. Larvae produced by second-generation adults overwinter and pupate in late May or early June.

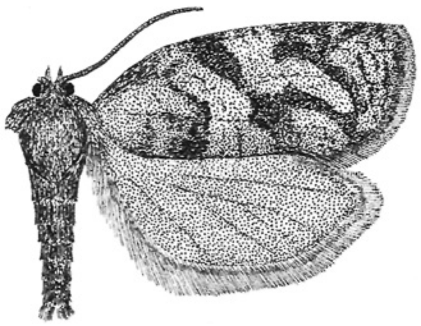


Fig. 285 Male summer fruit tortrix moth, *Adoxophyes orana* (x6).

DESCRIPTION

Adult female 18-22 mm wingspan; *forewings* greyish-brown, with inconspicuous, reticulated markings; *hindwings* grey. **Adult male** 15-19 mm wingspan; *forewings* light greyish-brown, with dark brown to ochreous markings; *hindwings* grey **(Fig. 285). Larva** up to 20 mm long; *body* yellowish-green to dark green; *pinacula* small and yellowish; *head and prothoracic plate* yellowish-brown. **Pupa** 10-11mm long, dark brown.

Archips podana **(Scopoli)**
Fruit tree tortrix moth

This is one of the most abundant tortricid species to occur on fruit crops. The larvae damage the buds, leaves and developing fruits of apple, pear, plum, currant, raspberry and many other plants.

BIOLOGY

Adults are usually most abundant in July. They deposit eggs in flat, green batches on the leaves of various trees. The eggs hatch about 3 weeks later and the larvae then feed beneath silken webs often formed between leaves and adjacent maturing fruits. Larvae eventually hibernate, usually in their third instar; under favourable conditions, however, some may complete their development in the summer to produce a partial second generation in the autumn. In early spring, overwintered larvae, including those from any second generation, again become active; they attack buds and young leaves. Most larvae are fully grown in late May or June. They then pupate in spun leaves and adults emerge several weeks later.

DESCRIPTION
Adult female 20-28 mm wingspan; *forewings* purplish-ochreous, with darker reticulated markings and with a dark apical spot; *hindwings* brownish-grey. **Adult male** 19-23 mm wingspan; *forewings* purplish-ochreous to dark purplish, with bluish, yellow and dark chestnut-brown marking; *hindwings* grey, orange-tinged apically **(Plate 12a).** **Larva** up to 22 mm long; *body* green to greyish-green; *pinacula* pale greenish; *head* brown;*prothoracicplate* chestnut-brown with dark markings and a pale anterior margin; *anal plate* green or grey **(Plate 12b).** **Young larva** yellowish; *head* black.

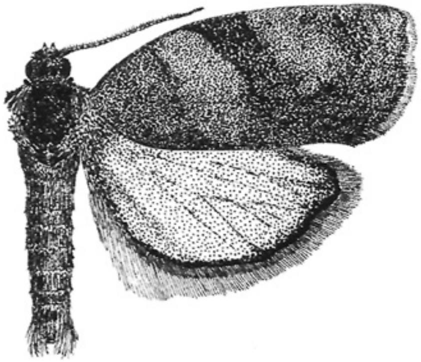


Fig. 286 Male carnation tortrix moth, *Cacoecimorpha pronubana* (x6).

Cacoecimorpha pronubana (Hiibner)
Carnation tortrix moth

This species is extremely polyphagous and attacks a wide range of crops, including maize, raspberry, strawberry and many ornamentals. The larvae attack buds, leaves, flowers and fruits, and can be very damaging. The pest is of African origin and, in northern Europe, is most harmful on protected crops.

BIOLOGY
All stages of this pest may be found throughout the year. However, it tends to occur in two main generations, with adults flying in sunny weather from May to June and from August to September. Eggs are laid on leaves in large, green, scale-like batches. They hatch 2-3 weeks later. The larvae feed voraciously, often sheltering in spun leaves, but the rate of development varies considerably depending on temperature. Pupation occurs in a folded leaf or amongst other shelter, and adults emerge shortly afterwards. Outdoors, this species usually overwinters as small larvae.

DESCRIPTION
Adult female 18-22 mm wingspan; *forewings* pale orange-brown, reticulated with darker brown; *hindwings* mainly orange. **Adult male** 12-17 mm wingspan; *forewings* orange-brown, with reddish-brown and blackish markings; *hindwings* orange with a blackish border **(Fig. 286).** **Larva** up to 20 mm long; *body* olive-green to bright green; *pinacula* pale green but inconspicuous; *head* yellowish-green or yellowish-brown, marked with dark brown; *prothoracic plate and anal plate* green, marked with dark brown; *anal* comb green, often with six teeth. **Pupa** 9-12 mm long, brownish-black to black; *cremaster* long, tapered with eight strong spines **(Fig. 283b).**

Clepsis spectrana (Treitschke)
Straw-coloured tortrix moth

This widespread moth is a pest of various glasshouse plants; infestations also occur on various outdoor crops, including black currant, rhubarb and strawberry. The larvae cause considerable leaf damage, especially to the younger shoots, and also attack buds and flowers.

BIOLOGY
Moths occur in two main generations, from June to July and from August to September. Eggs are deposited in small groups on the leaves of host plants and they hatch 2-3 weeks later. Larvae inhabit webbed leaves and may also spin the petals of flowers together to form shelters. When

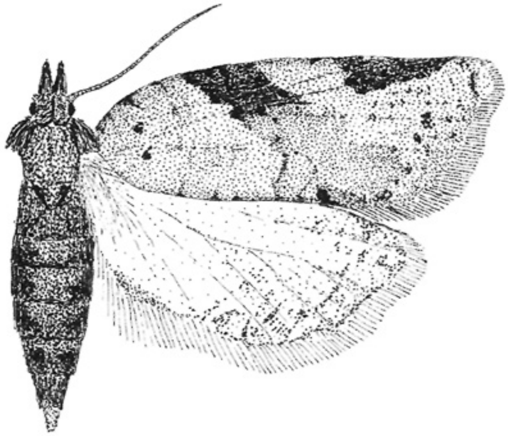


Fig. 287 Female straw-coloured tortrix moth, *Clepsis spectrana* (x6).

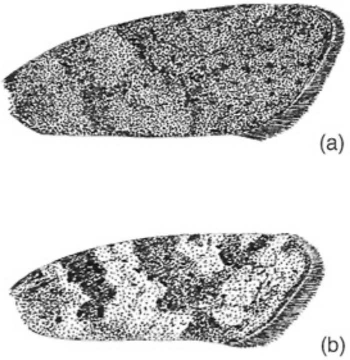


Fig. 288 Forewings of *Cnephasia:* (a) flax tortrix moth, *C. asseclana:* (b) light grey tortrix moth, *C. incertana* (x6).

fully grown, each pupates in its habitation or amongst dead leaves. Adults emerge 2-3 weeks later. Second-generation larvae usually overwinter whilst still very small and complete their development in the spring. In glasshouses, development may be continuous.

DESCRIPTION

Adult 15-24 mm wingspan; *forewings* pale ochreous-yellow to yellowish, with dark brown to blackish markings; *hindwings* pale grey **(Fig. 287). Egg** orange, flat and oval. **Larva** up to 25 mm long; *body* greyish-green to brownish, but paler dorsally; *pinacula* whitish; *head and prothoracic plate* black or blackish-brown; *anal plate* whitish-brown, with darker markings; *anal comb* with six to eight teeth. **Pupa** 10-14 mm long, dull black; *cremaster* elongate, with stout hooked spines (Fig. 283c).

Cnephasia asseclana **(Denis & Schiffermiiller)**
Flax tortrix moth

This species is a potentially important pest of various crops, the larvae (sometimes known as 'poppy leaf rollers') often feeding in large numbers on the leaves of lettuce, linseed, pea, poppy and *Vicia* bean. Infestations also occur on various other crops, including currant, raspberry, strawberry and sunflower. When disturbed, unlike most other members of the family Tortricidae, larvae of the genus *Cnephasia* usually do not wriggle backwards, but roll into a tight 'C and drop to the ground.

BIOLOGY

Adults are active from June to August. Eggs are laid on fence posts, tree trunks or other structures and hatch about 3 weeks later. Apart from devouring their egg shells, the larvae do not feed until the following year. Instead, they form silken hibernacula in which to overwinter. In spring, the larvae invade various plants, at first mining the leaves and forming blotches. In their later instars, the larvae usually inhabit spun leaves **(Plate 12c);** they also attack open flowers. It is not uncommon, however, to find relatively large larvae still mining within leaves. When fully grown, the larvae pupate in spun leaves or amongst debris on the ground. Adults emerge shortly afterwards.

DESCRIPTION

Adult 15-18mm wingspan; *forewings* whitish-grey, more or less suffused with darker, often black-edged, markings **(Fig. 288a);** *hindwings* greyish-brown. **Larva** up to 14 mm long; *body* grey to greyish-green; *pinacula* black; *head* pale brown, marked with black; *prothoracic plate and anal plate* brown marked with black; *anal comb*

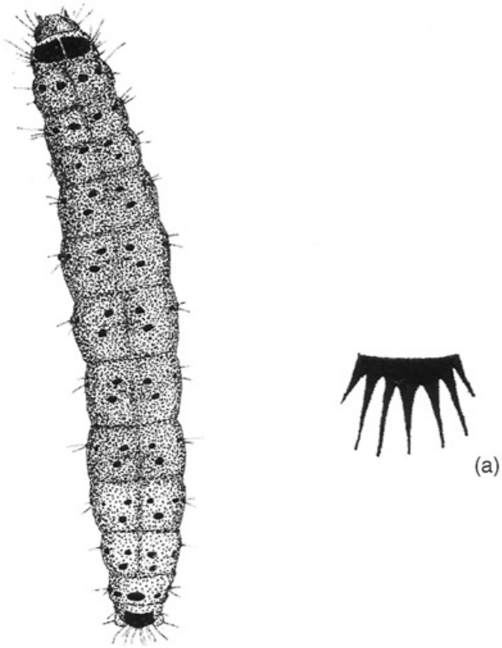


Fig. 289 Larva of flax tortrix moth, *Cnephasia asseclana* (x6): (a) anal comb (further enlarged).

present and with about six teeth **(Fig. 289)** (cf. *Cnephasia incertana,* p. 217). **Pupa** 7-8mm long; light brown; *cremaster* armed with spines which terminate in strong, noticeably thickened, hooks (cf. *C. incertana,* p. 217).

Cnephasia longana **(Haworth)**
larva = **Omnivorous leaf tier**

This locally common pest is polyphagous, but associated mainly with wild Asteraceae, including thistles. Crops attacked include apple, barley, bean, beet, linseed, maize, strawberry and wheat.

BIOLOGY
Moths are active in July and their eggs are then laid on tree trunks and other surfaces. The larvae overwinter in silken hibernacula, having fed only on their egg shells. In spring they invade various host plants and usually inhabit folded leaves or a shelter of webbed-down petals. They complete their development in June and then pupate in a silken cocoon on the host plant. Adults emerge 2-3 weeks later.

DESCRIPTION
Adult 15-22 mm wingspan; *forewings* whitish-ochreous to brownish-ochreous (in the female with darker markings); *hindwings* light grey. **Larva** up to 18 mm long; *body* greenish-grey to yellowish-grey, with pale stripes along the back; *head* light brown; *prothoracic plate and anal plate* light brown **(Plate 12d). Pupa** 7-8 mm long, light brown.

Cnephasia pumicana **(Zeller)**
larva = **Cereal leaf roller**

This species is associated mainly with cereals, and is reported as a potentially important pest in parts of continental Europe, especially northern France. The larvae also feed on various other plants, although on many such 'hosts' they cannot complete their full development. Most significant damage is caused to the ears of wheat and barley. In some instances, grains are totally destroyed or their development aborted. In other cases, following damage to the stem above the top-most node, the ear turns white; on barley, yield losses of over 20% are reported. This pest does not occur in the British Isles.

BIOLOGY
Adults are active in July. Eggs are then laid on the bark of trees and on other similar surfaces. First-instar larvae appear in August and then almost immediately spin hibernacula within which to overwinter. Larvae reappear in the spring, usually from March onwards. They then produce a line of silk and are carried by the wind until they alight on a suitable host plant. On cereals, the larvae at first mine within the leaves. In the later stages of their development, the larvae feed externally, attacking the stems and the developing ears. Fully fed larvae pupate within the shelter of the ear sheath and adults emerge 2-3 weeks later. There is just one generation annually.

DESCRIPTION
Adult 16-20 mm wingspan; *forewings* mainly yellowish-grey; *hindwings* pale yellowish-grey. **Egg** 1 mm long, elliptical, pale yellowish-orange

but later becoming reddish-orange. **Larva** up to 12 mm long; *body* mainly greyish to pale ochreous; *pinacula, prothoracic plate and anal plate* slightly darker than the body. **Pupa** 7 mm long, reddish-brown.

Cnephasia incertana (Treitschke)
Light grey tortrix moth

This species is essentially similar in habits and appearance to *Cnephasia asseclana* (p. 215) but the adults have slightly narrower, usually paler, forewings **(Fig. 288b);** the larvae lack an anal comb and are usually paler in colour; the pupae are dull black and the spines on the cremaster do not terminate in strongly thickened hooks. The larvae are polyphagous and damage a wide range of crops, including bean, clover, pea and strawberry.

Cnephasia pasiuana (Hiibner)

This often common species is associated with *Ranunculus* and various kinds of Asteraceae. Although not usually of pest status, larval infestations are sometimes found on sunflower crops in May and June. Adults, that occur in June and July, are similar to those of *Cnephasia asseclana* (p. 215) but usually distinguished by the less strong and more uniform markings on the forewings and the relatively broad median fascia. Larvae (up to 14 mm long) are mainly yellowish-brown to greenish-grey, with black pinacula, a pale yellowish-brown (black-marked) head, a yellowish-brown (black-speckled) prothoracic plate and a black anal comb.

Cydia funebrana (Treitschke)
Plum fruit moth

This insect is a widely distributed and locally common pest of damson and plum; infestations are often also abundant on *Prunus spinosa.* The larvae, known as 'red plum maggots', feed singly within the flesh of developing fruits, and often cause premature ripening and fruit drop. Unlike fruitlets attacked by larvae of the fruitlet-mining tortrix moth, *Pammene rhediella* (p. 222) and plum sawfly, *Hoplocampa flava* (p. 251) wet, brown larval frass accumulates within the fruit and is not ejected from the feeding gallery during larval development. This pest is of particular importance in years when fruit set is light and in conditions favourable for development of a noticeable second generation. Second-generation or late-developing larvae are a particular problem as they often occur inside harvested fruits. Even very small numbers of infested fruits may be sufficient for processors to reject crops at the factory.

BIOLOGY
Moths are most numerous from mid-June to mid-July, but may occur at any time from the end of May to September. Eggs are laid singly on developing fruitlets. The eggs hatch in about 2 weeks and the young larvae then burrow into the flesh to begin feeding. Larval development lasts for approximately 5 weeks. Fully fed individuals vacate the fruits from late July or early August onwards. They then spin cocoons in sheltered positions on the bark of host trees, overwinter and pupate in the spring. Under favourable conditions, early-developing larvae may pupate immediately and give rise to a partial second generation of adults in August or September. Second-generation larvae complete their development in the autumn.

DESCRIPTION
Adult 11-15 mm wingspan; *forewings* dull purplish-grey, with darker but obscure markings, and irregularly suffused with ash-grey; *hindwings* brownish-grey **(Fig. 290).** **Egg** 0.7 x 0.6mm,

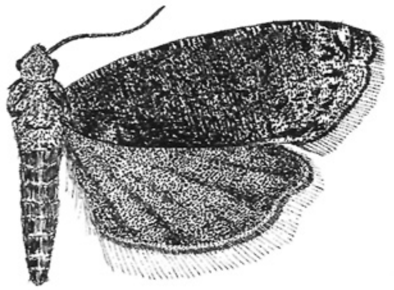


Fig. 290 Plum fruit moth, *Cydia funebrana* (x6).

flat, oval and translucent. **Larva** up to 12 mm long; *body* reddish (early instars whitish); *head* dark brown; *prothoracic plate and anal plate* light brown with darker markings; *anal comb* present but with a weakly sclerotized base (cf. that of *Pammene rhediella*, p. 222). **Pupa** 6-7 mm long, light brown.

Cydia nigricana (F.) Pea moth

This widely distributed species is an important pest of cultivated peas. The larvae bore into the developing seeds **(Plate 12e),** and heavy infestations cause considerable losses to field crops and to garden peas. The insect also attacks other cultivated and wild Fabaceae. The extent of damage within infested pods tends to be greatest in dry-harvested peas, as these are harvested later in the season, but significant damage rarely occurs in early-sown peas due to be harvested before July.

BIOLOGY

Moths occur from late May or early June onwards, but are usually most numerous during mid-July. They often congregate in suitable habitats, and fly during the afternoon in warm, sunny weather and in the evening. Eggs are laid mainly on the underside of expanded leaves and stipules of host plants, either singly or in small groups; they are usually deposited on the upper half of the plant and hatch about 8 days later. The young larvae are very active and each crawls rapidly over the host plant before locating a pod and burrowing inside to attack the seeds. Each larva feeds for several weeks and passes through five instars. When fully grown, usually in August or September, the larvae escape into the soil. Here they overwinter, each in an oval (c. 10 x 4.5 mm), thick-walled, silken cocoon incorporating particles of soil. Most cocoons are formed a few centimetres below the surface but some occur at much greater depths. In the following spring, earlier or later depending on temperature, larvae (but not necessarily all of those already close to the surface) emerge from the cocoons and move through the soil to spin feeble, web-like structures just below the surface. The larvae then pupate, and adult moths emerge about 2 weeks later. There is just one generation annually.

DESCRIPTION

Adult 12-16 mm wingspan; *forewings* mainly dark brown, suffused with grey, and marked with several black dashes below the apex of the costa and with several oblique whitish strigulae along the costal margin, especially towards the tip **(Plate 12f);** *hindwings* dark brown. **Egg** 0.7 x 0.5 mm, flattened and oval; yellowish-white when newly laid but each soon develops a pair of irregular pinkish-red markings that disappear before hatching. **Larva** up to 14 mm long; *body* yellowish-white, often greenish-tinged; *pinacula* greyish **(Plate 12e);** *head* yellowish-brown; *prothoracic plate* pale yellowish-brown, marked with dark brown or blackish; *anal comb* absent. **Pupa** 7-8 mm long, dark brown.

Cydia ***pomonella*** (L.) Codling moth

This notorious worldwide apple pest is often responsible for considerable fruit losses, especially on unsprayed or infrequently sprayed trees. The larvae (apple maggots) burrow singly into the flesh of infested apples, filling the cavity with brownish frass; larvae will also feed on the pips. Infested fruits often have a distinct frass-filled hole in the side, surrounded by a reddish ring; sometimes, however, this hole occurs close to the calyx (eye) and is then less obvious. Attacked fruits ripen prematurely and often drop before harvest. Damage is often particularly serious in years when a noticeable second generation occurs. Pear is also attacked. Codling moth larvae occur later in the year and, therefore, in larger fruits than those of the fruitlet-mining tortrix moth, *Pammene rhediella* (p. 222) or apple sawfly, *Hoplocampa testudinea* (p. 250). Also, larvae of both other pests typically eject frass from their galleries.

BIOLOGY

First-generation adults occur mainly from mid-June to mid-July but, depending on the season, may be found at any time from mid-May or late May to August. The moths fly at dusk and activity is favoured by temperatures in excess of 15°C. Eggs are laid either on the foliage or directly on the fruits. They hatch in approximately 2 weeks and the larvae burrow into the flesh of developing fruits, often entering through the calyx (eye). Larvae occur mainly in July and August, and are fully fed in about a month. They then migrate from the fruit and spin cocoons on the bark of host trees. Most larvae overwinter and pupate in the spring. However, in favourable years, individuals spinning-up by the end of July may pupate and give rise to a partial ;econd-generation of adults. Late-developing and second-generation larvae often complete their development only after apples have been harvested. They will then pupate in apple boxes and in sheds where fruit or such boxes are stored.

DESCRIPTION

Adult 15-22 mm wingspan; *forewings* mainly blackish-brown, more or less suffused with ash-grey, and with a large, metallic, bronzy-black blotch near the tip; *hindwings* brown **(Fig. 291). Egg** 1.3 x 1.0 mm, flat, oval and translucent. **Larva** up to 20 mm long; *body* pinkish-white but younger instars whitish; *pinacula* dark; *head and prothoracic plate* brown; *anal plate* pale; *anal comb* absent. **Pupa** 8-10 mm long, yellowish-brown to dark brown.

Enarmonia formosana (Scopoli)
Cherry bark tortrix moth

This moth is mainly a pest of mature trees (Ro^aceae), including apple and cherry. The larvae burrow within the bark of the trunks and main branches; attacked trees are weakened and may be killed.

BIOLOGY

Adults emerge over a long period, from May to September. They are often active in sunshine but remain settled on the bark in dull weather conditions. Eggs are usually laid on infested parts of host trees and hatch 2-3 weeks later. The larvae feed within the bark for several months, before pupating in the following spring or summer, each in a silken cocoon spun within the larval gallery.

DESCRIPTION

Adult 15-18 mm wingspan; *forewings* purplish-brown with irregular, yellowish-orange markings and silvery-white striae on the costa; *hindwings* dark brown **(Fig. 292). Larva** up to 11mm long; *body* brownish to pinkish; *pinacula* brownish; *head* light brown; *prothoracic plate and anal plate* light greyish-brown. **Pupa** 7-9 mm long, light brown; *cremaster* broad and blunt.

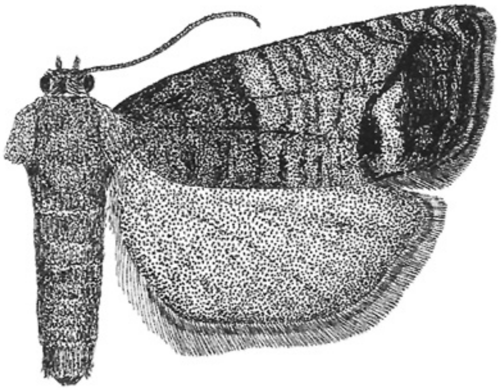


Fig. 291 Codling moth, *Cydia pomonella* (x6).

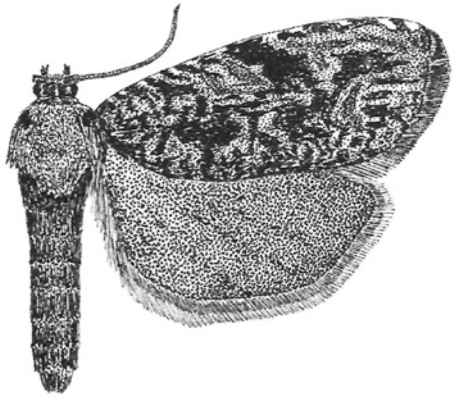


Fig. 292 Cherry bark tortrix moth, *Enarmonia formosana* (x6).

***Endothenia gentianaeana* (Hiibner)**

This locally distributed moth is associated with *Dipsacus fullonum.* Infestations also occur on cultivated teasel, the seed heads of which are used in preparing (teasing) high-quality cloth such as that used as billiard-table baize. Infested seed heads are weakened and easily collapse, making them unsuitable for commercial use.

BIOLOGY
Adults occur in July and deposit eggs on teasel. The larvae feed singly within the pith of the seed heads during September and October, partly filling the receptacles with masses of blackish frass and whitish webbing. An emergence hole, through which the adult moth will eventually emerge, is bored through the wall of the seed head. The fully fed larva then overwinters, still within the seed head, and pupates in the late spring.

DESCRIPTION
Adult 15-19 mm wingspan; *forewings* ochreous-white, suffused with blackish-brown, especially basally, and irregularly marked with black, white and bluish-grey; *hindwings* dark grey with creamish-white cilia. **Larva** 12-15 mm long; *body* greyish-cream to whitish-grey; *pinacula* indistinct, greyish or brownish-grey: *head and prothoracic plate* blackish-brown; *anal plate* pale brown. **Pupa** 9-12 mm long, reddish-brown with paler wing pads.

***Epiblema uddmanniana* (L.)**
Bramble shoot moth

This species is an important pest of blackberry and loganberry. The larvae, commonly known as 'bramble shoot webbers', destroy buds, and also cause death and distortion of shoots. Canes of heavily infested plants are weakened and crop yields in the following year are reduced.

BIOLOGY
Small larvae overwinter in silken cocoons. In spring, they attack the flower buds. Later, each feeds on the shoots within a shelter of tightly webbed leaves. These habitations, within which masses of frass accumulate, are formed both on the fruiting canes and on the new growth. Pupation takes place within the larval habitation from May onwards and the adult emerges about 3 weeks later. There is just one generation annually.

DESCRIPTION
Adult 15-20 mm wingspan; *forewings* pale grey to brownish-grey, with a white-bordered chocolate-brown blotch on the hind margin; *hindwings* grey **(Fig. 293).** **Larva** up to 15 mm long; *body* dark brown; *pinacula, head, prothoracic plate and anal plate* black or brownish-black **(Fig. 294).**

***Hedya dimidioalba* (Retzius)**
Marbled orchard tortrix moth

This polyphagous species attacks various trees and shrubs, especially *Crataegus* and other

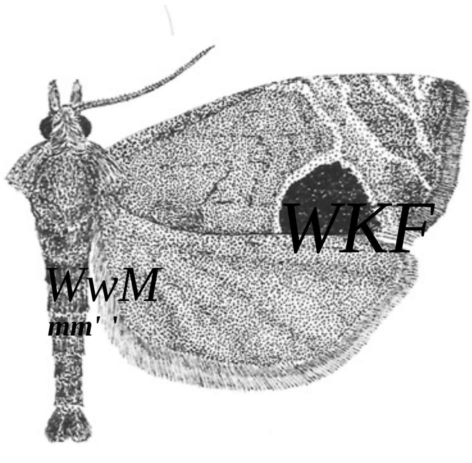


Fig. 293 Male bramble shoot moth, *Epiblema uddmanniana* (x6).

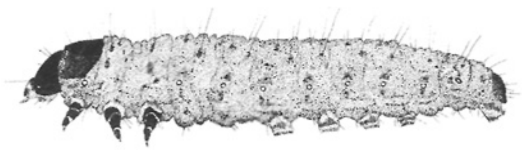


Fig. 294 Bramble shoot webber, *Epiblema uddmanniana* (x5).

Rosaceae. The larvae sometimes cause damage to the leaves and blossoms of orchard trees such as apple, cherry, pear and plum; they may also bore into the young shoots, causing the tips to wilt and die.

BIOLOGY
Adults occur in June and July. Eggs are deposited mainly on the underside of leaves of host plants and hatch in about 2 weeks. The larvae feed for a short time during the summer but then spin cocoons (e.g. in bark crevices) within which to overwinter. Activity is resumed in the spring. The larvae then attack the buds, blossom trusses and young leaves, often spinning leaves together with silk. Pupation takes place in late May or June, either within the larval habitation or between freshly spun leaves.

DESCRIPTION
Adult 15-21 mm wingspan; *forewings* ochreous-white, suffused with black, blue and grey markings **(Fig. 295a). Larva** up to 20 mm long; *body* olive-green to dark green; *pinacula* black; *head, prothoracic plate, thoracic legs, anal plate and anal comb* black or brownish-black.

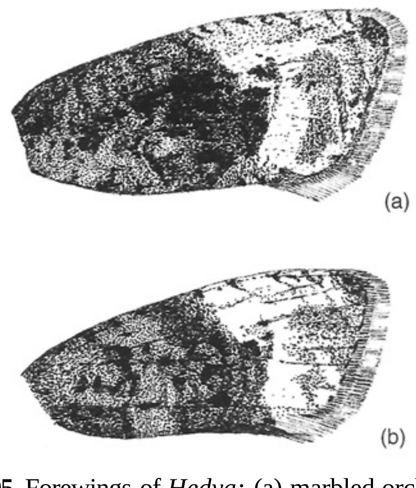


Fig. 295 Forewings of *Hedya:* (a) marbled orchard tortrix moth, *H. dimidioalba;* (b) plum tortrix moth, *H. pruniana* (x6).

Hedya pruniana **(Hiibner)**
Plum tortrix moth

This pest is essentially similar to the previous species but is associated mainly with *Prunus* (especially *P. spinosa),* including cultivated plum. Larvae cause damage in the spring to the leaves and shoots. Adults (14-18 mm wingspan) are slightly smaller than those of *Hedya dimidioalba* and the background colour of each forewing is distinctly white **(Fig. 295b).** Larvae (up to 18 mm long) are bright green with the head, prothoracic plate, pinacula and thoracic legs black.

Lobesia botrana **(Denis & Schiffermiiller)**
European vine moth

This species is an important pest of grape vines in southern Europe. Larvae destroy flower buds and, sometimes, cause the death of complete inflorescences; later in the season, larvae damage or destroy the developing grapes. Moulds often develop on the damaged tissue, which can lead to additional problems.

BIOLOGY
Adults of this species emerge in late April or early May. Eggs are laid mainly on flower buds and hatch a week or so later. Larvae of the first generation feed within the flower buds and may also burrow into peduncles. Pupation occurs in the larval habitation, moths of the next generation appearing in about a week. Development of the second generation is often very rapid and, if conditions are particularly favourable, there may be further generations. The winter is passed in the pupal stage, within cocoons spun under bark, in cracks on supporting posts and in other sheltered situations.

DESCRIPTION
Adult 15-20 mm wingspan; *forewings* creamish-white, with a variegated pattern of reddish-brown and blackish markings; *hindwings* dark brownish-grey (female) or whitish-grey (male). **Larva** up to 9 mm long; *body* greyish-green or

yellowish-green to brownish; *head* yellowish-brown; *prothoracic plate* brown; *anal plate* pale brownish-yellow; *anal comb* with six to eight prongs.

Olethreutes lacunana **(Denis & Schiffermiiller)**
Dark strawberry tortrix moth

This generally common, polyphagous species occurs mainly on herbaceous plants and is sometimes very damaging to strawberry crops grown under cloches. Other hosts include apple, field bean and raspberry.

BIOLOGY
The winter is passed as young hibernating larvae. These become active in early spring, sheltering in spun leaves and feeding avidly on foliage and flowers. They eventually pupate, and adults appear from May or June onwards. These adults lay eggs in pairs or in small groups on the leaves of host plants. These eggs hatch 2-3 weeks later. Larvae of the summer brood feed up to produce adults in August or September. In some situations this species completes just one generation in a year, overwintering in the pupal stage.

DESCRIPTION
Adult 15-18 mm wingspan; *forewings* whitish-ochreous to greyish-ochreous, marked with olive-green and brownish-black; *hindwings* brownish-grey **(Fig. 296).** **Larva** up to 14 mm long; *body* narrow and mainly dark: purplish-brown; *pinacula* blackish; *head, prothoracic plate and anal plate* blackish-brown; *anal comb* blackish, with five long teeth. **Pupa** 8-10 mm long, dark brown; *cremaster* bluntly tapered and with relatively long, hooked spines **(Fig. 283d).**

Pammene rhediella **(Clerck)**
Fruitlet-mining tortrix moth

This species is a pest of apple and plum. The larvae mine within the developing fruitlets that then either drop prematurely or, if damaged only superficially, will mature on the tree and bear corky scars.

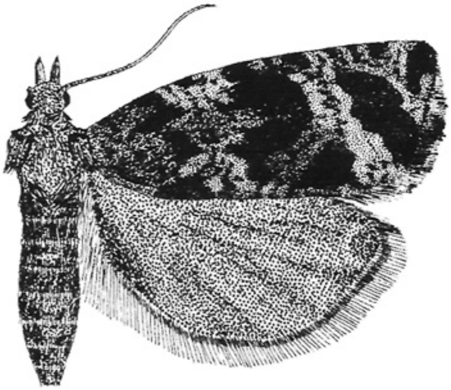


Fig. 296 Dark strawberry tortrix moth, *Olethreutes lacunana* (x6).

BIOLOGY
Adults are active in May and June, and often fly in sunny weather. Eggs are deposited singly on leaves growing close to developing fruitlets. The eggs hatch about 2 weeks later. Larvae then attack the fruitlets. They graze on the skin and also penetrate deeply into the flesh. Unlike other related species, the larvae web fruitlets and adjacent leaves together with strands of silk, amongst which particles of frass expelled from their feeding galleries accumulate; galleries in infested fruits, however, are typically frass-free (cf. codling moth, *Cydia pomonella,* p. 218, and plum fruit moth, *C. funebrana*, p. 217). In late June or early July, the fully-fed larvae seek shelter on the bark of host trees and spin hibernacula. They then overwinter and pupate in the spring, shortly before the emergence of the adults.

DESCRIPTION
Adult 9-11 mm wingspan; *forewings* dark purplish-brown basally and centrally, orange apically; *hindwings* dark brown **(Fig. 297).** **Larva** up to 6 mm long; *body* whitish; *pinacula* light brown; *head, prothoracic plate, anal plate and anal comb* brown.

Spilonota ocellana **(Denis & Schiffermiiller)**
Bud moth

This pest is of local importance on fruit trees and, less often, cane' fruits. The larvae bore into the

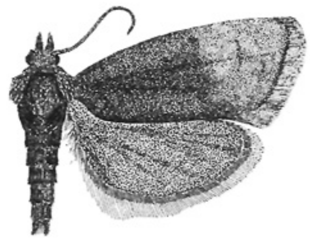


Fig. 297 Fruitlet-mining tortrix moth, *Pammene rhediella* (x6).

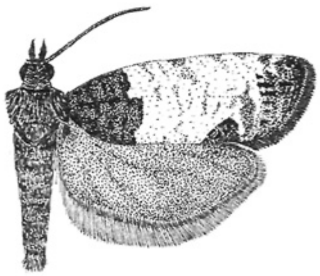


Fig. 298 Bud moth, *Spilonota ocellana* (x6).

buds and destroy them; they also feed on the blossoms and leaves.

BIOLOGY

Adults are active from June to August. Eggs are laid on the leaves of host plants and hatch 1-2 weeks later. The larvae feed on leaves during the autumn and then overwinter in silken retreats on the bark. In spring, the larvae bore into the buds and may also attack leaves and blossom trusses, often hiding between spun leaves. Pupation occurs in late May or early June, either in the larval habitation or amongst debris on the ground. Adults appear about a month later.

DESCRIPTION

Adult 12-16 mm wingspan; *forewings* white, marked with blue, grey and black; *hindwings* dark grey **(Fig. 298). Larva** up to 12 mm long; *body* dark purplish-brown; *pinacula* light brown but inconspicuous; *head, prothoracicplate and anal plate* black or brownish-black **(Fig. 299). Pupa** 6-7 mm long, shiny brown; *wing pads* with outline darker than abdomen.

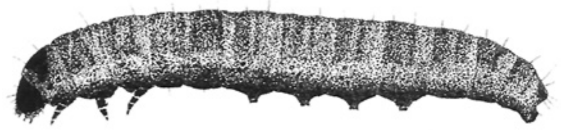


Fig. 299 Larva of bud moth, *Spilonota ocellana* (x6).

Family PYRALIDAE

Agriphila straminella (Denis & Schiffermiiller)

This widely distributed and generally common grass moth sometimes causes damage to grass and cereal ciops, including both spring- and autumn-sown barley and wheat. The larvae bite into the base of the stems and, in spring, often cause death of the central shoots. Damage is also caused to leaves. Holes formed in plant stems, unlike those caused by leatherjackets (p. 163) and wireworms (p. 132), are smooth-sided and not ragged. Attacks occur most frequently on cereal crops following leys or permanent grass.

BIOLOGY

Moths appear from June to August and are often abundant in grassy situations. In common with other related species, they fly mainly at dusk and at night, but they are readily disturbed during the daytime when they fly short distances before resettling, head downwards, on grass stems or other plant material. Eggs are laid during the summer and hatch in the autumn. The larvae feed from September onwards, each inhabiting a flimsy, silk-lined tunnel formed amongst the basal parts of host plants, and in which green particles of frass accumulate. They hibernate in these tunnels during the winter and recommence feeding in the spring. Larvae sometimes occur within the stems of host plants, typically head downwards. Pupation occurs within oval, frass-covered, silken cocoons formed just below the soil surface.

DESCRIPTION

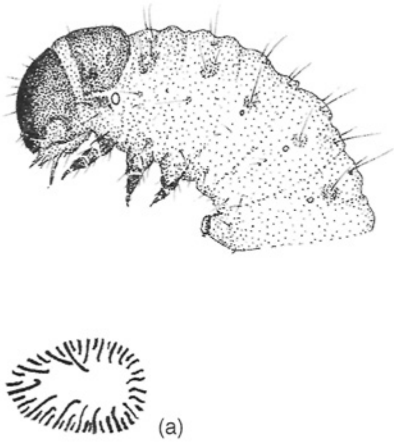
Adult 18-20 mm wingspan; *labial palps* prominent; *forewings* mainly white to brownish-white; *hindwings* grey. **Larva** up to 13 mm long; *body* pale purplish-brown; *pinacula* brown; *head and prothoracic plate* brown with darker markings.

Chrysoteuchia culmella **(L.)**
Garden grass veneer moth

This generally abundant species sometimes causes severe damage in permanent grassland. Attacked plants are severed at or below ground level, damage being caused both to the leaves and the root system. Large patches of dead grass occur in heavily infested sites, and damage may extend over several hectares.

BIOLOGY
Adults occur in June and July. They fly mainly at dusk but, if disturbed during the daytime, they fly away erratically to settle again a short distance ,away, typically head downwards on grass stems. Eggs are dropped at random onto the soil in grassy situations; they hatch shortly afterwards. The larvae. attack the base of grass stems; the larvae also;,giaze on the leaves. They shelter in the soil within the root system, typically adopting a C-shaped posture; unlike various closely related species (e.g. *Agriphila straminella*, p. 223), they do not form silken galleries Individuals are usually fully fed by the autumn. They then overwinter and pupate in the late spring.

DESCRIPTION
Adult 20-24 mm wingspan; *forewings* yellowish-brown, marked with black and with a pale, distinctly bent subterminal line **(Plate 13a);** *hindwings* brownish-grey. **Larva** up to 15 mm long; *body* yellowish-white to dirty greenish-white; *pinacula* large and shiny (but pale and often indistinct), each bearing a relatively long, stout, black seta; *spiracles* small and jet black **(Fig. 300);** *head* chestnut-brown; *prothoracic plate and anal plate* yellowish-brown to brownish-black **(Plate 13b).**



^ S l i # (a)

Fig. 300 Anterior part of larva of garden grass veneer moth, *Chrysoteuchia culmella* (xlO): (a) arrangement of crochets on an abdominal proleg (further enlarged).

Evergestis forficalis **(L.)**
Garden pebble moth

Infestations of this often common but usually minor pest occur on the leaves of various brassica crops, including broccoli, Brussels sprout, cabbage, cauliflower and turnip. The larvae, sheltered by masses of fine webbing in which their frass accumulates, also invade the heads of broccoli and cabbages; such plants are often rendered unmarketable. Although rarely troublesome on field crops, infestations can be of significance in allotments, market gardens and on garden vegetable plots.

BIOLOGY
Adults of the first generation occur in May and June. Eggs are then laid in small batches on the leaves of host plants. They hatch about 10 days later. The larvae feed for about 3 weeks, often webbing young leaves together; there are four larval instars. Pupation takes place in the soil in strong silken cocoons formed a few centimetres below the surface. Adults emerge in August and September. Second-generation larvae feed during the autumn, and complete their development before the onset of winter. They then enter the soil where they overwinter; they eventually pupate in the spring. Under favourable conditions there may be a partial third generation.

DESCRIPTION
Adult 25-27 mm wingspan; *forewings* brownish-white, with brown and blackish markings **(Plate**

13c); *hindwings* pale creamish-white with pale greyish markings and a dark submarginal line. **Larva** up to 18mm long; *body* greenish to yellowish and somewhat translucent, with a dark, dorsal stripe and a pale spiracular stripe, small black spiracles and pale hairs **(Plate 13d);** fully fed individuals are distinctly glossy; *head and prothoracic plate* brownish-green to yellowish-green.

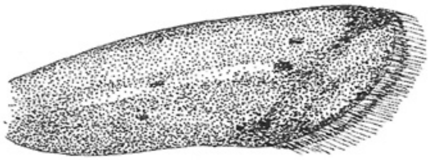


Fig. 301 Forewing of sunflower moth, *Homoeosoma nebulella* (x5).

Homoeosoma nebulella
(Denis & Schiffermiiller)
Sunflower moth

This moth is associated with various members of the Asteraceae and, in the warmer parts of continental Europe, is a pest of sunflower. The larvae feed on the inflorescences of host plants, at first devouring pollen but later burrowing into the flowers or maturing seeds. In severe cases over a quarter of sunflower seed yields may be lost. Although present and widely distributed in England, this species is not of pest status in the British Isles.

BIOLOGY
Larvae of the first generation occur on wild hosts, usually feeding in late May and early June. Sunflower crops are attacked by larvae of the second generation, rather than the first, as eggs will not be deposited unless flowers are producing pollen. Attacks will continue into early winter, so long as the crop has not been harvested and suitable flowers are still available. The pest usually completes two or three generations in a season.

DESCRIPTION
Adult 22-27 mm wingspan; *forewings* ash-grey with a brownish sheen, and each marked with a few scattered dark spots **(Fig. 301);** *hindwings* pearly and translucent. **Egg** 1mm long, yellowish-white. **Larva** up to 14 mm long; *body* pale greenish-yellow to dirty grey, marked with reddish or purplish dorsal, subdorsal and spiracular lines; *head* brown; *prothoracic plate* green.

Margaritia sticticalis (L.)
***larva* = Beet webworm**

Larvae of this species feed mainly on *Artemisia vulgaris* but they will also attack sugar beet, spinning the leaves of young plants together; when numerous, the larvae cause extensive defoliation but the major veins are left intact. Although an important pest in continental Europe and in North America, it is of little or no importance in Britain, where it occurs mainly in sandy districts such as the Brecklands of East Anglia.

BIOLOGY
Adults occur in June and there may be a partial second flight in August and September. Although active mainly at night, the moths sometimes also fly in hot, sunny weather. Eggs are laid on the leaves of host plants, mainly in early June. They hatch shortly afterwards. Larvae then feed on the leaves, and often web leaves together to form a tube which extends down to the soil surface. The larvae are very active and, when disturbed, will move rapidly backwards and often seek shelter in cracks in the soil. The winter is passed in the pupal stage.

DESCRIPTION
Adult 20-25 mm wingspan; *forewings* brownish-black with a creamish subcentral spot and pale submarginal markings **(Fig. 302);** *hindwings* pale brownish-black. **Larva** up to 25 mm long; *body* slender, grey to yellowish; *pinacula* pale, black-edged; *head* black; *prothoracic plate* black or grey.

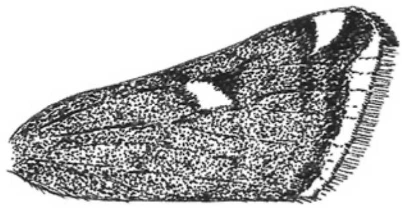


Fig. 302 Forewing of *Margaritia sticticalis* (x5).

Ostrinia nubilalis **(Hiibner)**
larva **= European corn borer**

This migratory species is a major pest of maize and sweet corn in continental Europe and in North America but it occurs only rarely in the British Isles. The larvae bore within the maize stems, usually causing them to break; the cobs are also attacked. Infestations can occur on various secondary hosts, including barley, beet and potato; a race of this insect is associated with *Artemisia vulgaris.*

BIOLOGY
Adults emerge in June. Eggs are then laid on the underside of leaves of host plants, typically in batches of about 20; the eggs hatch about 10 days later. The larvae at first feed externally but then bore into the stems where they develop. When fully fed, the larvae enter diapause inside the stems or in stubble. In the spring they pupate *in situ* or in the soil. In northerly parts of its range, this species has just one generation annually; in southern districts, it is capable of completing two or more generations annually. The overwintering stage, although capable of surviving low temperatures, is very susceptible to excessive dampness.

DESCRIPTION
Adult 25-32 mm wingspan; *forewings* pale yellowish to olive-brown, with irregular greyish markings; *hindwings* mainly pale grey, with darker grey markings. **Larva** up to 25 mm long; *body* pale purplish-brown; *pinacula* brownish but pale-centred; *head* brownish-black; *prothoracic plate* pale brown with blackish-brown markings **(Plate 13e).**

Pyrausta aurata **(Scopoli)**

In parts of continental Europe, this moth is considered a significant pest of cultivated mint. The larvae web the leaves together with silk and also cause defoliation. In the British Isles, larvae sometimes infest mint growing in gardens and allotments, especially in chalkland areas, but attacks are not of commercial importance.

BIOLOGY
Adults fly in sunshine, and those of the first generation are active in May and June. First-generation larvae feed in June and July on wild and cultivated mint (and related plants), living amongst spun leaves. Each eventually pupates on the host plant in a tough, brownish cocoon. Adults of the second generation occur in July and August, with second-generation larvae feeding in September and October. When fully fed, these larvae overwinter in cocoons formed on plant stems and pupate in the spring.

DESCRIPTION
Adult 16-18 mm wingspan; *forewings* purplish-brown marked with yellow **(Plate 13f). Larva** up to 17 mm long; *body* dull green with yellow longitudinal lines and numerous yellow-edged black spots; *head and prothoracic plate* light brown, speckled with black **(Plate 14a).**

Family PIERIDAE

Pieris brassicae (L.)
Large white butterfly

This species is an often common pest of vegetable brassicas, including broccoli, Brussels sprout, cabbage and cauliflower, but of significance mainly in allotments and gardens. Young larvae graze away the lower epidermis of the leaves but older ones cause extensive defoliation, and often reduce plants to a skeleton of stems and major veins. Plants are also soiled by accumulations of frass. Although capable of infesting field crops, including mustard, rape, swede and turnip, infestations on such crops are of little importance.

BIOLOGY
Adults of the spring generation occur in April and May. Eggs are then laid in batches, mainly on the underside of leaves. They hatch 1-2 weeks later, depending on temperature. The larvae feed gregariously and are fully grown in 4-6 weeks. They then pupate, usually suspending themselves by a strand of silk to a nearby wall, fence or other suitable support. Adults emerge 10-15 days later. Larvae of the summer generation occur from July onwards. In summer, large numbers of adults may arrive from abroad and these immigrants often boost resident populations. The winter is passed in the pupal stage.

DESCRIPTION
Adult 55-65 mm wingspan; *forewings of male* mainly white with the tip bordered in black (tip pale yellow below); *forewings of female* more extensively blackened above, including two subcentral black spots; *hindwings* mainly white above, yellow below. Egg 1.5 mm long, yellow, spindle-shaped and ribbed longitudinally. **Larva** up to 40 mm long; *body* mainly yellow to pale bluish-green, irregularly patterned with black; *head* black anteriorly, blue posteriorly **(Plate 14b).** **Pupa** 20-24mm long, dull greenish-grey to whitish, spotted with black.

Pieris napi (L.)
Green-veined white butterfly

Although larvae of this widely distributed species often feed on cultivated brassica plants, they are rarely numerous and occur mainly on wild plants such as *Sisymbrium officinale.* This species is, therefore, of little economic importance.

BIOLOGY
Adults occur in May and June, and in late July and August. Eggs are laid singly on the leaves of host plants and the larvae feed in summer and autumn.

DESCRIPTION
Adult 40-44 mm wingspan; *forewings of male* mainly white, more or less suffused with black both apically and basally, and venation darkened; *forewings of female* more extensively blackened, including two subcentral black spots; *hindwings* with underside mainly pale yellow, the venation dusted with black scales. **Egg** 1.3 mm long, pale green, spindle-shaped and ribbed longitudinally. **Larva** up to 30 mm long; *body* mainly velvet-green with yellow markings along either side (unlike the following species there is no yellow dorsal line).

Pieris rapae (L.)
Small white butterfly

Larvae of this generally common pest often cause damage to broccoli, Brussels sprout, cabbage, cauliflower, horseradish and other vegetable brassica crops. They devour the leaves and also contaminate plants with frass. During the daytime, the cryptically coloured larvae often lie stretched out along the veins of the leaves and, although often on the upper surface, are easily overlooked.

BIOLOGY
Adults of the spring generation occur mainly in March and April, and are very active in sunny weather. They deposit their eggs singly on both sides of the leaves of host plants. Larvae of the first generation eventually pupate to produce a second generation of adults in mid-summer. Their larvae, which feed in late summer and early autumn, are usually more numerous than those of the earlier generation, especially if a summer immigration of adults has occurred.

DESCRIPTION
Adult 40-45 mm wingspan; *forewings of male* mainly white with tip and base more or less black, and a subcentral black spot (the latter often absent in spring specimens); *forewings of female* similar to those of male but with two subcentral spots and a blackish dash on the hind margin; *hindwings* mainly white above, with a

blackish mark on the anterior margin; mainly dusky yellow below. **Egg** 1.3 mm long, yellow, spindle-shaped and ribbed longitudinally. **Larva** up to 30 mm long; *body* velvet-green, finely speckled with black, with a yellow line along the back (absent in early instars) and yellow markings along each side **(Plate 14c).** **Pupa** 20 mm long, pale brown to grey or pale greenish, with black markings.

Family LASIOCAMPIDAE

Malacosoma neustria **(L.)**
Lackey moth

Minor infestations of this polyphagous species sometimes occur on fruit trees. The gregarious larvae can cause extensive defoliation, and this can have a detrimental effect on crop yields.

BIOLOGY

Adults occur from late July to September. Eggs are deposited in a batch around a twig and then coated by the female with a varnish-like secretion. The eggs hatch in the following spring and the larvae then feed within a silken web which is gradually extended as the larvae develop. When leaves in the vicinity of the web are devoured the larvae move to another branch and again form a communal web. Pupation occurs in tough double-walled cocoons on the host tree or amongst debris on the ground. Adults emerge about 3 weeks later.

DESCRIPTION

Adult 30-40 mm wingspan; *forewings* pale ochreous-brown to dark brown, often with a broad, pale-bordered, median cross-band **(Fig. 303);** *hindwings* pale ochreous brown to dark brown; *antennae* bipectinate, more strongly in male. **Larva** up to 50 mm long; *body* blue with a white line along the back, and black-edged red longitudinal lines along the back and sides; *body hairs* gingery; *head* blue, with two black spots.

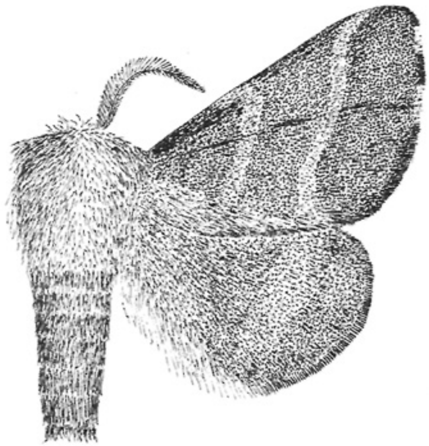


Fig. **303** Lackey moth, *Malacosoma neustria* (x3).

Family GEOMETRIDAE (geometer moths)

Abraxas grossulariata (L.)
Magpie moth

This species is rarely of commercial significance but it can cause defoliation of gooseberry bushes in allotments and gardens; currant bushes, plum trees and certain ornamental shrubs are also attacked.

BIOLOGY

Adults occur in July and August. Eggs are laid on the leaves of host plants and they hatch about 2 weeks later. Young larvae feed briefly and then overwinter. They become active again at bud burst (much earlier than larvae of the common gooseberry sawffy, *Nematus ribesii,* p. 251). When disturbed, larvae often drop from the foliage but will dangle on a thread of silk, adopting a U-shaped posture. Larvae are fully grown in May or June. They then pupate on the host plant, or on nearby walls and fences, larvae at first spinning a flimsy cocoon. Although this species is usually single-brooded, under favourable conditions there may be a partial second generation.

DESCRIPTION

Adult 35-40 mm wingspan, black and ochreous-yellow; *forewings* mainly white with large black-

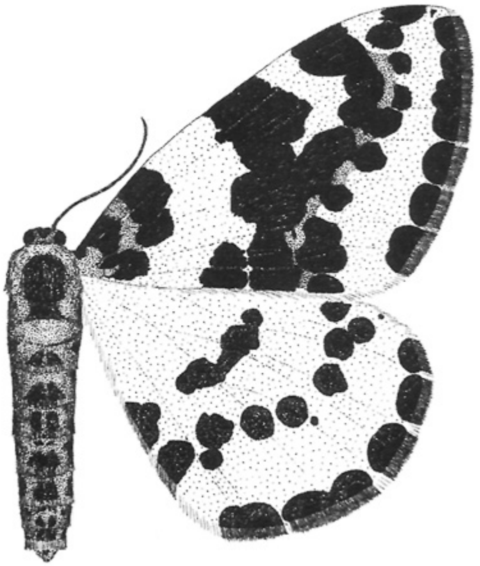


Fig. 304 Magpie moth, *Abraxas grossulariata* (x3).

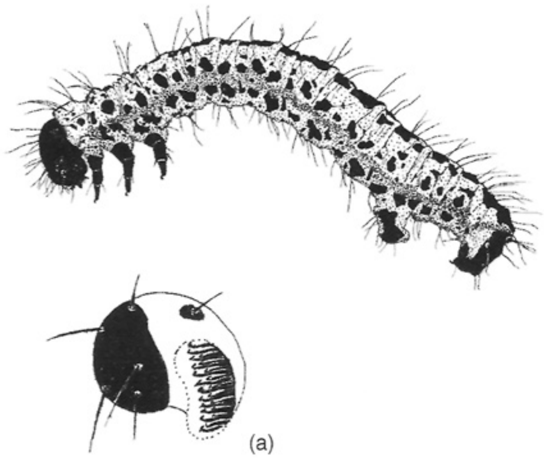


Fig. **305** Larva of magpie moth, *Abraxas grossulariata* (x3): (a) abdominal proleg and crochets (further enlarged).

ish spots, a narrow yellowish-orange cross-band and a partly yellowish-orange base; *hindwings* mainly white with blackish markings **(Fig. 304). Larva** up to 40 mm long; *body* pale yellowish-white, extensively marked with black; two pairs of prolegs; *head* black **(Fig. 305). Pupa** 15 mm long, black with yellow cross-bands.

Alsophila aescularia (Denis & Schiffermiiller) March moth

The March moth is an often common pest of orchard trees. In spring, the larvae damage the unopened buds; they also attack the expanded leaves, blossom trusses and fruitlets.

BIOLOGY
Adults occur throughout March. Eggs are laid in a batch, which encircles a twig. They are then coated in hairs from the female's anal tuft. Larvae feed from April to June and then pupate in the soil within silken cocoons. Adults emerge in the following spring.

DESCRIPTION
Adult female 8 mm long, wingless; *body* greyish-brown, with a prominent anal tuft of hair.

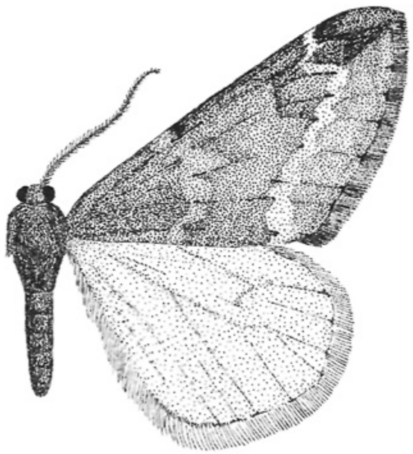


Fig. 306 Male March moth. *Alsophila aescularia* (x3).

Adult male 25-30 mm wingspan; *forewings* distinctly angular, grey to brownish-grey, with pale markings **(Fig. 306);** *hindwings* pale grey. **Larva** up to 25 mm long; *body* pale green with a dark green dorsal stripe and yellowish-white longitudinal lines, including one passing below the spiracles; one vestigial and two functional pairs of abdominal prolegs (cf. winter moth, *Operophtera brumata*, p. 231); *head* green.

Biston betularia **(L.)**
Peppered moth

This species is a generally common pest of trees and shrubs, including fruit crops, but is of most significance on herbaceous ornamentals such as chrysanthemum and pot marigold. The larvae can cause noticeable defoliation but damage to trees and shrubs is usually unimportant as the bulk of feeding occurs relatively late in the season.

BIOLOGY
Larvae occur from July to September or October. At night, they feed ravenously on the foliage; during the daytime, they rest with the body held straight out at an angle of about 45°, mimicking a shoot or broken twig. Fully grown larvae enter the soil to pupate, and adults emerge in the following year, usually in May, June or early July.

DESCRIPTION
Adult 42-55 mm wingspan; *body and wings* white, peppered with black **(Fig. 307);** entirely black (ab. *carbonaria)* and intermediate (ab. *insularia)* forms also occur; *antennae* in the male, strongly bipectinated (Fig. 307). **Egg** 0.7 x 0.5 mm, whitish-green. **Larva** up to 50 mm long; brown or green, with pinkish markings; *spiracles* reddish; *body* stick-like, with a pair of dark purplish prominences on the fifth abdominal segment; *head* purplish-brown with a distinct central cleft **(Fig. 308)**. **Pupa** 20-22 mm long; blackish-brown, *cremaster* spike-like.

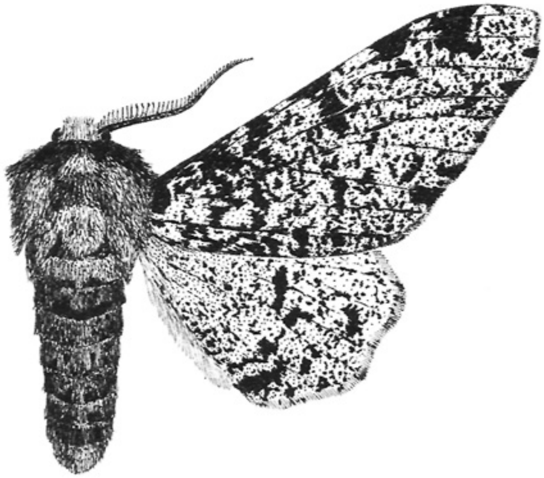


Fig. 307 Male peppered moth, *Biston betularia* *(XLS).*

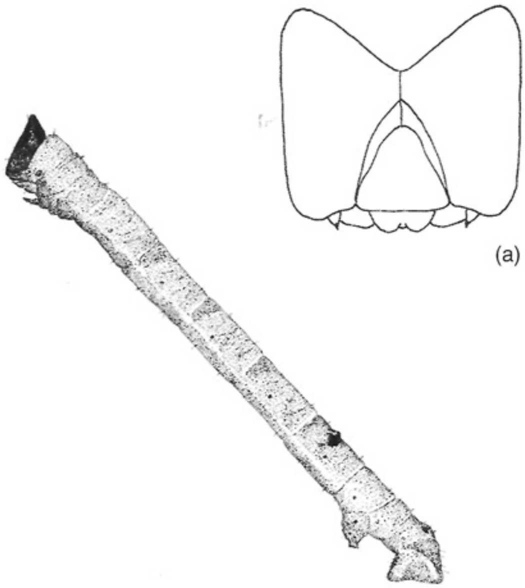


Fig. 308 Larva of pepppered moth, *Bison betularia* (x2): (a) head (further enlarged).

Erannis defoliaria **(Clerck)**
Mottled umber moth

This moth is a generally common pest of deciduous trees and is sometimes of importance in orchards and in bush-fruit plantations.

BIOLOGY
Adults are active from mid-October onwards. Eggs are eventually laid in crevices in the bark of host plants and these hatch in the following spring. Larvae feed from late March or early April to June. When disturbed they drop from the tree on a silken thread. Fully fed larvae enter the soil where they eventually pupate.

DESCRIPTION
Adult female f0-15 mm long, mainly ochreous-yellow, mottled with black, and wingless **(Fig. 309). Adult male** 35-38 mm wingspan: *forewings* extremely variable, usually pale yellow to reddish-brown with darker markings: *hindwings* whitish-grey **(Fig. 310). Larva** up to

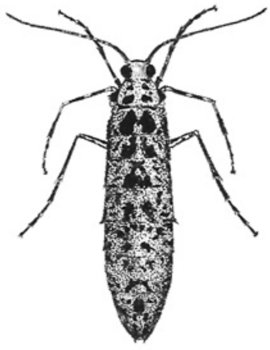


Fig. **309** Wingless female mottled umber moth, *Erannis defoliaria* (x3).

Fig. 311 Male winter moth, *Operophtera brumata* (x3).

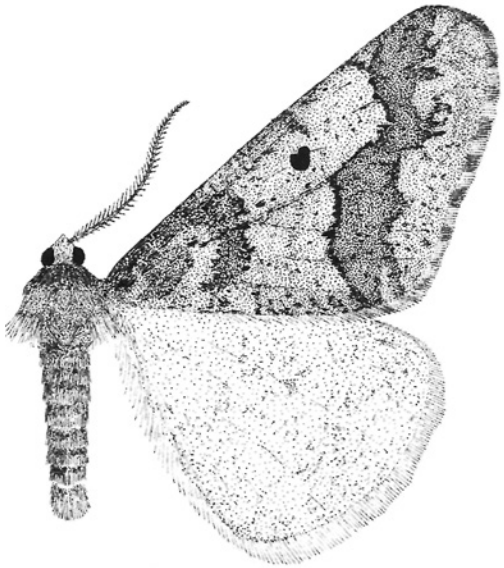


Fig. 310 Male mottled umber moth, *Erannis defoliaria* (x3).

35 mm long; *body* reddish-brown with yellow or whitish markings on the side of the abdomen, and a black line above the spiracles; two pairs of abdominal prolegs; *spiracles* white, black-ringed and often surrounded by reddish patches; *head* reddish-brown.

***Operophtera brumata* (L.)**
Winter moth

This species is an important orchard pest, especially of apple; infestations also occur on bush fruits, including blueberry, currant and gooseberry. The larvae destroy unopened buds and also invade the leaves and blossom trusses. Later, attacks on apple fruitlets often result in the development on malformed fruit with corky scars and deep cavities extending to the core.

BIOLOGY
Moths are most numerous in November and December. Eggs are laid singly on the bark of host trees and they hatch in the early spring. Very young larvae are often blown about on fine threads of silk and, by this means, are often able to invade previously uninfested trees. Older larvae are relatively sedentary and secrete themselves amongst webbed leaves or blossom trusses. Larvae feed until late May or early June and then pupate in the soil, each in a flimsy, silken cocoon.

DESCRIPTION
Adult female 5-6 mm long, dark greyish-brown, and virtually wingless. **Adult male** 22-28mm wingspan; *forewings* rounded, pale greyish-brown with wavy cross-lines; *hindwings* pale grey **(Fig. 311). Larva** up to 25mm long; *body* green with whitish or yellowish-white longitudinal lines, including one passing through the spiracles **(Fig. 312);** two pairs of abdominal prolegs (cf. March moth, *Alsophila aescularia*, p. 229); *head* green.

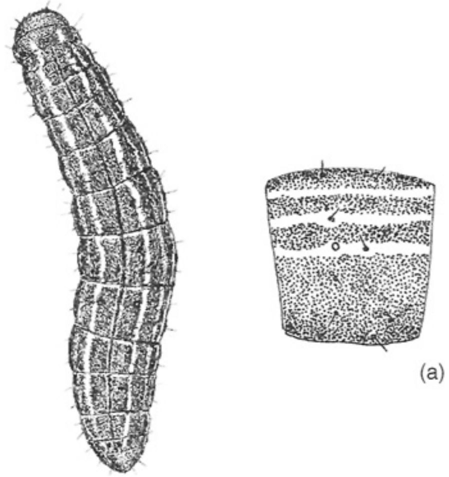


Fig. 312 Larva of winter moth, *Operophtera brumata* (x3): (a) lateral view of an abdominal segment (further enlarged).

Family SPHINGIDAE (hawk moths)

***Acherontia atropos* (L.)**
Death's head hawk moth

This African species is a regular migrant to more northerly areas but is usually uncommon in the British Isles and other parts of northern Europe. The larvae are minor pests of potato; they feed on the leaves but damage caused is usually of little or no importance.

BIOLOGY
Adults occur from May onwards but are usually most numerous in August and September. Eggs are then laid singly on the leaves of potato and on other Solanaceae. Larvae feed voraciously and, in the British Isles are most often found in September and October. Pupation takes place in the soil in fragile silken cocoons formed a few centimetres below the surface. This species is usually unable to survive the winter in northern Europe.

DESCRIPTION
Adult 100-130 mm wingspan, with an ochreous-yellow skull-like mark on the thorax; *forewings* blackish-brown, variably marked with whitish and blackish; *hindwings* yellow with blackish-brown veins and cross-bands. **Larva** up to 130 mm long; *body* usually yellowish-green, marked with purplish-black and with seven oblique, purple to purplish-brown stripes along each side; *posterior horn* yellow and S-shaped; *head* yellow with two broad black stripes.

***Smerinthus ocellata* (L.)**
Eyed hawk moth

This species is occasionally a minor problem on young apple trees. The larvae defoliate the shoots and can have a marked adverse effect on the growth of young trees. Attacks on older trees are of little or no importance.

BIOLOGY
Moths occur from May to July. Eggs are laid singly or in small groups on the leaves of host plants, and they hatch 2-3 weeks later. The larvae feed on the leaves from June to September and then enter the soil to pupate. Under favourable conditions a partial second generation of adults emerges in the late summer but most do not appear until the following year.

DESCRIPTION
Adult 75-85 mm wingspan; *forewings* greyish-brown to chocolate-brown, with pinkish-grey markings; *hindwings* brown to reddish, with a large blue, grey and black, eye-like mark. **Larva** up to 70 mm long green; *body* speckled with white, seven oblique whitish or yellowish stripes along each side; *spiracles* white, with red rims; *posterior horn* bluish.

Family NOTODONTIDAE

***Phalera bucephala* (L.)**
Buff-tip moth

Minor infestations of this common, polyphagous species sometimes occur on fruit trees. The gregarious larvae cause considerable defoliation but are of greater significance on forestry and ornamental trees and shrubs.

BIOLOGY

Moths are active from late May or June to July. Their eggs are laid in large batches on the underside of leaves and then covered in hairs from the female's abdomen. Larvae feed gregariously from July or August onwards but, unlike many other gregarious species, they do not form webs. In their final instar, the larvae tend to become solitary. Pupation occurs in the autumn in earthen cells, and adults emerge in the following year.

DESCRIPTION

Adult 55-65 mm wingspan, body noticeably hairy; *forewings* light grey to silver-grey, with scattered reddish-brown and black markings and a prominent whitish-yellow apical blotch; *hindwings* pale yellow to whitish **(Fig. 313).** **Larva** up to 60 mm long; *body* pale yellow with black longitudinal stripes interrupted by yellowish-orange intersegmental cross-bands; *body hairs* fine and whitish; *head* mainly black and shiny. **Pupa** 25-28 mm long, purplish-brown; *cremaster* with four short spines.

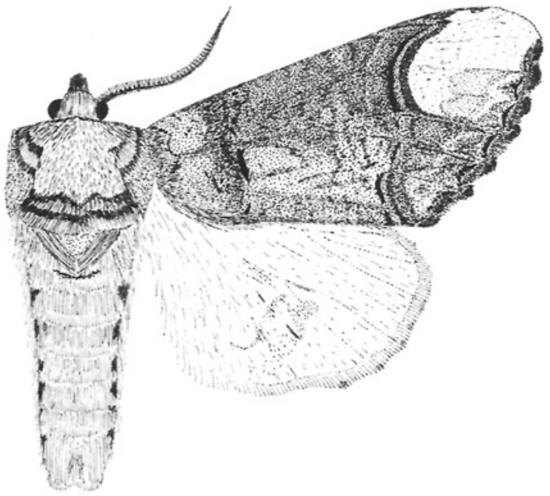


Fig. 313 Buff-tip moth, *Phalera bucephala* (x2).

Family LYMANTRIIDAE

Euproctis chrysorrhoea (L.)
Brown-tail moth

In areas such as the coastal regions of southeastern England, infestations of this locally distributed and sporadically important species occur occasionally on fruit trees. The pest is, however, far more notorious as a public nuisance and defoliator of hedges. The urticating hairs of the larvae can cause skin rashes.

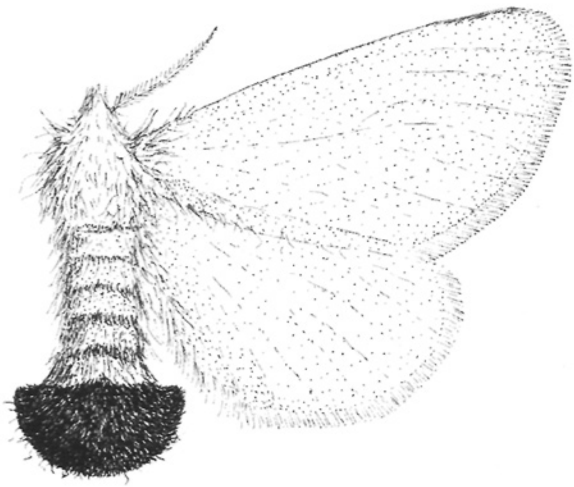


Fig. 314 Female brown-tail moth, *Euproctis chrysorrhoea* (x3).

BIOLOGY

Adults fly in July and August. Egg batches, covered in hairs from the female's anal tuft, are then laid on twigs of host plants, especially *Crataegus monogyna* and *Primus spinosa.* Eggs hatch in about 3 weeks and the larvae immediately spin a dense, opaque communal web or tent in which they feed and eventually hibernate. In spring, larvae become active and often bask on the outside of the tent during sunny weather. The webbing is extended over the branches as the larvae grow. Older larvae often wander away and become more or less solitary. Pupation occurs singly or in groups on host plants, amongst a web of silk.

DESCRIPTION

Adult 32-42mm wingspan; *head and thorax* white and fluffy; *abdomen* brown, with a distinct anal tuft of hair (in the female, bulbous and dense) **(Fig. 314);** *forewings* brilliant white (in the male, occasionally with a few black dots); *hindwings* white. **Larva** up to 40mm long; *body* black with white subdorsal patches, a pair of sometimes indistinct broken red lines along the back, and tufts of gingery hair arising from prominent black warts; a prominent orange-red spot (gland) on the sixth and another on the seventh abdominal segment; *head* black and shiny **(Plate 14d).**

Orgyia antiqua (L.)
Vapourer moth

Although mainly of significance as a defoliator of specimen trees in towns and cities, larvae of this pest also attack fruit trees. Damage on fruit crops, however, is rarely of significance.

BIOLOGY
Adults occur from July to September. The flightless females are sedentary and, following their emergence, stay on the remains of the pupal cocoon. Males, however, are very active and, in sunny weather, fly rapidly in search of newly emerged females. Eggs are laid in a large batch of several hundred on the outer surface of the pupal cocoon; the female then dies. The eggs overwinter and hatch over an extended period from May onwards. Larvae feed avidly on foliage and are very active, often migrating from one host plant to another. When fully grown, the larvae spin large pupal cocoons on tree trunks or branches; pupal cocoons are also often formed on walls and fences some distance from the final foodplant. Although usually univoltine, in favourable situations there may be two or more generations annually.

DESCRIPTION
Adult female 10-15 mm long, plump-bodied, dark yellowish-grey and virtually wingless. **Adult male** 25-33 mm wingspan; *forewings* ochreous-brown to chestnut-brown, with dark wavy cross-lines and a white spot close towards the hind angle; *hindwings* ochreous-brown to chestnut-brown **(Fig. 315).** **Egg** 0.9mm in diameter, pale brownish-grey. **Larva** up to 35 mm

Fig. **315** Male vapourer moth, *Orgyia antiqua* (x3).

long; *body* dark grey with tufts of greyish-white hairs arising from reddish warts; a pair of long, forward-directed tufts (pencils) of black hairs arising from the first thoracic segment; a long, posterior-directed tuft of hair arising from the centre of the seventh abdominal segment; brush-like tufts of yellow hairs on abdominal segments 1-4 (see Fig. 139); *head* black and shiny.

Family NOCTUIDAE

Agrotis segetum **(Denis & Schiffermuller)**
Turnip moth

The turnip moth is a major pest of vegetable crops such as carrot, leek, lettuce, onion, parsnip, potato, red beet and turnip; it is also a minor problem on cereals, strawberry and various ornamental plants. The larvae damage plants at or about soil level, often causing them to wilt and die. Attacks are particularly severe in light soil during hot, dry summers and tend to be most significant on younger, unirrigated, slower-growing hosts, including seedlings and recent transplants. **Carrot, red beet and other root vegetables:** larvae hollow out large cavities in the tap root, destroying roots or reducing their marketability. **Leek:** attacked plants develop distorted top-growth, and the stems become characteristically twisted. **Lettuce:** plants are very susceptible to damage, often being cut off at ground level or

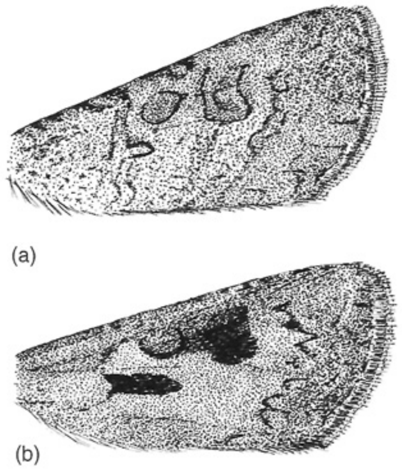


Fig. 316 Forewings of *Agrotis:* (a) turnip moth, *A. segetum:* (b) heart & dart moth, *A. exclamationis* (x3).

their stems partially severed; recent transplants and seedlings are worst affected. **Potato:** roots and stems are severed and tubers hollowed out **(Plate 14e);** the most significant damage is caused before July.

BIOLOGY

Adults fly from late May to June or early July. Eggs are laid in batches on the leaves of various host plants and hatch within approximately 3 weeks. Young larvae feed on the leaves but, on attaining the third instar, they become subterranean and act as typical 'cutworms'. They are active at night but, during the daytime, may be found resting in the soil close to plant roots. Most larvae are fully fed by the autumn. They then overwinter and pupate in the spring, each in an earthen cell. Under favourable conditions, however, some larvae will pupate before overwintering to produce a partial second generation of adults in the autumn. Survival of this species is greatly hampered by rainfall during the critical early stages of larval development.

DESCRIPTION

Adult 38-44 mm wingspan; *forewings* whitish-brown with brownish-black or blackish-edged markings, including a basal dash and two subcentral stigmata **(Fig. 316a);** *hindwings*

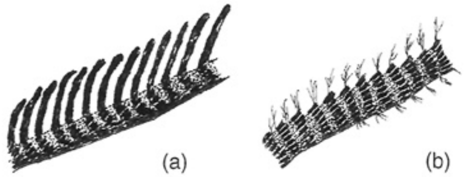


Fig. 317 Part of antenna of *Agrotis:* (a) turnip moth, *A. segetum;* (b) heart & dart moth, *A. exclamationis.*

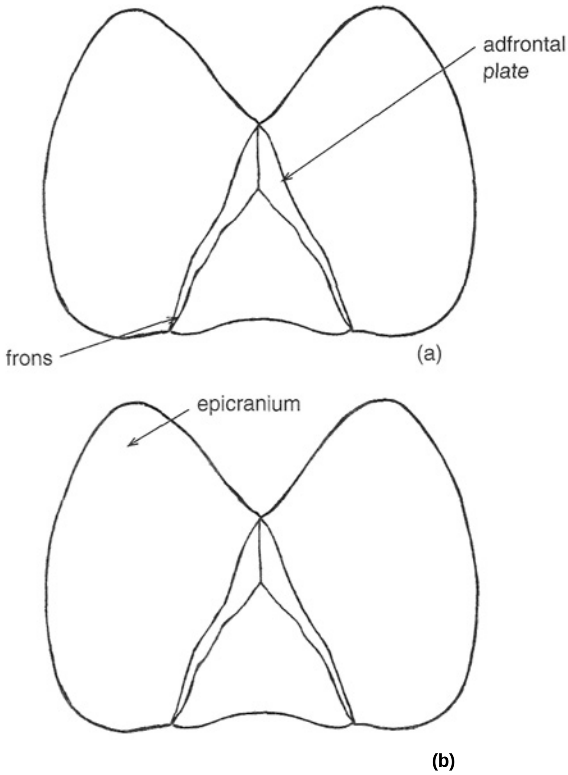


Fig. 318 Frontal view of head of cutworms: (a) turnip moth, *Agrotis segetum;* (b) heart & dart moth, *A. exclamationis.*

pearly-white; *antennae of male* bipectinate **(Fig. 317a). Egg** 0.6mm diameter, pale grey to creamish, hemispherical and distinctly ribbed. **Larva** up to 35 mm long; *body* plump; glossy greyish-brown, with a yellowish or pinkish tinge and indistinct darkish lines along the back; *pinacula* black; *head* yellowish-brown; *adfrontal plates* blunt at apex **(Fig. 318a)** (cf. *Agrotis exclamationis*, p. 236); *mandibles* elongate (cf.

A. vestigialis, below); *spiracles* black. **Pupa** 18-20mm long, reddish-brown and glossy; *cremaster* with two divergent spines.

Agrotis exclamationis (L.)
Heart & dart moth

Although an often abundant moth, larvae of this pest are far less troublesome than those of the previous species. Larvae (up to 35 mm long) are similar to those of *Agrotis segetum* (p. 234), but the adfrontal plates are pointed apically **(Fig. 318b),** the body less shiny and the spiracles noticeably larger. They feed from July onwards, normally overwinter as fully fed individuals and pupate in the spring. Adults (38-40 mm wingspan) are mainly brown with blackish markings (including a distinctive black "dart') **(Fig. 316b)** and greyish (female) or whitish (male) hindwings; unlike the previous species, the antennae of male moths are not noticeable bipectinate **(Fig. 317b).** They fly in June and July.

Agrotis ipsilon (Hufnagel)
Dark sword-grass moth

This cutworm species, although often important in continental Europe, is of only minor importance in the British Isles, where it causes damage only sporadically. The larvae attack various plants, including asparagus, lettuce, onion, potato, red beet and sweet corn. Adults occur from July to September and the larvae feed from autumn onwards; they complete their development in the following spring and early summer. Adults (40-55 mm wingspan) have mainly dark purplish-brown to pale ochreous forewings and pearly-white, blackish-suffused hindwings. The larvae (up to 40 mm long) are grey to bronzy-brown with two white spots on the head, a ring of four black spots on each of the first two thoracic segments and two black spots on each of the remaining body segments; the skin is noticeably warty. Infestations of this species in northern Europe are usually dependent upon significant northerly migrations of adults from Mediterranean areas.

Agrotis vestigialis (Hufnagel)
Archer's dart moth

Minor damage to grass and cereal crops is occasionally attributable to this locally distributed species, usually in coastal districts. Adults occur in July and August and the larvae feed from August to the following May. Adults (32-38 mm wingspan) have pale brown, whitish-marked forewings and (in male) whitish or (in female) greyish hindwings. Larvae (up to 35 mm long) are greyish-green to greyish-brown and purplish-tinged, with darker longitudinal lines, black pinacula and spiracles, and distinctly quadrate mandibles; both the head and prothoracic plate are banded with black (cf. *Agrotis segetum*, p. 234).

Apamea sordens (Hufnagel)
Rustic shoulder knot

This generally common species is a minor pest of wheat and barley; the larvae also attack various grasses. The larvae feed mainly on leaves and stems but, in summer, the young larvae will also invade the ears and bore into the developing grain. The cause of the hollowed grain often goes unrecognized.

BIOLOGY
Moths occur in May and June, and deposit their eggs on the leaves and developing ears of grasses and cereals. After egg hatch, the larvae feed mainly in the ears where they attack the developing grain. They are active only at night, and remain hidden during the daytime. In autumn the larvae enter hibernation. They reappear early in the following spring and then attack the plant stems and leaves. Fully feed larvae pupate in the soil, each in an earthen cell, and adults emerge a few weeks later.

DESCRIPTION
Adult 34-42 mm wingspan; *forewings* pale brown with a short black basal streak; *hindwings* pale brown with a darker margin. **Larva** up to 35 mm long; *body* greyish-brown to olive-brown

with a paler stripe along the back, edged by irregular black bars, and an interrupted black spiracular line; *head* black; *prothoracic plate* black with whitish lines.

Autographa gamma (L.)
Silver y moth

This moth is a notorious migrant, and populations spread northwards and westwards each year from Mediterranean areas, where the pest is endemic. The larvae attack various glasshouse and outdoor plants, including brassicas, celery, field bean, lettuce, linseed, pea, potato and strawberry. Defoliation is usually the main problem but frass pellets accumulating between the leaves of infested lettuce plants are also often an important problem.

BIOLOGY
The first immigrants usually arrive in northern Europe in May, but can sometimes occur much earlier. Eggs are laid singly or in small groups on various foodplants and they hatch 1-2 weeks later. Larvae feed for about a month before pupating, each in a flimsy silken cocoon between leaves. Adults appear within about 2 weeks and often fly during sunny weather, to feed on nectar from various flowers. A second, and sometimes a **third,** generation may be completed during the summer and autumn. However, although capable of breeding continuously in heated glasshouses, outdoor populations in the British Isles are unable to survive the winter and autumn-reared adults usually migrate southwards, back to more favourable breeding grounds.

DESCRIPTION
Adult 35-45 mm wingspan; *forewings* greyish-brown to velvet-black, suffused with whitish-grey, often tinged with purplish, and bearing a silver, y-shaped mark **(Fig. 319);** *hindwings* light brown with a darker border. **Larva** up to 45 mm long; *body* varying from green to blackish-green, with a whitish or yellowish spiracular line, an often dark dorsal stripe and pale wavy lines along the back; three pairs of abdominal prolegs;

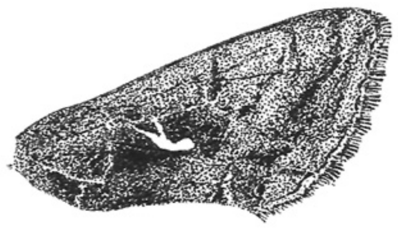


Fig. 319 Forewing of silver y moth, *Autographa gamma* (x3).

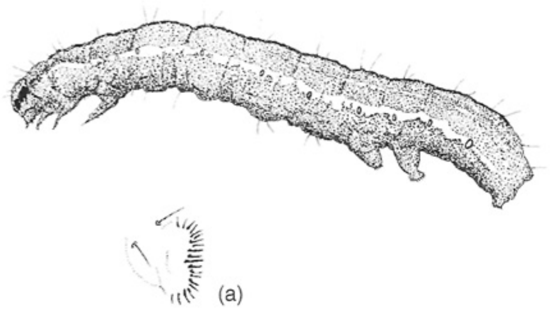


Fig. 320 Larva of silver y moth, *Autographa gamma* (x2): (a) abdominal proleg and crochets (further enlarged).

head mainly green, marked with black on each 'cheek' **(Fig. 320).**

Cerapteryx graminis (L.)
Antler moth

The antler moth is a sporadic pest of grasses, especially hard-textured species. Although present in various lowland sites, most damage is caused in upland areas. The larvae, sometimes known as 'armyworms', damage the roots and shoots; they occasionally migrate in large numbers, devouring grasses as they advance, and can then cause death of plants over a wide area.

BIOLOGY
The moths are usually most abundant in August and early September. They fly both at night and during the daytime, often in considerable numbers. Eggs, usually about 200 per female, are dropped at random as the moths fly over grass-

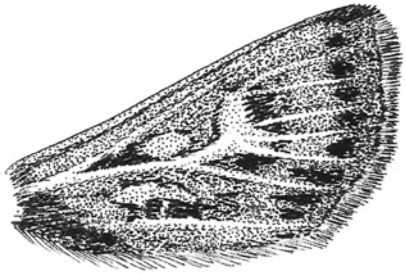


Fig. 321 Forewing of antler moth, *Cerapteryx graminis* (x4).

land. Some of the eggs hatch in the autumn but most do not do so until the following February or March. The larvae feed for several months and eventually pupate in the soil, from late June onwards.

DESCRIPTION

Adult 28-38 mm wingspan; *forewings* greyish-brown to reddish-brown, with a whitish to ochreous antler-like pattern **(Fig. 321);** *hindwings* pale brown to brownish-black. **Larva** up to 35 mm long; *body* glossy, bronzy-brown with broad, pale yellowish-brown, black-edged longitudinal lines and pale apical margins to each segment; *spiracles* black; *head* brownish.

***Cucullia umbratica* (L.)**
Shark moth

Although associated mainly with wild Asteraceae, especially *Crepis, Hieracium, Lactuca* and *Sonchus,* the larvae also attack cultivated lettuce, occasionally causing minor damage in allotments and gardens.

BIOLOGY

Adults occur from June to early August. Eggs are deposited singly on the leaves of host plants, and they hatch within a week. The young larvae are relatively active and often feed during the daytime; older larvae, however, feed at night. Larvae are fully fed by late August or early September. They then pupate in strong cocoons formed in the soil, and adults emerge in the following summer.

DESCRIPTION

Adult 48-55 mm wingspan; *forewings* lanceolate, greyish to ochreous-grey, streaked with black **(Plate 14f);** *hindwings* greyish-white to greyish-ochreous, dark brown in female. **Larva** up to 52 mm long; *body* greyish-ochreous to purplish-brown, paler specimens with a reticulated pattern variably marked with black; *pinacula* black; *spiracles* black, ringed with whitish; *head* black; *prothoracic plate* brownish-black, marked with yellow.

***Euxoa nigricans* (L.)**
Garden dart moth

This is a widely distributed and common allotment and garden pest of vegetable crops; damage is also caused to field crops such as carrot, potato and sugar beet. The larvae cause typical cutworm injury to roots and crowns of host plants, and attacks are particularly noticeable in dry conditions in May and June.

BIOLOGY

Larvae of this species feed from early spring onwards and become fully grown in June. They then pupate in the soil within earthen cells and the adult moths emerge in August. There is just one generation annually.

DESCRIPTION

Adult 35-40 mm wingspan; *forewings* blackish-brown with darker cross-lines and pale stigmata; *hindwings* whitish, suffused with brownish, darker in female. **Larva** up to 40 mm long; *body* pale ochreous, greenish-tinged laterally, with pale dark-edged longitudinal lines and a double whitish lateral stripe; *pinacula* blackish; *head* greyish-brown marked with black.

***Helicoverpa armigera* (Hiibner)**
Scarce bordered straw moth

In parts of southern Europe, this notorious tropical and subtropical pest is considered a significant pest of vegetable crops such as artichoke, bean, cucumber and tomato; in some areas, infestations also occur regularly on glasshouse-grown ornamentals such as carnation and chrysanthemum. The moths sometimes migrate northwards (but they very rarely reach the British Isles) where, if conditions are favourable, they may breed; the pest may also, occasionally, be introduced accidentally into such areas on imported produce. The larvae (known as Old World bollworms) are capable of causing considerable defoliation. Also, on tomato, the young larvae often bore into the fruits and may then become important contaminants in crops sent for processing.

BIOLOGY
In Europe, adults of this migratory, multivoltine species occur at any time from April to October. However, the number of generations completed varies depending on temperature. For example, the larvae require temperatures above 21°C for their continued development, with temperatures in the high 20s being the optimum. In temperate regions, pupae may be able to overwinter in the soil but they cannot survive cold conditions.

DESCRIPTION
Adult 30-40 mm wingspan; *forewings* mainly pale ochreous, greenish-grey to reddish-brown, with slightly darker markings (including a slightly smoky reniform stigma); *hindwings* creamish-white with a broad blackish border that is more or less straight along its inner edge (cf. bordered straw moth, *Heliothis peltigera,* below). **Larva** up to 40mm long; *body* with distinct humps on the first and eighth abdominal segments; *body* extremely variable in colour, ranging from purplish-brown with darker pinacula and a pale spiracular band to greenish or yellowish with less conspicuous pinacula; *head* brown and distinctly speckled; *prothoracic plate* brownish or blackish. **Pupa** 15-20 mm long, reddish-brown; *cremaster* very short, with two long straight spines.

Heliothis peltigera (Denis & Schiffermiiller)
Bordered straw moth

This subtropical, migratory, multivoltine species occurs occasionally in northern Europe, including the British Isles, where infestations sometimes occur on pot marigold and certain other cultivated Asteraceae. In southern Europe, the larvae sometimes cause damage to field crops, including lucerne, maize, mint and tomato. The greenish, pale-marked larvae (up to 38 mm long when fully grown) are often mistaken for those of the silver y moth, *Autographa gamma* (p. 237) but are at once distinguished by the greater number of abdominal prolegs (there are five pairs) and the characterstic pale spinules that occur liberally over much of the body surface **(Plate 15a).** Adults (35-40mm wingspan) are mainly ochreous-yellow, with distinctive darker olive-brown markings on the forewings (including a distinct, blackish reniform stigma); the hindwings are pale yellowish, with a broad, blackish border which has a curved inner edge (cf. scarce bordered straw moth, *Helicoverpa armigera,* above).

Hydraecia micacea (Esper)
Rosy rustic moth

This moth is a minor pest of crops such as barley, beet, hop, maize, onion, potato, rhubarb, strawberry and wheat. Larvae (sometimes known as 'potato stem borers') tunnel singly within the crowns or stems; attacked plants are weakened and may wilt and die. Infestations are particularly likely to occur in weedy sites.

BIOLOGY
Moths occur from August to October or November. Eggs are laid on low-growing plants, including many weeds, but do not hatch until the following spring. Larvae feed from spring onwards, and then often invade crop plants. Larval development is usually completed in July or August. Individuals then pupate in the soil but without forming cocoons.

DESCRIPTION
Adult 40-45 mm wingspan; *forewings* reddish-brown, usually darker centrally; *hindwings* pale brown with a darker median line **(Fig. 322).** **Larva** up to 45 mm long; *body*

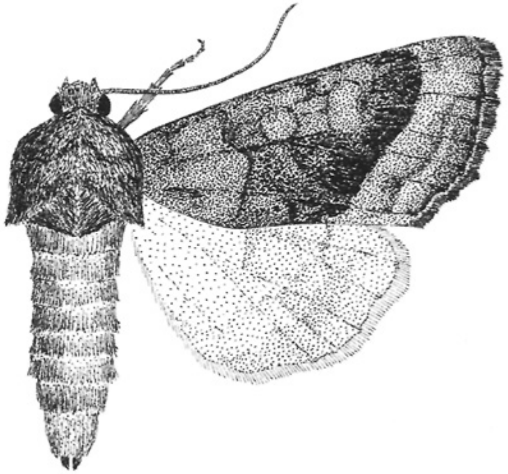


Fig. 322 Rosy rustic moth, *Hydraecia micacea* (x3).

slender, dull pinkish to dark brown: *pinacula* blackish-brown; *head* yellowish-brown and glossy; *prothoracic plate* yellowish-brown, marked with brown anteriorly **(Plate 15b).**

Lacanobia oleracea (L.)
Tomato moth

This often common pest attacks various herbaceous plants, but is of greatest importance as a pest of glasshouse-grown vegetables, including cucumber and tomato. Although young larvae merely graze the leaves, older larvae cause extensive defoliation. They also tunnel into developing tomatoes, rendering the fruit unmarketable.

BIOLOGY
Outdoors, adults occur mainly from late May to early July. Eggs are laid in large batches on the underside of leaves and they hatch 1-2 weeks later. The larvae at first feed gregariously. On attaining the second instar the larvae disperse and feed singly. They usually pupate by September, each spinning a flimsy cocoon in the soil or amongst debris on the ground. Adults usually emerge in the following year but, under favourable conditions, there may be a partial second generation. As many as three generations can occur in heated glasshouses.

DESCRIPTION
Adult 35-40 mm wingspan; *forewings* purplish-brown, with a yellowish stigma and a whitish, irregular subterminal line; *hindwings* greyish. **Egg** hemispherical, ribbed and reticulated, whitish to greenish. **Larva** up to 40 mm long; *body* green or brown, speckled finely with white and with a pale subspiracular stripe; *spiracles* white, ringed with black; *head* pale brown; **(Plate 15c).** **Pupa** 16-19mm long, dark brown to black and coarsely sculptured; *cremaster* with two T-headed spines.

Mamestra brassicae (L.)
Cabbage moth

The cabbage moth is a generally common and often important pest of vegetable crops, including brassicas, lettuce, onion, pea and sweet corn. Infestations often occur in glasshouses, especially on lettuce and sweet pepper and, less often, other crops, including ornamentals. The young larvae graze on the surface of leaves, leaving the upper epidermis intact ('windowing' symptom) **(Plate 15d)** but older larvae bite right through the lamina. The larvae also burrow into the heart of cabbages and foul plants with their frass.

BIOLOGY
Moths fly mainly in June and July. Eggs are laid in large batches of 20-30 on the underside of leaves of host plants and hatch within about 2 weeks. Larvae feed for about 5 weeks and then pupate in the soil, each in a flimsy cocoon. Adults usually emerge in the following spring but, under favourable conditions (especially under glass), a partial second generation emerges in the late summer or early autumn.

DESCRIPTION
Adult 38-45 mm wingspan; *forewings* greyish-brown to blackish-brown, with often inconspicu-

ous whitish markings; *hindwings* brownish. **Egg** hemispherical, distinctly ribbed and reticulated; mainly whitish, becoming brownish. **Larva** up to 45 mm long; *body* varying from green to blackish-brown, with blackish markings along the back (these form a saddle-like mark on the slightly humped eighth abdominal segment), and a pale spiracular band; *spiracles* white with black rims; *head* pale brown. **Young larva** pale green and shiny, speckled with black; later, banded with yellow intersegmentally. **Pupa** 17-22 mm long, reddish-brown and finely sculptured; *cremaster* with two short, hooked spines.

***Melanchra persicariae* (L.)**
Dot moth

The polyphagous larvae of this generally common moth attack various herbaceous plants, including beet, brassicas and potato, and are sometimes minor pests in allotments, gardens and nurseries. The larvae feed voraciously and, if numerous, can cause significant defoliation.

BIOLOGY
Moths occur mainly from June to August and deposit their eggs singly or in untidy batches on the leaves of various plants. The eggs hatch about 8 days later. Larvae feed until the autumn and then pupate in flimsy cocoons formed in the soil. Adults emerge in the following year.

DESCRIPTION
Adult 38-48 mm wingspan; *forewings* bluish-black, with a prominent, white reniform stigma; *hindwings* greyish but whitish basally **(Fig. 323).** **Egg** hemispherical, ribbed and slightly reticulated, whitish-green becoming pinkish-brown. **Larva** up to 45 mm long; *body* pale brown or pale green, with a white line along the back and darker V-shaped markings that are particularly obvious on abdominal segments 1, 2 and 8 (these segments also noticeably humped); *head* pale brown; *prothoracic plate* brown or green, with three white lines **(Fig. 324).** **Pupa** 22-24 mm long, chestnut-brown; *cremaster* with two short, divergent spines.

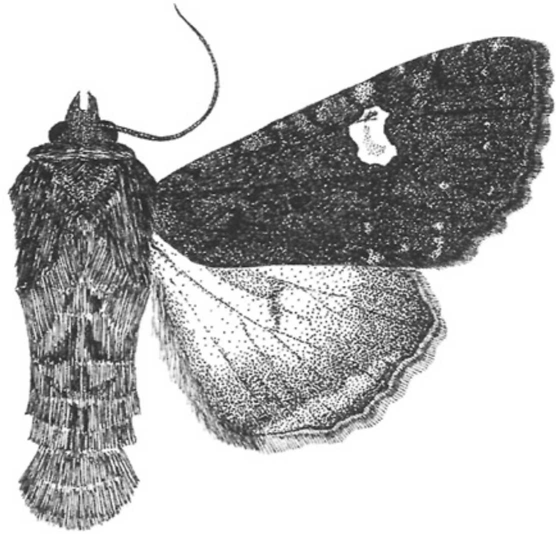


Fig. 323 Dot moth, *Melanchra persicariae* (x3).

Fig. **324** Larva of a dot moth, *Melanchra persicariae* (x2).

***Mesapamea secalis* (L.)**
Common rustic moth

[illegible]

will readily transfer from ploughed-up grasses to young cereal plants, especially barley, oats and wheat. Each larva also typically invades several shoots during the course of its development.

BIOLOGY
The moths occur mainly in July and August, and deposit their eggs on grasses and cereal plants. The larvae feed from autumn onwards. They typically burrow singly within the lowermost f Ocm of a shoot, usually feeding with the head directed downwards. As tissue is destroyed, and the shoot becomes filled with frass, the larva invades another shoot. Larvae are fully grown in the following spring. They then pupate in the soil, and the adults emerge several weeks later. There is just one generation each year.

DESCRIPTION
Adult 30mm wingspan; *forewings* brownish-grey to dark brown, often with a pale reniform stigma and paler areas along the hind i:argin and between the stigma and the la; ral margin; *hindwings* pale bi ownish-grey. Larva up to 25 mm long; *body* pale green and shiny, with a pair of often indistinct purplish-red iongitudinal stripes along the back; *spiracles* dirty whitish; *head*]_ale yellowish; *prothoracic plate and anal plate* greenish to light brown **(Plate 15e).**

***Mesoligea literosa* (Haworth)**
Rosy minor moth

This widely distributed species is a minor pest of cereals and grasses, especially in coastal areas. However, attacks on field crops are rarely of significance. The larvae feed within the plants during the spring and early summer; the central shoots of infested plants turn white or yellow and eventually die.

BIOLOGY
Larvae feed from September to June within the stems of cereals and grasses. When fully fed they pupate in the soil. Adults fly in late July and August.

DESCRIPTION
Adult 23-27 mm wingspan; *forewings* grey to ochreous, more or less suffused with violet or reddish-brown, and of variable appearance; *hindwings* mainly pale grey. **Larva** up to 25 mm long; *body* dirty ochreous-yellow with a purplish stripe along the back; *spiracles* black; *head and prothoracic plate* blackish-brown.

Noctua ***pronuba*** (L.)
Large yellow underwing moth

This widespread and generally common 'cutworm' attacks various vegetable crops, including brassicas, carrot, celery, leek, lettuce, onion, potato and red beet, especially in gardens and allotments. On vegetable crops, the larvae often bite out large cavities in the roots; minor damage is also caused to other horticultural crops, including strawberry. Unlike many other 'cutworm' species, the larvae frequently ascend plants to feed on leaves and other aerial parts; they are, therefore, referred to as 'climbing cutworms'. Unlike turnip moth, *Agrotis segetum* (p. 234), this species is often damaging in cool, damp summers.

BIOLOGY
Adults fly mainly from mid-June to August. Eggs are laid in large batches on the leaves of various plants and hatch about 3 weeks later. Larvae occur from July onwards and most complete their development in the following May. A few, however, may develop more rapidly and produce a partial second generation of adults in the autumn. Pupation occurs in an earthen cell, without forming a cocoon.

DESCRIPTION
Adult 50-60 mm wingspan; *forewings* extremely variable, ranging from yellowish-brown to dark brown; *hindwings* dusky-yellow with a blackish-brown border **(Fig. 325). Egg** hemispherical, ribbed and reticulated, creamish-white to purplish-grey. **Larva** up to 50 mm long; *body* plump but narrowed anteriorly; colour varies from ochreous or brown to green, with a pale

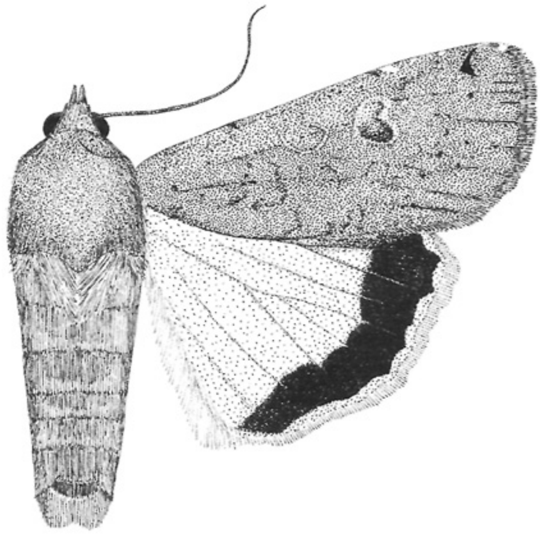


Fig. 325 Large yellow underwing moth, *Noctua pronuba* (x2).

dorsal line and distinctive pairs of black bars on the abdominal segments; *spiracles* black; *head* light brown with darker markings. **Pupa** 22-25 mm long, plump, reddish-brown and glossy; *cremaster* with two strong spines.

***Oligia strigilis* (L.)**
Marbled minor moth

This moth is a minor pest of cereals and grasses. The larvae burrow within the shoots and cause their death. Infestations are of greatest significance on crops of cocksfoot grass.

BIOLOGY
Moths occur in June and July. Eggs are then laid in rows on the leaves and stems of host plants. Following egg hatch, the larvae burrow into the stems and shoots, where they feed from August or early September onwards. Larvae hibernate during the winter and complete their development in the spring. Pupation takes place in the soil in earthen cells.

DESCRIPTION
Adult 22-27 mm wingspan; *forewings* blackish-brown with whitish or bronze markings but appearance extremely variable; *hindwings* greyish. **Larva** up to 25 mm long; *body* greyish-ochreous to purplish-brown, with pale stripes; *pinacula* very small and black; *spiracles* black and prominent; *head* very small, brown and shiny; *prothoracic plate* large and pale brown; *anal plate* very large and ochreous-brown.

***Oria musculosa* (Hiibner)**
Brighton wainscot moth

Although an important pest of cereals (mainly barley) in parts of central and eastern Europe, this moth has only relatively recently become established in the British Isles where it sometimes causes minor damage to cereal crops in parts of Wiltshire. The larvae attack the stems and also the developing ears, often feeding on the latter whilst these are still hidden within the leaf sheaths.

BIOLOGY
The moths occur from mid-summer to early autumn and deposit their eggs in large batches on stubble, on rocks or directly on the lower parts of the stems of host plants. The eggs overwinter and hatch from March onwards. The larvae feed until June, and each is capable of damaging up to 20 stems. Pupation occurs in the soil.

DESCRIPTION
Adult 28^34 mm wingspan; *forewings* ochreous with two longitudinal whitish-ochreous bands; *hindwings* greyish with whitish cilia. **Larva** up to 30 mm long; *body* pale green with dark green subdorsal stripes; *pinacula and spiracles* small and black; *head* ochreous-yellow; *prothoracic plate* greenish-ochreous, marked with black.

***Orthosia incerta* (Hufnagel)**
Clouded drab moth

This generally common moth is sometimes of pest status in apple orchards. The larvae feed on the leaves but, more significantly, also bite into the developing fruitlets. Attacked fruitlets often fall prematurely or, if reaching maturity, are deformed and bear corky scars.

BIOLOGY

Moths fly in March and April. Eggs are then laid on the leaves of various food plants and hatch in about 10-14 days. The larvae feed from May onwards and are fully grown in June or July. They then pupate in flimsy subterranean cocoons. Adults emerge in the following spring.

DESCRIPTION

Adult 32-42 mm wingspan; *forewings* extremely variable, ranging from grey to brown or purplish-black, with often indistinct markings; *hindwings* grey to brownish-grey **(Fig. 326).** **Larva** up to 45 mm long; *body* varying from green to bluish-green, distinctly speckled with white, and with a broad white line along the back and a white or yellow spiracular stripe, edged above with black; *head* pale green or yellowish brownish.

Phlogophora meticulosa (L.)
Angle-shades moth

Larvae of this species feed on various herbaceous plants, including lettuce, spinach, strawberry and other field crops; they are, however, of greatest significance as pests of tomato and other glasshouse crops, especially those growing in structures with artificial lighting. The young larvae graze on the underside of leaves but leave the upper epidermis intact. Older larvae bite right through the leaves and, when numerous, can cause significant defoliation. Larvae also attack buds and flower trusses.

BIOLOGY

Moths occur throughout much of the year but are particularly numerous in May and June and in the autumn. When at rest, the wings are folded longitudinally and the moth resembles a withered leaf. Eggs are laid singly or in small batches on the leaves of host plants. They hatch within about 10 days, but usually more rapidly under glass. Larvae may be found feeding throughout the year, but are usually present as two indistinct broods from autumn to spring and in the summer. Fully fed larvae pupate in the soil, each in a flimsy cocoon.

DESCRIPTION

Adult 40-50 mm wingspan; *forewings* pale pinkish-brown, darker basally, with a large olive-green and pinkish V-shaped median mark; *hindwings* whitish **(Fig. 327).** **Egg** 0.8mm

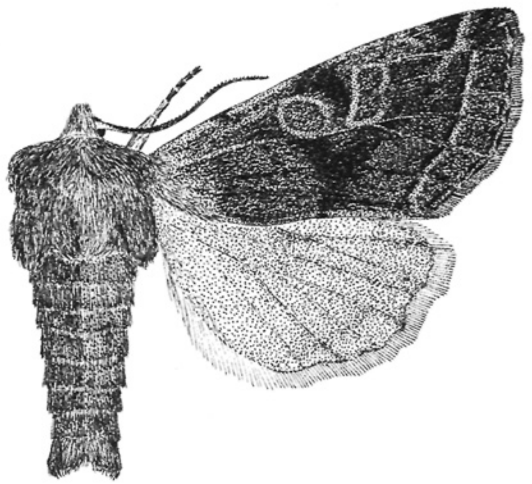


Fig. 326 Clouded drab moth, *Orthosia incerta* (x3).

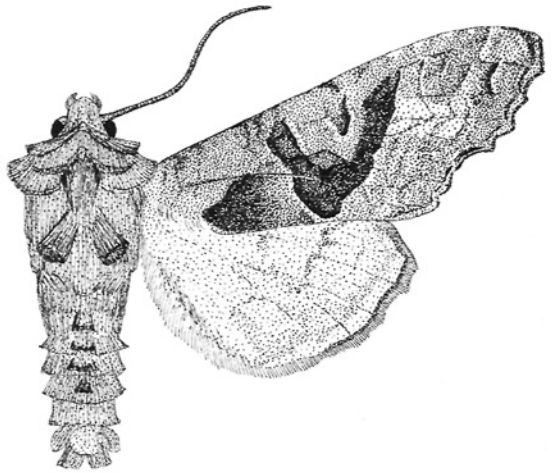


Fig. 327 Angle-shades moth, *Phlogophora meticulosa* (x2.5).

in diameter, hemispherical and strongly ribbed; pale yellow, with darker markings. **Larva** up to 40 mm long; *body* plump, yellowish-green or brownish, with a thin, broken line, and feint V-shaped or W-shaped marks along the back; *spiracles* white and black-rimmed.

***Spodoptera littoralis* (Boisduval)**
Mediterranean brocade moth

This tropical and subtropical pest is established in various parts of southern Europe where it attacks a range of crops, including glasshouse-grown ornamentals and vegetable crops. The larvae (often known as 'Mediterranean climbing cutworms') cause extensive defoliation; they also damage stems and flowers. In the British Isles, larvae are found occasionally on imported plants, especially chrysanthemum; the adult is a very rare 'natural' immigrant.

BIOLOGY
Eggs are laid in groups and then covered with hairs from the adult moth. The eggs hatch within a few days at normal glasshouse temperatures. The larvae feed mainly at night and, when fully grown, pupate in the soil a few centimetres below the surface. The development and survival of this multivoltine species depends considerably on temperature; breeding is continuous whilst conditions remain favourable.

DESCRIPTION
Adult 35-40 mm wingspan; *forewings* reddish-brown, with pale markings (some of which highlight the veins) and partly suffused with grey (fresh specimens have a purplish sheen) **(Plate 15f);** *hindwings* mainly whitish. **Larva** up to 45 mm long; *body* extremely variable in colour (ranging from green to dark brown), often noticeably speckled with white and with paired velvet-black patches on at least the first and eighth abdominal segments.

ORDER HYMENOPTERA (ANTS, BEES, SAWFLIES, WASPS, ETC.)

Family PAMPHILIDAE

***Neurotoma saltuum* L.**
Social pear sawfly

Infestations of this local, southerly distributed and sporadic pest occur on pear and, occasionally, other rosaceous hosts (Rosaceae) such as cherry and plum. The larvae feed gregariously in conspicuous webs, and often completely strip the foliage from affected shoots and branches. Attacks occur most frequently on young trees.

BIOLOGY
The active, fast-flying adults occur in May and June. Eggs are laid in large batches of about 50 on the underside of leaves and are then covered in a sticky, protective secretion. Larvae occur mainly in June and July. They feed voraciously, and their silken tents soon become very obvious. Fully fed individuals overwinter in the soil and eventually pupate in the spring, each in a flimsy silken cocoon.

DESCRIPTION
Adult 11-14 mm long; *head* black with a distinctive yellow patch between the antennae **(Fig. 328);** *thorax* black, with yellow tegulae; *abdomen*

Fig. 328 Head of social pear sawfly, *Neurotoma saltuum.*

orange apically and marked with yellow laterally; *antennae* yellow basally; *legs* yellow. **Egg** 1.5 mm long, yellow. **Larva** up to 25 mm long; *body* yellowish-orange with pale longitudinal stripes, a pair of shiny black prothoracic plates laterally, a pair of prominent antennae and prominent anal cerci; *head* black and shiny; *thoracic legs* well developed; *abdominal prolegs* absent (see Fig. 145).

Family CEPHIDAE (stem sawflies)

Cephus pygmeus (L.)
Wheat stem sawfly

This widely distributed sawfly is a pest of winter wheat but will also attack barley, rye, other cereals and grasses. Although of major importance in many parts of its range (notably in eastern Europe) in some areas (including the British Isles) the insect is now less important than formerly; possibly, numbers declined following the adoption of post-harvest straw burning. It remains to be seen whether banning of straw burning will lead to an increase in the pest status of this insect. Plants attacked by wheat stem sawfly larvae are undernourished, dwarfed and weakened; typically, the ears fail to develop properly and the seed heads turn white. Such plants often break off a few centimetres above ground level, especially in heavy rain or in a strong wind.

BIOLOGY

Adults occur from late May or June to July. They are often found in the vicinity of cereal fields, where they forage for pollen on Umbelliferae and various other plants, including late-flowering oilseed rape. Eggs are laid singly in the stems of cereal plants, each inserted just below the ear through a slit formed close to the uppermost node. The egg hatches 7-10 days later. The larva then bores downwards within the pith and eventually, typically about a month later, reaches the base of the stem. The larva then bites around the wall of the stem to form a line of weakness, and plugs the hollow stem below this point with a mixture of frass and fragments of tissue removed from the wall; the larva then spins a cocoon within which to overwinter. Pupation occurs in the spring.

DESCRIPTION

Adult female 9-10 mm long, elongate, mainly black and shiny, with bright yellow patches or bands on the abdomen (especially on the fourth and sixth segments); *antennae* black, filiform and noticeably thickened towards the tip; *wings* hyaline, with black veins **(Fig. 329). Adult male** similar in appearance to female but marked more extensively with yellow **(Plate 16a). Larva** up to 12 mm long; *body* elongate and mainly yellowish-white; *head* yellowish-brown **(Plate 16b);** *anal segment* with a slightly chitinized dorsal spine; *thorax* with three pairs of fleshy leg-like tubercles (these are not always obvious) but body otherwise apodous **(Fig. 330).**

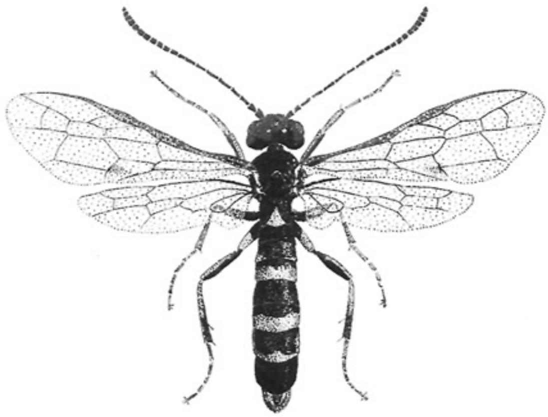


Fig. 329 Female wheat stem sawfly, *Cephus pygmeus* (x4).

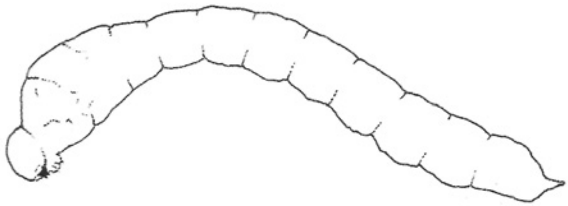


Fig. 330 Larva of wheat stem sawfly, *Cephus pygmeus* (x9).

Family ARGIDAE

Arge pagana **(Panzer)**
Variable rose sawfly

This often abundant species, which is widely distributed in continental Europe and in much of southern Britain, is a destructive pest of cultivated rose. The larvae cause extensive skeletonization and defoliation that affects the development and appearance of bushes.

BIOLOGY
Adults occur from May onwards. Eggs are deposited in rows within the young shoots and flower stalks, the female's ovipositor leaving long, characteristic scars. Larvae feed voraciously on the expanded foliage from June onwards. When fully fed, they pupate in the soil, each in a double-walled cocoon; adults emerge shortly afterwards. There are two main generations annually, but larvae continue to be found on bushes well into the autumn.

DESCRIPTION
Adult 7-9 mm long, black with a mainly yellow abdomen. **Larva** up to 25 mm long; *body* bluish-green, suffused with yellow dorsally; *pinacula* shiny black and arranged in distinct longitudinal and transverse rows; *head* black or yellowish-orange; *thoracic legs* black; *abdominal prolegs* five pairs present **(Plate 16c).**

Arge *ochropus* **(Gmelin in L.)**
Large rose sawfly

This sawfly also infests rose but, at least in Britain, is usually less abundant than the previous species, and often has just one generation annually. Adults are distinguished from those oiArge pagana (above) by their yellow pronotum and tegulae and partly yellow legs; pinacula on the larvae of *A. ochropus* tend to be noticeably larger than those of *A. pagana.*

Family TENTHREDINIDAE

Ametastegia ***glabrata*** **(Fallen)**
Dock sawfly

Dock sawfly is a widely distributed but minor pest of fruit crops, especially apple and grape vines. The larvae feed on various weeds and, when fully grown, sometimes bore into mature apple fruits; larvae may also bore into the pith of shoots or branches of young fruit trees, vines and other cultivated plants, often entering through pruning cuts. Damage in apple fruits is characteristic, and consists of a straight, often deep tunnel (up to 5 cm long), surmounted by a red-ringed entry hole about 2 mm in diameter; however, larvae are rarely found inside damaged fruits. The larvae have also been reported burrowing into plastic irrigation pipes.

BIOLOGY
The larvae feed during the summer on the leaves of weeds such as *Chenopodium, Polygonum* and *Rumex.* When fully fed, they usually pupate in pithy or hollow stems of plants such as *Rubus*, but individuals may also bore into low-growing branches of fruit trees. In autumn, fully fed larvae in their search for overwintering sites may also burrow into maturing apples; however, finding them unsuitable, they soon leave for other quarters. Two or three generations occur throughout the summer.

DESCRIPTION
Adult 5.5-8.0mm long and shiny purplish bronzy-black; *legs* mainly red. **Larva** 13-18 mm long; *body* apple-green; *head* brownish; *abdominal prolegs* eight pairs present.

Athalia rosae **(L.)**
Turnip sawfly

The turnip sawfly is a sporadically important pest of radish and turnip; it also damages Chinese leaf, mustard, oilseed rape and swede crops. Larvae skeletonize the leaves of host plants, and heavy infestations can be of considerable economic importance. Populations of this pest declined throughout northwestern Europe in the late nineteenth century, and the sawny then became extinct as a breeding species in the British Isles. Since the 1940s, however, numbers have increased and the sawfly (which is renowned as a migrant) has been reported on occasions in England, usually in the extreme southeast.

BIOLOGY

Adults occur from May to October, with up to three generations annually. They require warm conditions to be active, and fly only at temperatures above approximately 18°C. Eggs, up to 300 or more per female, are deposited singly in the leaf margins of host plants, and they hatch in about a week. In common with many related sawfiies, fertilized eggs give rise to female offspring and unfertilized eggs to males. At first, larvae mine within the leaf tissue; later, they graze externally, typically feeding gregariously. Individuals are fully grown in about 3 weeks. They then enter the soil, where each forms a cocoon within which to pupate; adults of the next generation appear 2-3 weeks later. Fully fed larvae of the final brood enter the soil to overwinter; they pupate in the spring and adults appear shortly afterwards.

DESCRIPTION

Adult 6-8 mm long, mainly yellow to reddish-yellow; *head and antennae* black. **Egg** 1mm long, white. **Larva** up to 18 mm long; *body* distinctly wrinkled, mainly grey or greenish-grey to velvety black, with a pale underside, a pale lateral band and a dark-edged dorsal stripe; *head* shiny black; *abdominal prolegs* eight pairs present.

Blennocampa pusilla **(Klug)**
Leaf-rolling rose sawfly

This sawfly is generally common on wild and cultivated rose, and is often an important pest in nurseries and gardens. The larvae feed in rolled, drooping leaflets; heavy infestations have a significantly detrimental effect on plant vigour. Cultivars with thick, shiny leaves are least likely to be attacked.

BIOLOGY

The adult sawfiies occur in May and June. The egg-laying females probe the leaves of rose and, in some of these punctures, eggs will be laid. Punctured leaves roll tightly inwards and downwards to form a long tube-like shelter on either side of the mid-rib, within some of which larvae will eventually feed and develop. Larvae occur from late May or early June to July or August. Fully fed individuals enter the soil and spin flimsy cocoons a few centimetres below the surface. Here they overwinter and eventually pupate in the spring. This species is univoltine.

DESCRIPTION

Adult 3.0-4.5 mm long, mainly black and shiny; *legs* partly whitish. **Larva** up to 10 mm long; *body* pale whitish-green, covered in short spines; *head* brown; *abdominal prolegs* eight pairs present.

Caliroa cerasi **(L.)**
Pear slug sawfly

This widely distributed and locally common pest occurs on various rosaceous trees and shrubs (Rosaceae), including ornamentals and fruit trees, especially cherry and pear. Larvae (known as 'pear & cherry slugworms') graze away patches of tissue on the upper surface of leaves and sometimes cause extensive damage that may lead to premature leaf-fall. Badly affected foliage appears scorched.

BIOLOGY

Adults of this mainly parthenogenetic species first appear in late May and June. Eggs are then deposited in the underside of leaves of host plants. The relatively sedentary, slow-moving larvae feed and rest openly on the upper surface of leaves. They may be found throughout the summer months and into the early autumn. Pupation occurs in the soil, each larva forming a small black cocoon about 10 cm below the sur-

Fig. 331 Pear & cherry slugworm, *Caliroa cerasi* (x8).

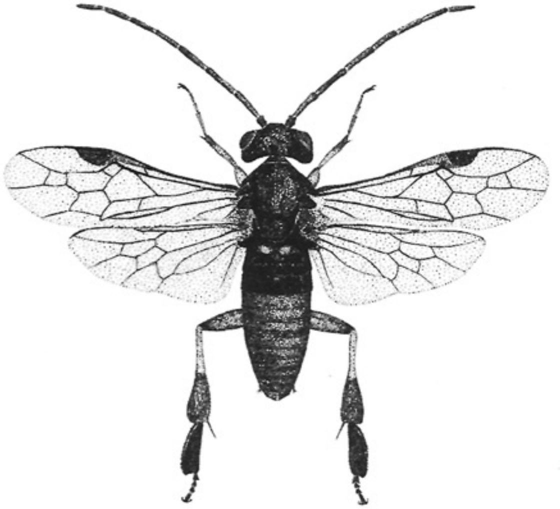


Fig. 332 Adult hazel sawfly, *Croesus septentrionalis* (x4).

face. There are usually two, sometimes more, generations each year.

DESCRIPTION

Adult 4-6 mm long, black and shiny. **Larva** up to 10 mm long; *body* pyriform, distinctly swollen anteriorly **(Fig. 331),** greenish-yellow to orange-yellow but covered in a shiny olive-black slime; *thoracic legs* inconspicuous; *abdominal prolegs* seven pairs present.

Croesus septentrionalis (L.)
Hazel sawfly

This generally common sawfly attacks a wide range of deciduous trees and shrubs (including *Alnus, Betula* and *Corylus).* The larvae often cause extensive damage to young ornamentals and can rapidly defoliate the branches; they are also minor pests in cob nut, filbert and hazel plantations.

BIOLOGY

Adults appear in May and June. Eggs are then deposited in small slits made in major leaf veins of host plants. After egg hatch, the larvae feed gregariously and voraciously. They rest in groups, with each larva grasping the leaf edge with the thoracic legs and arching the abdomen over the head (a posture common to many species of sawfly larvae). Fully fed larvae enter the soil where they spin brown cocoons. In favourable districts, where there is a second generation of adults in August, larvae may be found from mid-June to early autumn. Second-generation larvae overwinter in their subterranean cocoons and pupate in the spring.

DESCRIPTION

Adult 8-10 mm long; *head, antennae and thorax* black; *abdomen* mainly reddish-brown; *legs* black, the hind basitarsus and apex of hind tibia greatly expanded **(Fig. 332)**. **Larva** up to 22 mm long; *body* pale yellowish-green to bluish-green, and partly suffused with yellow on the first thoracic and apical abdominal segments; prominent, black, rounded patches along either side of the body; *head* shiny black; *abdominal prolegs* seven pairs present **(Fig. 333).**

Dolerus haematodes Schrank

This sawfly is a minor pest of grasses and cereals, including wheat and barley. The larvae graze openly on the leaves and typically devour the tissue from the tip downwards. Affected leaves often appear severed and frequently attract

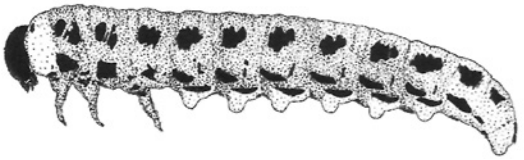


Fig. 333 Larva of hazel sawfly, *Croesus septentrionalis* (x4).

attention; damage, however, is of little or no importance.

BIOLOGY

Adults occur mainly from May to June. Eggs are deposited in the edges of expanded leaves; each egg enlarges before hatching to produce a prominent swelling in the leaf lamina. Larvae are most numerous in June and July. They feed on the leaf tissue for 4-6 weeks before becoming fully fed. They then moult into active prepupae and enter the soil, where they eventually pupate but without forming cocoons (cf. *Pachynematus clitellatus*, p. 252). There is one generation each year.

DESCRIPTION

Adult 9-10 mm long, mainly metallic black with a green and bluish sheen; *pronotum and tegulae* red (in female). **Larva** up to 18 mm long; *body* greenish-white to creamish-white, but blackish dorsally, with a black mark over each thoracic leg; *head* marked with black; *abdominal prolegs* eight pairs present **(Plate 16d).**

Dolerus puncticollis Thomson

This generally common and widely distributed species is also a minor pest of cereals. The adults (9-10mm long) **(Fig. 334)** are mainly black, with the apex of each femora and the base of each tibia reddish. They occur from late April or early May onwards and may often be seen flying around the periphery of cereal fields. The larvae feed on the foliage of cereals during the summer months and, eventually, pupate in the soil. There is one generation each year.

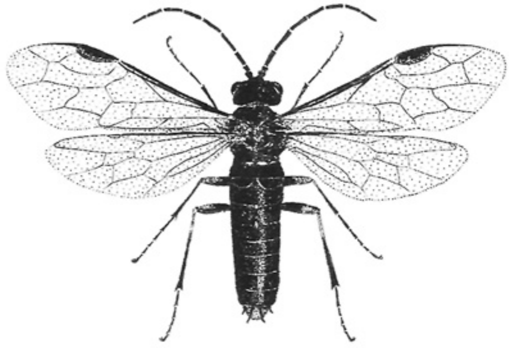


Fig. 334 Adult *Dolerus puncticollis* (x3.5).

Hoplocampa testudinea (Klug)
Apple sawfly

This sawfly is an important pest of apple. The larvae burrow singly within the developing fruitlets and produce masses of wet. black frass; this is exuded through a small hole (c. 1.5 mm in diameter) in the side of each infested fruitlet (cf. damage caused by codling moth, *Cydia pomonella*, p. 218, and fruitlet-mining tortrix moth. *Pammene rhediella*, p. 222). Attacked fruitlets remain small, are often deformed and are noticeably pubescent. They usually drop prematurely and crop losses can be considerable, particularly on susceptible dessert cultivars such as James Grieve and Worcester Pearmain. Attacked fruitlets sometimes bear long slit-like wounds that arise from the calyx; these indicate that the larva has failed to penetrate into the flesh. Such fruitlets often develop to maturity, with characteristic, corky, ribbon-like scars.

BIOLOGY

Adults occur during April and May. They are active during sunny weather, especially around mid-day. After mating, eggs (typically about 30 per female) are laid singly in the apple blossom, each inserted in a slit made immediately below the sepals by the female's saw-like ovipositor. Eggs hatch in about 2 weeks. Each larva then penetrates into the receptacle of the fruitlet to feed on the flesh; they also enter the ovary and attack the developing pips (seeds). Infested fruitlets usually fail to develop further. After

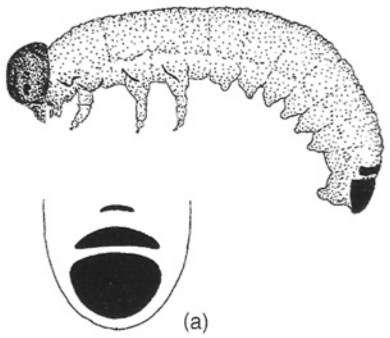


Fig. 335 Young larva of apple sawfly, *Hoplocampa testudinea* (x20): (a) tip of abdomen (further enlarged).

about 2-3 weeks, the larva vacates the original fruitlet and invades an adjacent one, usually entering directly through the skin on the basal half; further fruitlets may be attacked before larvae are fully grown and drop to the ground. Larvae overwinter in the soil in silken cocoons, formed several centimetres (and often as deep as 25 cm) below the surface. Pupation occurs in the spring, a few weeks before the emergence of the adults; some larvae, however, may remain in the soil for one or more seasons before attaining the adult stage.

DESCRIPTION

Adult 6-7 mm long, shiny black dorsally and orange ventrally; *wings* more or less clear, with brown veins. **Egg** 0.8 mm long, white and translucent, elongated and slightly curved. **Larva** up to 12 mm long; *body* whitish; *head* yellowish-brown; *abdominal prolegs* seven pairs present; *caudal plates* (on abdominal segments 8-10) inconspicuous. **Young larva** whitish; *caudal plates* on abdominal segments 9 and 10 very conspicuous **(Fig. 335)** but the plate on abdominal segment 8 small and inconspicuous **(Fig. 335a)**; *head* blackish.

***Hoplocampa brevis* (Klug)**
Pear sawfly

This species is associated with pear and, although local and uncommon in England, is an important pest in continental Europe. Unlike *Hoplocampa testudinea* (p. 250), males are fare and reproduction is mainly parthenogenetic; otherwise, the biology of both species (apart from choice of host plant) is very similar.

***Hoplocampa flava* (L.)**
Plum sawfly

Infestation of this local species occur on damson and plum. Losses on garden and orchard trees can be considerable but attacks tend to be sporadic and unpredictable. The mainly brownish to orange-coloured adults (3.5-5.5 mm long) occur in April, and eggs are then deposited singly in the fruitlets of host plants. The creamish-white larvae feed within the fruitlets. They produce masses of wet, black frass (cf. fruitlet-mining tortrix moth, *Pammene rhediella*, p. 222). Fully grown larvae enter the soil and form cocoons, in which they eventually overwinter. In common with related species, there is just one generation annually.

***Nematus ribesii* (Scopoli)**
Common gooseberry sawfly

This generally abundant sawfly is a notorious pest of gooseberry; infestations also occur on, for example, red currant and white currant, but not on black currant (cf. *Nematus olfaciens*, p. 252). Two- or three-year-old bushes are most likely to be attacked. Initial infestations tend to occur on the central, lower parts of bushes but they soon spread upwards and outwards. The larvae feed gregariously and rapidly defoliate the branches to leave only a skeletal framework of major veins. Heavy infestations cause considerable loss of plant vigour and cropping potential is reduced.

BIOLOGY

Adults occur from April or May onwards. Eggs are eventually laid in rows in slits made in the major veins on the underside of the leaves of host plants. The eggs hatch about 8-10 days later. Larvae then feed ravenously. They pass through

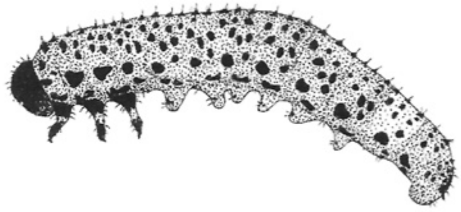


Fig. 336 Larva of common gooseberry sawfly. *Nematus ribesii* (x4).

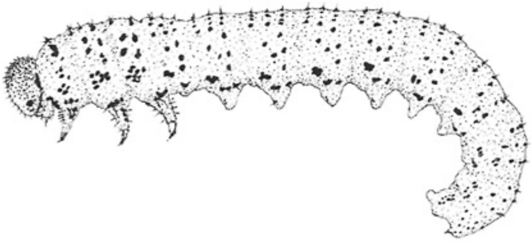


Fig. 337 Larva of pale-spotted gooseberry sawfly. *Nematus leucotrochus* (x4).

several instars and become fully grown in about 3 weeks. Individuals then moult into active prepupae (these are sometimes thought to be larvae of a different species of sawfly; see description below). The prepupae soon disperse and enter the soil to spin oval, dark brown, parchment-like cocoons 10-15 cm below the surface. Individuals then pupate, and adults of the next generation appear shortly afterwards. There are usually up to three generations annually, and larvae occur throughout the summer into early autumn.

DESCRIPTION

Adult female 6-7 mm long, mainly yellow with a black-marked thorax; *head* black; *antennae* dark above and pale below. **Adult male** 5-6 mm long, dark-bodied; *antennae* entirely dark. **Egg** 1.2mm long, pale greenish-white. **Larva** up to 20 mm long; *body* mainly green, with the first, part of the second and last two body segments orange; *pinacula* large, black and shiny, each bearing one or more black setae; *head* black and shiny; *thoracic legs* black; *abdominal prolegs* seven pairs present **(Fig. 336)** (cf. magpie moth, *Abraxas grossulariata*, p. 228). **Prepupa** mainly pale bluish-green, with the first and last two body segments pale orange; *pinacula* inconspicuous.

Nematus leucotrochus **Hartig**
Pale-spotted gooseberry sawfly

This species is associated with gooseberry and, occasionally, red currant and white currant. Unlike *Nematus ribesii* (p. 251), it is univoltine; adults occur in May and the larvae feed mainly in May and June. The larvae, which usually occur in only small numbers, are distinguished from those of *N. ribesii* by their green, black-spotted head and their smaller pinacula **(Fig. 337).**

Nematus olfaciens Benson
Black currant sawfly

This pest occurs on various kinds of *Ribes* but is associated mainly with black currant. The larvae sometimes cause extensive defoliation. In commercial black currant plantations, the larvae may also contaminate trays of mechanically harvested fruit. There are two or three generations annually. The green-headed larvae (cf. *Nematus ribesii.* p. 251) are similar in appearance to those of *N. leucotrochus* (above) but the pinacula are noticeably larger and often coalesce.

Pachynematus clitellatus **(Lepeletier)**

This sawfly is associated with various members of the Poaceae, including cultivated wheat. The larvae feed on the leaves; they cause noticeable, but only minor, damage.

BIOLOGY

Adults of this univoltine species occur from May onwards, and eggs are deposited in the edges of expanded leaves. Larvae occur mainly in June and July. Fully grown individuals enter the soil where they eventually pupate, each in a thin cocoon (cf. *Dolerus* spp., p. 249 *etseq.).*

DESCRIPTON

Adult 6-7 mm long, black, marked extensively with pale yellow; *male* with head and thorax entirely black. **Larva** up to 18 mm long; *body* green, speckled with black; *head* yellowish-green to greyish-green.

Family FORMICIDAE (ants)

Lasius spp.

In the tropics and subtropics, ants are of considerable economic importance and various species cause considerable damage to cultivated plants. Ants are far less significant in temperate regions, although *Lasius fidiginosus* (Latreille) and members of the genus *Camponotus* Mayr are considered forestry pests in continental Europe.

In Britain, ants (especially the yellow meadow ant, *L. flavus* (F.)) sometimes damage potato tubers, causing a noticeable pitting of the surface; the pits sometimes coalesce to become distinctive surface depressions. Such attacks occur mainly in gardens and allotments, and are most often noticed in July and August. Under dry spring conditions, ants will also cause slight damage to ornamental trees and shrubs (and also to fruit trees, especially apple); they either bite into the soft, young tissue of the buds and unfurling leaves or sever the stamens of open blossoms in their attempts to reach the nectaries and imbibe nectar. Most frequently, however, worker ants ascend trees and shrubs to collect honeydew excreted by aphids and other pests; such ants will 'defend' aphid colonies from attacks by natural enemies. Subterranean activities by ants are, occasionally, a problem to horticulturists, as the insects accidentally disturb seeds, seedlings and older plants; invasion of stored compost by ants is also an unwelcome inconvenience.

Family VESPIDAE (wasps)

Vespula germanica (F.)
German wasp

Vespula vulgaris (L.)
Common wasp

Wasps are generally abundant, well-known insects and are often regarded as pests. They feed avidly on ripening or over-ripe apples, grapes, pears, plums and other fruits, especially those previously damaged by birds or other agents; wasps thereby become a nuisance. The presence of such insects in fruit plantations at harvest is also a potential hazard to fruit pickers, even when the insects are foraging only on fallen fruits. Wasps are sometimes also a problem in flower borders and nurseries, where they may remove tissue from the stems of woody plants such as garden dahlia; injured plants often then collapse. This plant material, in common with that removed from wooden posts, shed walls, etc., is used in nest construction. Although much maligned, wasps are also beneficial insects, as they prey during the spring and summer on harmful caterpillars and other pests that are then fed to their developing brood.

BIOLOGY

Vespid wasps are social insects, with three distinct castes: queens, workers and males. Young, fertilized queens overwinter and eventually emerge in the spring. Each soon begins to search for a suitable nesting site, such as a hollow tree or a dry, underground cavity in the soil. A wasp's nest is formed from grey (as in *Vespula germanica)*, brown or yellow (as in *V. vulgaris)*, masticated wood pulp and contains numerous papery cells in each of which an egg is laid and a larva reared. As the season progresses, new cells are constructed and further eggs are deposited. The colony increases rapidly in size, especially after the first young adult worker wasps have emerged and aid the mother queen in the task of tending the brood. Workers also eventually take over all foraging duties; this allows the queen to remain within the comparative safety of the nest. Although adult wasps feed mainly on sugary substances, their larvae are fed mainly on dead insects. A successful colony may contain several thousand individuals and, at the height of its development, the nest will have reached the size of a football. At this stage, males and new queens are reared. These young queens, usually having mated in the field with males from other colonies, soon hibernate. As autumn approaches, wasp colonies gradually decline and the ageing workers, males and foundress queens eventually die.

DESCRIPTION

Adult queen 18-20 mm long, black and yellow, with a distinctive narrow 'waist' and a pointed abdomen armed with an unbarbed sting; *antennae* 12-segmented. (The clypeus of *Vespula germanica* is yellow, usually marked with three black spots; in *V. vulgaris*, the black clypeal markings are more extensive and often form a broad, axe-like patch.) **Adult worker** similar to queen but smaller. **Adult male** 15-18 mm long, similar in appearance to female (i.e. queen or worker) but abdomen less pointed and without a sting; *antennae* 13-segmented.

Mites

ORDER PROSTIGMATA

Family PHYTOPTIDAE

Phytoptus avellanae **Nalepa**
Filbert bud mite

This widely distributed mite is generally common on cob nut, filbert and hazel. The mites induce the formation of swollen buds ('big buds'); infestations also cause blind shoots. Any detrimental effect on the yield of nut-producing trees is of little or no significance, except in countries such as Italy, Spain and Turkey where a large proportion of buds may be galled.

BIOLOGY
The mites breed throughout the late summer, autumn and winter in the buds of host plants. Infested buds develop into swollen galls, which become noticeable from September onwards. The mites also occur in female flowers and male catkins. In March and April, adult females invade the underside of expanding leaves. Eggs are then laid and these give rise to active protonymphs that eventually develop into more or less sedentary summer deutonymphs, found mainly alongside the major leaf veins. These deutonymphs finally moult into adults that invade new terminal buds to initiate the next generation of 'big-buds'.

DESCRIPTION
Adult 0.3 mm long, whitish and spindle-shaped, with numerous narrow tergites and sternites; *prodorsal shield* with two pairs of dorsal setae (see Fig. 168a). **Summer deutonymph** flat-bodied, with just a few, very broad tergites.

Family ERIOPHYIDAE (gall mites)

Abacarus *hystrix* **(Nalepa)**
Cereal rust mite

Infestations of this widely distributed mite occur on various cereals and grasses but are most often present on ungrazed or uncut Italian rye-grass and perennial rye-grass, especially the latter. The pest is a well-known vector of rye-grass mosaic virus. In North America, it is also implicated in the spread of Agropyron mosaic virus. When numerous, the mites cause direct damage and infested leaves become discoloured. The combined effect of mite feeding and virus infection results in undersized plants, which lack vigour and give reduced yields.

BIOLOGY
Adult females overwinter on tender tissue at the tips of host plants and become active in the spring. They then invade the upper surface of the young leaves, and eventually deposit eggs within the longitudinal grooves between the veins. Breeding continues throughout the summer months and populations reach peak numbers in late August or early September. Mites feeding on virus-infected plants pick up the virus

within a couple of hours; they are then capable of transmitting the disease to healthy plants.

DESCRIPTION
Adult 0.18-0.20mm long, whitish, elongate and slender-bodied; *hysterosoma* subdivided into numerous tergites and sternites; *prodorsal shield setae* directed backwards.

Acalitus essigi (Hassan)
Blackberry mite

This species is widely distributed and sometimes common on cultivated and wild blackberry. The mites do not damage the leaves (cf. raspberry leaf & bud mite, *Phyllocoptes gracilis*, p. 259) but cause a characteristic uneven ripening of infested fruits, the basal drupelets of which remain hard and greenish-red to red whilst the rest mature, a condition known as 'red-berry' disease. The incidence of 'red-berry' tends to increase as the season progresses, with late-maturing fruits the most severely affected. Physiological factors may cause uneven ripening of blackberries, but not necessarily of the basal drupelets, and affected areas often become softened (a clear indication that mites are not the cause).

BIOLOGY
Mites hibernate in various sheltered situations on host plants, and become active in the early spring. They then move to the new shoots to feed and breed amongst the hairs on the leaves and petioles. Later, the mites migrate to the opening blossoms and will eventually become established around the base of the developing fruits, sheltered by the remains of the calyxes; here, they feed on the basal drupelets. There are several overlapping generations annually. Populations diminish rapidly in the autumn, and survivors eventually overwinter.

DESCRIPTION
Adult mite 0.16-0.18 mm long, whitish and vermiform; *prodorsal shield setae* long and directed backwards.

Aceria lycopersici (Wolffenstein)
Tomato erineum mite

This widely distributed tropical and subtropical pest occurs in greenhouses in various parts of Europe, especially on aubergine and tomato. It induces the development of whitish, hairy patches (erinea) on the leaves, petioles and stems, and causes most damage under hot, dry conditions. The mites inhabiting these erinaceous galls are vermiform, 0.15-0.20 mm long, with equal numbers (c. 60) of tergites and sternites (cf. tomato russet mite, *Aculops lycopersici*, below).

Aculops lycopersici (Massee)
Tomato russet mite

This mite is an important pest of tomato; other cultivated hosts include aubergine, potato and sweet pepper. In temperate regions, such as Europe, the pest occurs in glasshouses and breeds continuously without a dormant stage. Infestations lead to significant bronzing of leaves and stems; damaged areas often also crack and become distorted. Symptoms usually first appear at the base of plants and gradually spread upwards. Most significant damage occurs on tomato; leaves may desiccate and drop off, and infested plants are often killed. The free-living mites are pale yellowish-brown, 0.15-0.18 mm long and wedge-shaped, with about 27 broad tergites and 60 narrow sternites (cf. tomato erineum mite, *Aceria lycopersici*, above, which is a far less important pest).

Aculus schlechtendali (Nalepa)
Apple rust mite

This mite is a widely distributed and generally common pest of apple; occasionally, the mites also occur on pear (cf. pear rust mite, *Epitrimerus piri*, p. 258). Although implicated in causing leaf bronzing and fruit russeting in apple orchards, large numbers of mites can be tolerated before there is any adverse effect on cropping. Apple cultivars vary in their susceptibility to this pest. In integrated pest management systems, the presence of this mite can be useful for maintaining populations of predatory mites (e.g. *Typhlodromus pyri* Scheuten) at times when spider mites (the preferred hosts) are at low levels.

BIOLOGY

The mites are free-living and deuterogenous, with two adult female forms (protogynes and deutogynes) which differ both structurally and physiologically. Protogynes (= summer females) and males are the primary forms; these breed normally throughout the summer, and there are several (often four or five) overlapping generations each year. Development from egg to adult includes two nymphal stages and is completed in just over 2 weeks at temperatures of 16°C; the egg stage is relatively protracted. Deutogynes (= winter females), for which there is no equivalent male stage, appear in increasing numbers from July onwards. They hibernate under bud scales, and reappear early in the following spring. They then invade the opening buds and eventually lay eggs that give rise to the first generation of protogynes and males. Large numbers of mites of all stages of development may be found on expanded leaves throughout the summer months but populations decline rapidly following the production of deutogynes and their subsequent migration to overwintering sites.

DESCRIPTION

Protogyne 0.14-0.18 mm long, yellowish-brown to dark orange-brown and fusiform; *prodorsal shield* slightly granular; *prodorsal shield setae* long and directed backwards. **Deutogyne** similar to protogyne but prodorsal shield not granular and prodorsal shield setae shorter. **Adult male** 0.14-0.15 mm long, orange-yellow to dark orange brown. **Egg** 0.05 x 0.03 mm, oval and translucent. **Nymph** whitish to pale orange-brown; *prodorsal shield* granular.

Aculus fockeui (Nalepa & Trouessart)
Plum rust mite

Recently, infestations of this generally common pest have become more significant (at least in some areas). The mites inhabit the underside of expanded leaves of both fruiting and ornamental species of *Primus,* often in considerable numbers. Infestations on young leaf trusses result in the development of large spots on young green shoots, a distinctive yellow flecking of the leaves and, sometimes, distortion. Heavy populations may cause severe bronzing and lead to the death of young leaves. Along with certain other free-living species, the mites attack both established and young trees and are sometimes troublesome in gardens, nurseries and orchards. Some fruiting cultivars, especially Victoria, are particularly susceptible.

Cecidophyopsis ribis (Westwood)
Black currant gall mite

This mite is an important and widely distributed pest of black currant. The mites induce the formation of characteristic 'big buds'. Also, leaves that emerge from infested apical shoots are often deformed and have rounded outlines to the main lobes. Affected bushes grow vigorously but crop poorly. 'Big buds', that may reach 15mm in diameter, are particularly noticeable after leaf-fall. They remain on bushes throughout the winter and into the following summer, when they eventually dry out and die. Although having a direct effect on host plants, black currant gall mite is of greatest significance as a vector of reversion virus disease. The presence of this virus is often a major cause of the decline of bushes and it will shorten considerably the economic life of plantations.

BIOLOGY

Black currant gall mites live and breed within the shelter of swollen, galled buds, each of which may contain many thousands of individuals. Adult mites begin to emerge from these 'big buds' in the early spring, from the grape growth stage onwards; emergence is favoured by warm, humid conditions, the mites often swarming on the outside of the galls in considerable numbers. Individuals eventually migrate over the bushes and are also carried from bush to bush by insects, wind or rain. This dispersal period lasts into the summer but is at its peak in May, from early flowering to early fruit swelling. New buds are invaded in June or early July, when egg laying begins. The mites breed rapidly within the buds from early summer onwards, particularly as the buds begin to swell, and populations reach their maximum in September. Egg laying ceases temporarily in the early winter but resumes in January; breeding activity reaches a second peak in the early spring, when attacks may also spread to the growing points of apical shoots.

DESCRIPTION

Adult mite 0.2-0.4 mm long, whitish and vermiform; *hysterosoma* finely cross-striated, with equal numbers of tergites and sternites; *prodorsal shield setae* absent.

NOTE Similar-looking mites associated with other *Ribes* hosts are recognized as distinct species, e.g. *Cecidophyopsis grossulariae* Collinge on gooseberry and *C. selachodon* Eyndhoven on red currant.

Colomerus vitis **(Pagenstecher)**
Vine leaf blister mite

Infestations of this widely distributed pest occur on grape vines; the mites sometimes induce the development of large, whitish to yellowish erinea on the underside of the leaves; the upper surface of each gall becomes reddish-brown and blister-like (cf. leaf galls on vines inhabited by the grape phylloxera, *Viteus vitifoliae*, p. 123). Such damage often causes considerable leaf deformation and is attributable to the erineum strain of the mite. Two other strains are known: a bud strain (= 'grape bud mite') and a leaf-curling strain. Adult mites are 0.16-0.20mm long, elongate and pale yellowish in colour.

Epitrimerus piri **(Nalepa)**
Pear rust mite

Heavy infestations of this widely distributed pest sometimes develop on pear trees. The mites then cause extensive bronzing of the underside of leaves and also russeting of ripening fruits, especially around the calyx and on the cheeks. Infestations also occur on *Crataegus*.

BIOLOGY

This mite is free-living and deuterogenous, with two adult female forms (protogynes and deutogynes) (see under apple rust mite, *Aculus schlechtendali*, p. 256). The mites occur on unfurling leaves, blossoms and developing fruitlets but are most numerous beneath the fully expanded leaves. There are several overlapping generations throughout the summer, and breeding continues into the early autumn. Deutogynes (= winter females) appear in increasing numbers from July onwards; they overwinter beneath bud scales and in other shelter, eventually reappearing and depositing eggs in the spring.

DESCRIPTION

Protogyne 0.13-0.16mm long, yellowish to brownish-orange, fusiform and rather flattened; *hysterosoma* with numerous microtubercles and a distinct mid-dorsal ridge; *prodorsal shield* with an anterior lobe; *prodorsal shield setae* short and directed inwards (cf. pear leaf blister mite, *Eriophyes pyri*, below). **Deutogyne** similar to protogyne but smaller and the hysterosoma without microtubercles.

Eriophyes pyri **(Pagenstecher)**
Pear leaf blister mite

This widely distributed gall mite is a generally common pest of pear. The mites induce the development of blister-like galls on the underside of leaves, especially along either side of the midvein. The often reddish-tinged galls are visible from above as pale green to yellowish blisters, each 2-5 mm in diameter; these may spread over much of the leaf surface. The galls eventually turn brown and, finally, black. Attacks can also occur on the developing fruitlets which, in common with badly affected leaves, may then become distorted and drop prematurely. Infestations also occur on other members of the family Rosaceae, including *Crataegus, Malus* and *Sorbus;* mites on such hosts are sometimes afforded separate subspecific or specific status.

BIOLOGY

Adult mites overwinter beneath the outer scales of buds and become active in the early spring as the buds begin to swell. The mites then penetrate deeper to feed and deposit eggs. Later, they feed on the underside of expanding or expanded leaves, forming distinctive blisters. The centre-most epithelial cells at the base of these blisters eventually die, so that pocket-like galls are formed, with an opening on their ventral surface **(Fig. 338).** Breeding in these galls continues throughout the summer, and newly reared mites regularly escape and migrate to younger tissue, where they initiate further galling. Galls are abandoned as they age and become uninhabitable, and breeding eventually ceases in the autumn as young adults depart to take up their winter quarters.

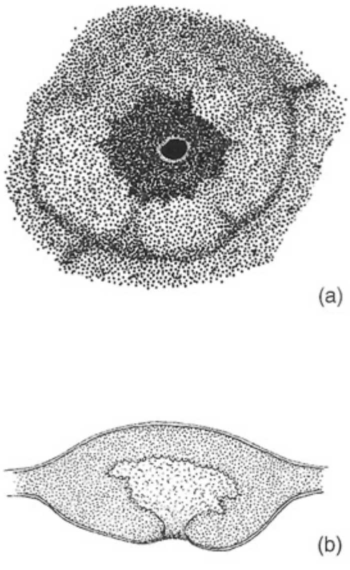


Fig. 338 Leaf gall of pear leaf blister mite, *Eriophyes pyri:* (a) ventral view; (b) vertical section (x8).

DESCRIPTION

Adult 0.22 mm long, whitish to pale brownish, and cigar-shaped; *prodorsal shield setae* directed forwards (cf. pear rust mite, *Epitrimerus piri,* p. 258).

Eriophyes padi (Nalepa)
Plum leaf gall mite

Eriophyes similis (Nalepa)
Plum pouch-gall mite

These two gall mites are associated with plum. They also occur on various other kinds of *Primus,* especially *P. spinosa.* Although the galls of each species are distinct (see below), both have sometimes been described both as pouch-shaped, and this has led to misidentification and confusion. Galls inhabited by *Eriophyes padi* are lantern- or finger-shaped (4-5 mm long), and occur on the upper surface of leaves, especially towards the centre of the lamina. Galls inhabited by *E. similis* are pouch-like (4-5mm long), and occur in greatest profusion around or towards the periphery of infested leaves. In plum orchards, *E. similis* (which appears to be the more abundant species in the British Isles) tends to be of greater significance, as the mites can also cause direct damage to the fruits. Affected plums enlarge more or less normally but their surface becomes distinctly uneven and develops irregular, sunken patches; fruits of certain cultivars, notably Purple Pershore and Yellow Egg, are especially liable to be attacked.

Phyllocoptes gracilis (Nalepa)
Raspberry leaf & bud mite

Although associated mainly with raspberry, this widely distributed and often common pest will also attack blackberry, loganberry and other kinds of *Rubus,* including tayberry. On raspberry, the mites cause distortion and the development of distinctive yellow blotches on the upper surface of the foliage; the underside of these galls appears shiny and pale green (rather than the normal dull whitish-grey), owing to destruction of the leaf hairs. The mites may also cause the death of apical buds, so that weak lateral shoots are produced; mites can also invade the fruits, again destroying patches of hairs and also causing uneven ripening and malformation. Damage is usually most severe under hot, dry conditions and in sheltered situations; Mailing Jewel is a particularly susceptible cultivar. On blackberry, heavy infestations may result in the appearance of mildew-like leaf blotches but this host is rarely affected to any significant degree (cf. blackberry mite, *Acalitus essigi*, p. 256).

BIOLOGY

Adult female mites overwinter in the shelter of the buds. They emerge at bud burst and then migrate to the underside of the expanding leaves to feed. Individuals may also become active at any stage during the winter if temperatures exceed 11°C. In spring, eggs are deposited amongst the leaf hairs, where colonies of mites then develop; there are several overlapping generations throughout the season. Populations on the fruiting canes reach their peak from mid-summer onwards. Mites sometimes occur on the flowers and developing fruits. Infestations also spread to the new vegetative growth, especially as leaves on the fruiting canes harden and become less suitable as feeding sites.

DESCRIPTION

Adult female 0.f2mm long, pale yellow and elongate (overwintering form darker in colour); *prodorsal shield setae* of medium length.

Family TARSONEMIDAE (tarsonemid mites)

Phytonemus pallidus **(Banks)** **Cyclamen mite**

This widely distributed mite is a major pest of glasshouse ornamentals, including African violet, begonia, cyclamen, ivy and many others. The mites attack the growing points and recently emerged young growth, and cause considerable distortion, stunting and discoloration of leaves and flowers; affected tissue often appears shiny and may also become brittle. Heavily infested plants can be killed. *Phytonemus pallidus* ssp. *asteris* (Karl) damages aster (especially *Aster novi-belgii)*, the flower heads on heavily infested plants being replaced by stunted rosettes of small leaves. *Phytonemus pallidus* ssp. *fragariae* (see p. 261) is a pest of outdoor strawberry.

BIOLOGY

The mites breed continuously under glasshouse conditions, so long as conditions remain favourable, and pass through several overlapping generations each year. In unheated glasshouses, however, breeding ceases during the winter. Development includes an egg, a larval and a quiescent nymphal stage. The nymphs do not feed and are enclosed within the bloated, cast-off skin of the larva. Females at this transitional resting stage are often carried around by adult males, the male holding a female nymph aloft with the aid of a genital sucker. Tarsonemid mites are light-shy and relatively inactive. They often shelter within folded or crinkled young tissue and between bud scales, where they also feed and breed. Development from egg to adult takes about 2 weeks during the summer but is much slower when temperatures are low, duration of the egg stage then becoming especially protracted. The mites rarely, if ever, move over glasshouse staging or soil but adults will transfer from plant to plant where adjacent leaves or shoots are touching.

DESCRIPTION

Adult female 0.25 mm long, elongate-oval, somewhat barrel-shaped, pale brown, shiny and translucent; *hindlegs* narrow, each ending in a whip-like seta; *gnathosoma* longer than broad (cf. bulb scale mite, *Steneotarsonemus laticeps*, p. 262). **Adult male** smaller than female; *body* with a genital sucker; *hindlegs* stout, each with a characteristic inner flange and a strong claw (see Fig. 171) (cf. broad mite, *Polyphagotarsonemus latus*, p. 261). **Egg** 0.12mm long, elliptical, whitish and translucent. **Larva** whitish, 6-legged; *tip of body* triangular.

***Phytonemus pallidus* ssp. *fragariae* (Zimmermann)**
Strawberry mite

This subspecies is a serious pest of outdoor strawberries. The mites cause discoloration and distortion of foliage and severe stunting of plants; fruits are also affected, those on badly infested plants remaining small and becoming leathery and dull in colour. Damage is most evident from July onwards and tends to be most significant on older plants, especially those grown in perennial matted rows. Heavy infestations in 1 year will also lead to a significant reduction in cropping in the following season.

BIOLOGY
Strawberry mites overwinter as adult females, deep within the crowns of plants. They become active in the following spring, and small colonies then develop in sheltered sites on the furled and unfurling leaves. The mites also occur under rolled edges on expanded leaves. Populations increase gradually to reach a peak in the late summer and early autumn. There are several overlapping generations each year, development from egg to adult taking 2-3 weeks during the summer months. Most females breed parthenogenetically and males usually form only a small proportion of the population. Unlike *Tetranychus urticae* (p. 267), the strawberry mite occurs mainly on young foliage; maturing leaves are unsuitable feeding sites and are abandoned as they harden.

DESCRIPTION
Morphological differences between this subspecies and *Phytonemus pallidus* (see p. 260) are uncertain.

***Polyphagotarsonemus latus* (Banks)**
Broad mite

In temperate regions, this tropical or subtropical mite infests a wide range of glasshouse-grown plants, including various ornamentals (e.g. begonia, chrysanthemum, cyclamen and gerbera) and vegetable crops (e.g. aubergine, cucumber, sweet pepper and tomato). Affected plants are stunted and discoloured, and the new growth often becomes brittle, distorted and shiny. Fruits of infested vegetable crops are small, deformed and discoloured, and often develop a corky, reticulated pattern **(Plate 16e).** Broad mite is a persistent pest and heavily infested plants may be killed.

BIOLOGY
Broad mites breed continuously under favourable conditions, development including an egg, a larval and a quiescent nymphal stage, the latter being passed within the cast-off larval skin. At normal glasshouse temperatures, eggs hatch in 2-3 days and larvae feed for about 4 days before moulting into 'resting nymphs'. The adult stage is reached a day or so later. Female nymphs are often carried around by adult males which, unlike other motile stages (e.g. larvae and adult females), frequently wander over host plants. Colonies of mites occur on the underside of young, expanded leaves and amongst still furled tender growth; leaves, however, become unsuitable as they mature and are then abandoned. All stages may be found together on infested plants, and adult females usually greatly outnumber males.

DESCRIPTION
Adult female 0.2 mm long, broad-bodied, whitish and translucent to greenish or yellowish; *hindlegs* each with a long whip-like seta (see Fig. 170). **Adult male** 0.14mm long, long-legged; *body* tapered posteriorly and with a genital sucker; *hindlegs* stout but unflanged **(Fig. 339)** (cf. cyclamen mite, *Phytonemus pallidus*, p. 260). **Egg** 0.11 x 0.07 mm, oval and translucent, with several rows of white, mushroom-like tubercles on the exposed surface **(Fig. 340). Larva** similar in appearance to adult but smaller and 6-legged; *tip of body* triangular **(Fig. 341).**

Fig. 339 Hindleg of male broad mite, *Polyphagotarsonemus latus.*

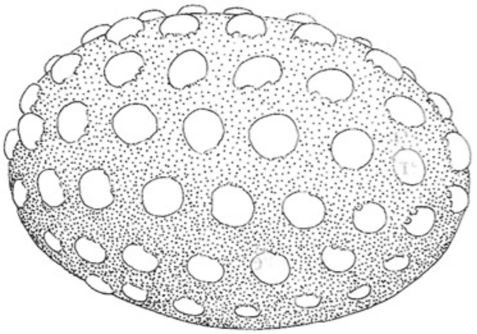


Fig. 340 Egg of broad mite, *Polyphagotarsonemus latus* (x550).

Steneotarsonemus laticeps (Halbert)
Bulb scale mite

Bulb scale mite is an important pest of forced narcissus; it is also associated with certain other members of the Amaryllidaceae, including amaryllis and eucharis. Stored infested bulbs dry out and, if cut across, show evidence of dead, dark brown tissue between the scales; such symptoms are particularly noticeable in the upper part of the neck. Heavy infestations in stored bulbs may be responsible for considerable losses. Leaves emerging from mite-infested narcissus bulbs are weak and often sickle-shaped or otherwise dis-

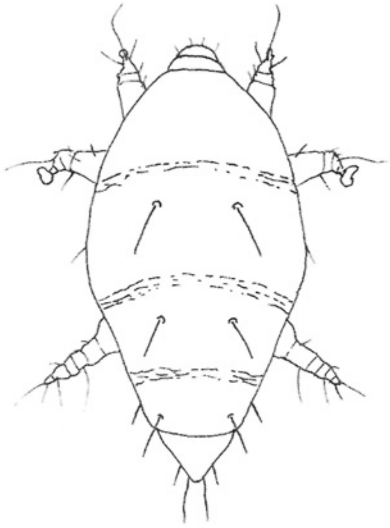


Fig. 341 Larva of broad mite, *Polyphagotarsonemus latus* (x400).

torted; they are also frequently bright green, lacking the greyish bloom of healthy tissue. Furthermore, leaves may become scarred and may develop yellow streaks and characteristic saw-tooth edges (see also damage caused by bulb mites, *Rhizoglyphus* spp., p. 269). Infestations have an adverse effect on flower production. On some host plants, such as amaryllis, the mites induce the formation of reddish spots or streaks on the emerging leaves.

BIOLOGY

Mites invade host bulbs in August and September, when they gain access to the spaces created by the shrinking scales. They then begin to feed, especially in the neck region, and breeding colonies soon develop. The mites breed continuously under favourable conditions, passing through an egg, a larval and a quiescent nymphal stage. Development to adulthood usually takes several weeks but becomes more rapid at bulb-forcing temperatures. Mites will continue to breed on infested bulbs planted in the field but, again, the rate of development (and, hence, colony growth) depends on temperature, usually becoming greatly protracted during the autumn and winter

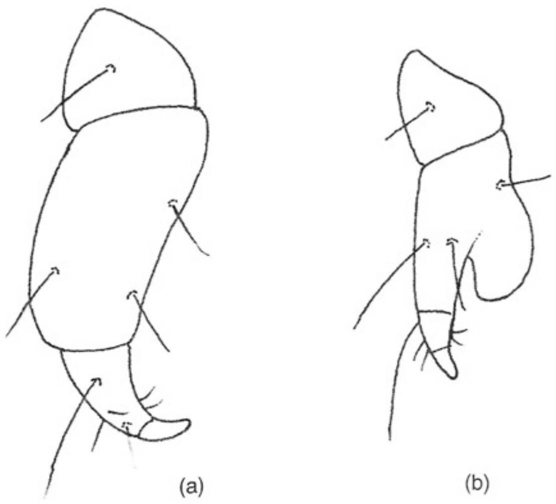


Fig. 342 Hindleg of male *Steneotarsonemus:* (a) bulb scale mite, *S. laticeps;* (b) oat spiral mite, *S. spirifex.*

but then increasing in the following spring with the onset of warmer weather. Damage in the field is likely to be seen only if the winter has been unusually mild. As the bulbs develop, infestations sometimes spread upwards onto the emerged leaves and flower stalks, but conditions on exposed tissue are generally unfavourable for mite development.

DESCRIPTION
Adult female 0.2 mm long, pale brown and translucent; *hindlegs* thin and each bearing a terminal, whip-like seta; *gnathosoma* broader than long, cf. cyclamen mite, *Phytonemus pallidus* (p. 260). **Adult male** similar in appearance to female but smaller; *hindlegs* robust, unflanged and each with a strong claw **(Fig. 342a). Egg** relatively large, oval, whitish and translucent. **Larva** whitish and 6-legged.

Steneotarsonemus spirifex **(Marchal)**
Oat spiral mite

This species is a minor pest of cereals, especially late-maturing oats. Inflorescences fail to emerge fully from mite-infested shoots, the rachis becoming spiralled and bearing blind spikelets **(Plate 16f);** the mites also cause reddening of tissue, and severely infested plants may be stunted. Most damage is caused in dry seasons. The mites also attack a wide range of grasses but, unlike several closely related grass-feeding mites (including grass & cereal mite, *Siteroptes graminum,* p. 264), not cocksfoot. Colonies develop within the upper section of leaf sheaths during the spring and summer, and their presence is usually noticeable from June onwards. Adult females are elongate (0.25 x 0.13 mm), pale brown and translucent, with thin hindlegs. Males are stouter-bodied, with robust hindlegs, and their hind femora are distinctively flanged **(Fig. 342b).** There are several generations in a season.

Tarsonemus myceliophagus **Hussey**
Mushroom mite

This species is an important pest of mushrooms, the relatively sluggish, barrel-shaped mites feeding on mushroom hyphae. Mite damage appears to encourage secondary breakdown of tissue, and this results in a reddish-brown discoloration around the base of the stipes; if the basal hyphae are severed, the developing stipes may also become loosened. The mites are also vectors of 'die back' virus. Development of the mite from egg to adult is favoured by spawning temperatures, requiring only 8 days at 24°C but taking about 12 days during the cooler cropping period. The mites are often particularly numerous if infestations develop during or soon after spawning. The adult mites are 0.2 mm long, pale brown, translucent and shiny; the hindlegs of males are robust, terminating in a strong claw, but lack a distinctive flange (cf. cyclamen mite, *Phytonemus pallidus,* p. 260). Mushroom mites are often preyed upon by long-legged mushroom mites, *Linopodes* spp. (family Penthaleidae), especially *L. motatorius* (L.). These very active predators (once thought to be damaging to mushrooms) are whitish in appearance, with very long, antenna-like front legs.

Family PYGMEPHORIDAE (red pepper mites)

***Pygmephorus mesembrinae* Canestrini;**
***P. sellnicki* Krczal**
Red pepper mites

Red pepper mites are frequently abundant in mushroom beds but are not regarded as harmful to crops, although their presence often causes concern. The mites breed within decomposing mushroom composts, where they feed on the weed mould *Trichoderma; Pygmephorus sellnicki* is capable of surviving on a wider range of weed moulds than *P. mesembrinae*, including *Humicola* and *Monilia.* Female red pepper mites deposit large numbers of eggs, and these hatch into small 6-legged larvae which develop to adults through an active 8-legged nymphal and a quiescent resting stage; the whole cycle is usually completed in a matter of days. Adults are wedge-shaped, 0.25 mm long and stout-legged; the legs and body bear feathery setae. Populations increase extremely rapidly under suitable conditions and, soon after casing, the mites may swarm over the beds and developing sporophores in reddish-brown masses; populations then decline rapidly. The mites do not cause damage to the sporophores, or reduce cropping, even when present in considerable numbers.

***Siteroptes graminum* (Reuter)**
Grass & cereal mite

Infestations of this widespread but sporadic and usually minor pest are sometimes noted on cereals (including wheat and barley) and grasses. Affected plants are stunted and their infloresences fail to emerge properly, becoming distorted and silvery in appearance (a condition known as 'silver top'). Attacks are usually established in association with the fungus *Fusarium poae.* A similar relationship occurs on glasshouse-grown carnation; this results in rotting and death of the buds (a condition known as 'bud rot' or 'central bud rot'). Such attacks are infrequent and usually initiated in the autumn after a period of hot, dry weather.

BIOLOGY
Colonies of this unusual mite occur in the shelter of leaf sheaths or bud scales. The females feed on plant tissue and on hyphae of the fungus *Fusarium poae,* with which they may form a symbiotic relationship. The immature stages (eggs, larvae and nymphs) develop within the swollen, sac-like body of the female. Adults eventually merge as the hysterosoma splits open and the maternal mite dies. There are several generations in the year, the mites being most numerous in the late summer and autumn.

DESCRIPTION
Adult female 0.19 x 0.07mm, shiny hyaline-whitish; *hysterosoma* elongate but globular and up to 3 mm or more in diameter when bloated with developing young. **Adult male** 0.15 mm long and stout-bodied; *head* very small.

Family EUPODIDAE

***Penthaleus major* (Duges)**
Red-legged earth mite

This mite is associated mainly with cereals and grasses but will also attack other plants, including vegetable crops. They cause a general silvering of infested foliage and, sometimes, withering of leaf tips. Damage, which may result in patches of poor growth, is most evident during the winter months. Development of the mites is favoured by cool conditions, and the life-cycle includes a period of extended summer aestivation in the egg stage. All stages of the mite occur during the autumn and winter; unlike summer eggs, winter eggs hatch in a few weeks. There are two generations annually. The mites (up to 1 mm long) are globular but pointed posteriorly and vary in colour from pale green to red or brownish, with either green or red legs; characteristically, the anus occurs on the dorsal surface of the hysterosoma. Although a well-known pest in Australia and North America, damage to crops in Europe is less often reported. The name 'red-legged earth mite' is also associated with a related species: *Halotydeus destructor* (Tucker), an economically more important but non-European pest.

Family TETRANYCHIDAE (spider mites)

Bryobia praetiosa **Koch**
Clover bryobia mite

This generally abundant species (along with the other species of *Bryobia* cited below) was once considered part of a complex of closely related biological races. Former members of this complex are structurally very similar, but there are noticeable differences in their habits and life-cycles. The clover bryobia mite infests clover (and many other legumes), grasses and various herbaceous plants; in glasshouses, damage is often caused to the leaves of cucumber plants. Especially in the early spring, the mites frequently invade buildings, where eggs may be laid; the mites also aggregate during the spring and summer on sunny window-sills and on recently constructed brick walls, where they also shelter in cracks and crevices. Infestations are particularly common in weedy, overgrown sites. Leaf injury on host plants varies from speckling to an overall bronzing or silvering and may result in premature leaf-fall; bryobia mites do not produce webbing (cf. fruit-tree red spider mite, *Panonychus ulmi*, p. 266; two-spotted spider mite, *Tetranychus urticae*, p. 267).

BIOLOGY
Mites produced from eggs deposited in the late summer or autumn develop slowly throughout the winter, and eventually reach the adult stage in the following February or March. Eggs deposited by the overwintered females produce a summer generation of mites, members of which feed on a wide variety of host plants and reach maturity by the autumn. Males are unknown and reproduction is entirely parthenogenetic. Migration to and from host plants is a common feature of bryobia mites and continues throughout the spring, summer and autumn, whenever the mites are active. Also, when about to moult from one growth-stage to another, nymphs usually vacate host plants to seek sheltered situations on nearby trees, walls or other structures, as do mature females when they are about to lay eggs.

DESCRIPTION
Adult female 0.7 mm long, blackish-red or dark reddish-brown; *legs* pinkish, the first pair very long; *body* oval and flattened; *dorsal setae* spatulate (cf. stone mite, *Petrobia latens*, p. 267). **Egg** 0.2 mm in diameter, dark red, roughly spherical. **Larva** reddish-orange, 6-legged. **Nymph** dark green to brown or dark red.

Bryobia cristata **(Duges)**
Grass/pear bryobia mite

This polyphagous bryobia mite occurs throughout the year on grasses and herbaceous plants, including various ornamentals. They feed on the upper surface of the leaves and cause speckling and silvering. There are several generations annually, and breeding continues throughout the year. Although there is no period of winter diapause, development is greatly protracted during cold weather. In late spring, infestations sometimes extend to trees and shrubs, including fruit trees and ornamentals, before a return migration to more normal hosts; such attacks, however, are of little or no importance. In common with *Bryobia praetiosa* (above) (from which it is distinguishable by the slightly narrower dorsal setae and other microscopic features), this mite often aggregates on walls and may enter buildings to lay eggs, especially in May and June.

Bryobia ribis **Thomas**
Gooseberry bryobia mite

This species was formerly an important pest of gooseberry but is now relatively uncommon. Heavy infestations have a pronounced effect on host bushes, the young foliage turning pale and then brown; damaged leaves often shrivel and fall prematurely. Attacks also have a detrimental effect on cropping, reducing both fruit size and quality. The mites are similar in appearance to

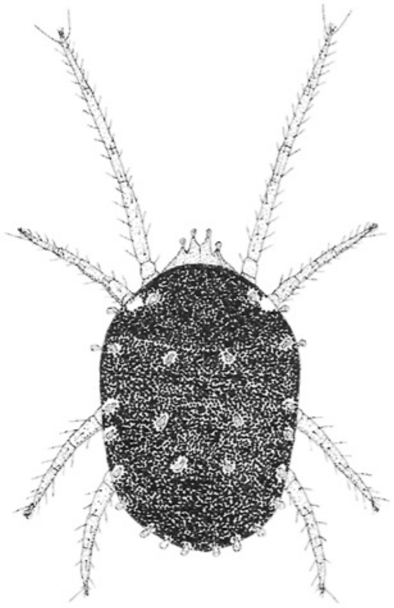


Fig. 343 Female apple & pear bryobia mite. *Bryobia nibrioculus* (x60).

Bryobia praetiosa but biologically distinct, as it overwinters in the egg stage. There is just one generation each year.

Bryobia rubrioculus (Scheuten)
Apple & pear bryobia mite

This widely distributed mite **(Fig. 343)** is associated with fruit trees, including apple, cherry, pear and plum; infestations, which may also occur on related ornamentals, rarely occur on sprayed trees. The mites feed mainly on the upper surface of the leaves. They also congregate in masses on the bark of shoots and branches whilst moulting from one stage to the next, especially in late May and June, August and September. The greyish-white cast-off skins remain *in situ* and are a useful clue to the presence of this pest. There are usually two or three generations each year, and this species overwinters in the egg stage. Aggregations of harmless oribatid mites on the bark of trees are sometimes mistaken for bryobia mites (see p. 270).

Panonychus ulmi (Koch)
Fruit tree red spider mite

This widely distributed species is an important pest of fruit trees, especially apple, damson and plum. Infestations also occur on other hosts, including cherry, pear, various ornamentals and, occasionally, bush or cane fruits; spider mite damage on these hosts, however, is usually attributable to the two-spotted spider mite, *Tetranychus urticae* (p. 267). The mites feed mainly on the underside of leaves, withdrawing the cell contents to produce a fine speckling, visible from above. As pest numbers increase, affected leaves become generally dull and pallid, and finally silvery or bronzed. Severely damaged leaves are brittle and may drop prematurely. Heavy infestations reduce plant vigour and will affect fruit yields and fruit bud formation for the following year. Damage is usually most evident from July onwards, and attacks are especially severe in hot, dry summers.

BIOLOGY
Mite eggs overwinter on the bark of host trees, often clustered in dense red masses on the spurs and small branches. Less frequently, winter eggs may occur on the young shoots. Eggs hatch from late April or May to about mid-June. However, the precise timing of egg hatch varies considerably from orchard to orchard, as there are both early- and late-hatching 'strains' of the mite. There are several, usually about five, overlapping generations during the summer, and development from egg (through larval, protonymphal and deutonymphal stages) to adult takes about a month: individuals developing into males often omit the deutonymphal stage. Colonies develop on the underside of the expanded leaves, where white cast-off nymphal skins accumulate and the paler-coloured summer eggs are laid (cf. colonies of *Bryobia* spp. on fruit trees, p. 265 *et seq.).* The mites do not shelter under webbing; however, individuals may produce strands of silk which will then allow them to be carried by the wind to adjacent trees. Winter eggs are laid in September, in response to shorter days and declining temperatures, but may be deposited earlier if

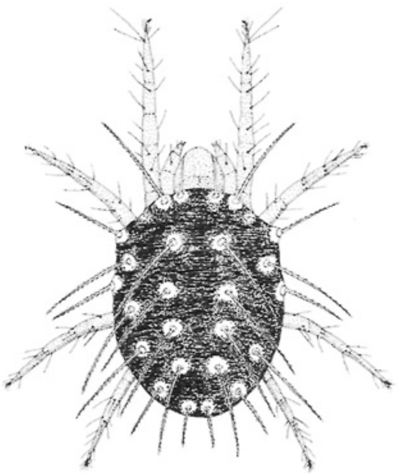


Fig. **344** Female fruit tree red spider mite, *Panonychus ulmi* (x80).

tree conditions become unsuitable for further breeding; this often occurs when mite numbers are large and foliage becomes badly bronzed.

DESCRIPTION
Adult female 0.4 mm long, oval, strongly convex, dark red; *hysterosomal setae* relatively long and arising from conspicuous white tubercles; *legs* pale **(Fig. 344).** **Adult male** smaller than female and pear-shaped, tapering posteriorly; yellowish-green to bright red. **Egg** red and shiny; more or less spherical (c. 0.1mm in diameter) but slightly flattened and the top drawn into a fine stipe. **Active immature stages** pale yellowish-green to bright red.

***Petrobia latens* (Miiller)**
Stone mite

This widespread but minor pest is associated mainly with members of the Poaceae and, if numerous, will cause damage to various crops, including carrot, lettuce and onion. Symptoms range from a yellow speckling of leaves to a general bronzing; also, the foliage often becomes shrivelled and brittle. Attacks, which tend to develop in patches, are most often noted under dry conditions; the symptoms caused appear similar to the effects of drought. The mites do not produce webbing.

BIOLOGY
Eggs are laid during the summer on stones, clods of soil and other non-plant surfaces, usually in the vicinity of host plants. Diapausing eggs remain *in situ* for extended periods during hot, dry conditions before hatching. Non-diapausing eggs, however, hatch in approximately 1-2 weeks, and the initially bright red immature stages feed for a similar period before becoming adults. This species is parthenogenetic and motile stages occur throughout the year.

DESCRIPTION
Adult female brown and broadly pear-shaped, tapering posteriorly; *legs* very long, especially the first pair, and relatively narrow; *body setae* simple (cf. clover bryobia mite, *Bryobia praetiosa*, p. 265). **Egg** more or less spherical and shiny, either white (a diapausing egg) or bright red (a non-diapausing egg); the latter has a distinctly ribbed cap.

***Tetranychus urticae* Koch**
Two-spotted spider mite

Infestations of this generally abundant mite occur on a wide range of plants, including glasshouse ornamentals (e.g. carnation, chrysanthemum and rose) and vegetables (e.g. cucumber, sweet pepper and tomato), indoor and outdoor fruit crops (especially wall-trained fruit trees, bush fruits, cane fruits and strawberry) and hops. Serious attacks may also occur on hardy ornamentals and outdoor vegetable crops (including French bean and runner bean), especially in hot, dry summers; occasionally, infestations also develop on potato and sugar beet. The mites feed mainly on the underside of leaves; they withdraw sap from the plant cells and this leads to a pale spotting of leaves and, later, distinct speckling, silvering or bronzing; infested parts of plants may also become coated in webbing. Heavy infestations often lead to withering of leaves and premature leaf-fall; on fruit crops, such as strawberry, this will have an adverse effect on plant vigour and cropping, and will reduce both fruit size and quality.

BIOLOGY
Adult female mites hibernate in cracks in glasshouse staging, posts, supporting stakes, walls and dry soil; they also find winter shelter in straw mulches and hollow bamboo canes, and amongst dead leaves and other plant debris. Activity is resumed in the early spring, usually when day length exceeds 14 hours. The mites then invade host plants and eventually lay eggs. Colonies soon develop on the underside of leaves, where the mites pass through egg, larval and two nymphal stages before maturing. The rate of development varies considerably, taking approximately 2-4 weeks during the summer but becoming greatly protracted at temperatures below 12°C. There are up to seven or more overlapping generations each year. All stages of the mite occur together, often protected by fine strands of silk (cf. bryobia mites, *Bryobia* spp., p. 265 *et seq.*; fruit tree red spider mite, *Panonychus ulmi*, p. 266). In September, as days become shorter (day length less than 14 hours), 'winter' females are produced. Colonies on host plants then decline as males and 'summer' females (the former usually forming no more than 20% of summer populations) die and breeding ceases.

DESCRIPTION
Adult female 0.5-0.6 mm long, oval, pale greenish to yellowish, with a pair of distinct dark lateral patches on the body **(Fig. 345);** 'winter' form orange to brick-red. **Adult male** 0.3-0.4 mm long, narrow-bodied and slightly pointed anteriorly and posteriorly. **Egg** 0.13 mm in diameter, globular, pearly-white and translucent, without a stipe (cf. fruit tree red spider mite, *Panonychus ulmi*, p. 266). **Active immature stages** pale green with darker markings.

Tetranychus cinnabarinus **(Boisduval)**
Carmine spider mite

Infestations of this subtropical species often occur in cooler regions, including northern Europe, where they are associated mainly with glasshouse-grown plants. Heavily infested hosts are often coated in masses of webbing. Unlike the previous species, with which they will interbreed, adults of *Tetranychus cinnabarinus* are bright red (both species have a pair of dark lateral markings); eggs are either whitish or pink and nymphs are greenish-yellow or green. The mites lack a diapause stage and, under suitable conditions, breed continuously.

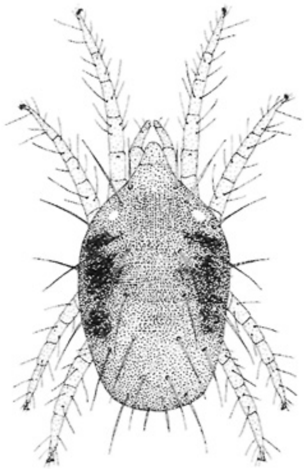


Fig. 345 Female two-spotted spider mite, *Tetranychus urticae* (x60).

Family TENUIPALPIDAE (false spider mites)

Cenopalpus pulcher **(Canestrini & Fanzago)**
Flat scarlet mite

Infestations of this widespread but usually unimportant pest are sometimes noted on unsprayed fruit trees, including apple, pear and plum. Although of little or no importance, the presence of the mites on trees often causes concern.

BIOLOGY
Mated females overwinter on the bark of host trees, frequently clustered together in suitable cracks and crevices. The mites become active in the spring. The first eggs are laid in April on the bark of host trees but most are deposited from

May to mid-July, along either side of the mid-rib on the underside of the expanded leaves. Eggs take several weeks to hatch, and juvenile mites appear on the foliage from June onwards. Young adult mites of both sexes occur in August and September. After mating, the males die and the females seek out sheltered situations on the bark in which to hibernate. In Europe, there is just one generation annually.

DESCRIPTION
Adult 0.3 mm long, bright red, distinctly flattened; *legs* short. **Egg** 0.11mm long, oval, bright red.

ORDER ASTIGMATA

Family ACARIDAE

***Rhizoglyphus callae* Oudemans;**
***R. robini* Claparede**
Bulb mites

Bulb mites are generally common but usually secondary pests of bulbs, corms and tubers; hosts include many ornamentals (e.g. freesia, gladiolus, hyacinth, iris, narcissus and tulip), vegetables (e.g. beet, onion and potato) and various other crops. The mites often invade diseased or damaged tissue and, once established, can cause considerable damage, especially in lifted bulbs being stored under warm conditions; the inside of severely infested bulbs, for example, often turns completely black and powdery. Unlike *Rhizoglyphus callae, R. robini* (a more frequently reported, slightly larger species with shorter body hairs) tends to favour relatively healthy hosts. Attacks can also occur in the field; the mites may then invade the growing points, so that emerging leaves become distorted and sometimes develop ragged or saw-tooth edges (the latter is also a symptom of attack by bulb scale mite, *Steneotarsonemus laticeps*, p. 262).

BIOLOGY
Bulb mites are associated mainly with stored crops or stored crop products, especially where conditions are damp or mouldy. Their development is favoured by warmth and high humidity, and the mites will breed continuously and multiply rapidly whilst conditions remain suitable. Development from egg through a larval and two nymphal stages to adulthood takes from 1 to 4 weeks according to temperature. A dispersal stage, known as the hypopus, may appear in some populations. These individuals cling onto passing insects, such as small narcissus flies, *Eumerus* spp. (p. 177 *et seq.)*, and then may be carried to other breeding sites.

DESCRIPTION
Adult 0.7 mm long, translucent-whitish, very shiny, with brownish internal markings; *body* globular, with several long hairs extending back beyond the tip of the hysterosoma; *legs* reddish-brown, short and stumpy. **Egg** 0.2 x 0.1mm, hyaline-whitish, smooth and shiny. **Hypopus** 0.3 mm long, dark brown; *legs* short, robust and each terminating in a large claw.

***Tyrophagus longior* (Gervais)**
Grainstack mite

This widely distributed pest, sometimes known as French 'fly', is often abundant in straw and undecomposed horse manure; infestations frequently develop on cucumber plants grown on straw bales or raised by traditional manure culture. The mites are also associated with various stored products and may occur as secondary invaders on bulbs and corms that have gone mouldy during storage. When swarming upon cucumber plants, the mites produce minute holes in the young leaves; they also cause shoot distortion and, sometimes, blindness.

BIOLOGY
The mites breed continuously under favourable conditions and the life-cycle (from egg through

one larval and two nymphal stages to adult) takes from 2 to 4 weeks, depending upon temperature. Infestations in straw bales and manure in cucumber beds often spread to the plants; the mites often hide within the shelter of the unfurling leaves, and feeding on cucumber plants is usually restricted to the young foliage and growing points. Although the mites may deposit eggs on infested cucumber plants, such sites appear to be unfavourable for breeding success and, in the absence of straw within which to overwinter, mite numbers decline.

DESCRIPTION

Adult 0.3-0.7 mm long, shiny, whitish, with very long bristle-like setae on the body (see Fig. 176); *legs* pale brown. **Egg** 0.1mm long, oval, hyaline-whitish, with a sculptured surface.

Tyrophagus neiswanderi **Johnston** & **Bruce**
Cucumber mite

This species may also infest cucumber plants; attacks have also been noted on damaged tissue of other glasshouse-grown plants, including chrysanthemum. The mites are similar in appearance to *Tyrophagus longior* (above) but slightly smaller; also, they possess a characteristic pair of pigmented, eye-like patches on the propodosomal shield. Populations of this species are capable of overwintering in glasshouses in the absence of straw and, although generally less common, the mites appear better adapted to survival as plant feeders than various other related species.

Tyrophagus putrescentiae **(Schrank)**
Mould mite

This small (0.3-0.5mm long), translucent, relatively slender-bodied mite is often reported infesting mouldy plant material, including laboratory plant tissue cultures on agar plates. The mites, along with other species of *Tyrophagus* (and certain related genera: e.g. *Caloglyphus)* also occur in mushroom beds. They often form pits in the mushroom stipes and caps, and may also hollow-out the tissue within the developing buttons; damaged areas usually become further broken down and moist, following associated bacterial decomposition (cf. pits formed by gunpowder-mites, *Hypogastrura* spp., p. 87).

Tyrophagus similis Volgin
Grassland mite

The grassland mite is very similar in both appearance and habits to *Tyrophagus longior* (p. 269), and is also reported damaging cucumber and certain other glasshouse-grown plants. The two species are frequently confused and detailed microscopic examination is necessary to distinguish between them.

ORDER CRYPTOSTIGMATA (BEETLE MITES)

Family MYCOBATIDAE

Humerobates rostrolamellatus **Grandjean**
Cherry beetle mite

This generally common mite is often recorded in considerable numbers on the trunks and branches of trees, including unsprayed fruit trees and ornamentals, where they feed mainly on algae, lichens and mosses. The mites will also congregate on split, ripening cherries and plums, but they do not attack sound fruits. The adult mites are globular, about 1 mm long, shiny, dark reddish or blackish (see Fig. 177). When clustered on the bark, they are often thought to be eggs of some kind of pest; they may also be mistaken for bryobia mites, especially the apple & pear bryobia mite, *Bryobia rubrioculus* (p. 266).

Cultivated Host Plants Cited in the Text Under Their Common Name

Common name	*Scientific name*	*Family*
almond	*Primus communis*	ROSACEAE
amaryllis	*Hippeastrum* spp.	AMARYLLIDACEAE
apple	*Malus pumila*	ROSACEAE
apple, crab	*Malus* spp.	ROSACEAE
apricot	*Prunus armeniaca*	ROSACEAE
artichoke	*Cynara scolymus* and *Helianthus tuberosus*	ASTERACEAE
asparagus	*Asparagus officinalis*	LILIACEAE
asparagus, ornamental	*Asparagus plumosus*	LILIACEAE
aster	*Aster* spp.	ASTERACEAE
aubergine	*Solanum melongena*	SOLANACEAE
barley	*Hordeum* spp.	POACEAE
bean(s)	*Phaseolus* spp. and *Vicia faba*	FABACEAE
bean, broad	*Vicia faba*	FABACEAE
bean, field	*Vicia faba*	FABACEAE
bean, French	*Phaseolus vulgaris*	FABACEAE
bean, runner	*Phaseolus multifiorus*	FABACEAE
beet	*Beta vulgaris*	CHENOPODIACEAE
beet, red	*Beta vulgaris*	CHENOPODIACEAE
begonia	*Begonia* spp.	BEGONIACEAE
blackberry	*Rubus fruticosus* agg.	ROSACEAE
borage	*Borago officinalis*	BORAGINACEAE
blueberry	e.g. *Vaccinium corymbosum*	ERICACEAE
brassicas	*Brassica* spp.	BRASSICACEAE
brassica seed crops	e.g. *Brassica napus*	BRASSICACEAE
broccoli	e.g. *Brassica oleracea* var. *italica*	BRASSICACEAE
Brussels sprout	*Brassica oleracea* var. *bullata*	BRASSICACEAE
buckwheat	*Fagopyrum esculentum*	POLYGONACEAE
cabbage	*Brassica oleracea*	BRASSICACEAE
cabbage,savoy	*Brassica oleracea* var. *subauda*	BRASSICACEAE
calabrese	*Brassica oleracea* var. *italica*	BRASSICACEAE
camellia	*Camellia* spp.	THEACEAE
carnation	*Dianthus caryophyllus*	CARYOPHYLLACEAE
carrot	*Daucus carota*	UMBELLIFERAE

Common name	*Scientific name*	*Family*
cauliflower	*Brassica oleracea* var. *botrytis*	BRASSICACEAE
celeriac	*Apium graveolens*	UMBELLIFERAE
celery	*Apium graveolens*	UMBELLIFERAE
cereals	e.g. *Hordeum* spp. and *Triticum* spp.	POACEAE
cherry	e.g. *Primus avium*	ROSACEAE
chicory	*Cichorium intybus*	ASTERACEAE
Chinese leaf	*Brassica chinensis*	BRASSICACEAE
chrysanthemum	*Chrysanthemum* spp.	ASTERACEAE
cinquefoil	*Potentilla fruticosa*	ROSACEAE
citrus	*Citrus* spp.	RUTACEAE
clematis	*Clematis* spp.	RANUNCULACEAE
clover	*Trifolium* spp.	FABACEAE
clover, red	*Trifolium pratense*	FABACEAE
clover, white	*Trifolium repens*	FABACEAE
cocksfoot	*Dactylis glomerata*	POACEAE
corn, sweet	*Zea mays*	POACEAE
crocus	*Crocus* spp.	IRIDACEAE
cucumber	*Cucumis sativus*	CUCURBITACEAE
currant	*Ribes* spp.	GROSSULARIACEAE
currant, black	*Ribes nigrum*	GROSSULARIACEAE
currant, red	*Ribes sativum* agg.	GROSSULARIACEAE
currant, white	*Ribes sativum* agg.	GROSSULARIACEAE
cyclamen	*Cyclamen* spp.	PRIMULACEAE
daffodil	*Narcissus* spp.	AMARYLLIDACEAE
dahlia	*Dahlia* spp.	ASTERACEAE
damson	*Primus domestica* agg.	ROSACEAE
endive	*Cichorium endivia*	ASTERACEAE
eucharis	*Eucharis* spp.	AMARYLLIDACEAE
false oat	*Arrhenatherum elatius*	POACEAE
fescue	*Festuca* spp.	POACEAE
filbert	*Corylus maxima*	CORYLACEAE
flax	*Linum usitatissimum*	LINACEAE
foxtail, meadow	*Alopecurus pratensis*	POACEAE
freesia	*Freesia* spp.	IRIDACEAE
garlic	*Allium sativum*	LILIACEAE
gerbera	*Gerbera* spp.	ASTERACEAE
gladiolus	*Gladiolus* spp.	IRIDACEAE
gooseberry	*Ribes uva-crispa*	GROSSULARIACEAE
grape vine	*Vitis vinifera*	VITACEAE
grasses		POACEAE
hazel	*Corylus avellana*	CORYLACEAE
hogweed, giant	*Heracleum mantegazzianum*	UMBELLIFERAE
hop	*Humulus lupulus*	CANNABACEAE
horseradish	*Armoracia rusticana*	BRASSICACEAE
hyacinth	*Hyacinthus* spp.	LILIACEAE
iris	*Iris* spp.	IRIDACEAE

Common name	*Scientific name*	*Family*
ivy	*Hedera helix*	ARALIACEAE
kale	*Brassica napus*	BRASSICACEAE
leek	*Allium ampeloprasum*	LILIACEAE
legumes	-	FABACEAE
lettuce	*Lactuca sativa*	ASTERACEAE
lily	*Lilium* spp.	LILIACEAE
linseed	*Linum usitatissimum*	LINACEAE
loganberry	*[Rubus loganobaccus] Rubus vitifolius* x *R. idaeus* (?)	ROSACEAE
lucerne	*Medicago sativa*	FABACEAE
lupin	*Lupinus* spp.	FABACEAE
lupin, white	*Lupinus albus*	FABACEAE
maize	*Zea mays*	POACEAE
mangold	*Beta vulgaris*	CHENOPODIACEAE
marigold, pot	*Calendula officinalis*	ASTERACEAE
meadow-grass	*Poa* spp.	POACEAE
medlar	*Mespilus germanica*	ROSACEAE
melon	*Cucumis melo*	CUCURBITACEAE
mint	*Mentha* spp.	LABIATAE
mushroom	e.g. *Agaricus bisporus*	AGARICACEAE
mustard	e.g. *Brassica alba* and *B. juncea*	BRASSICACEAE
mustard, brown	*Brassica juncea*	BRASSICACEAE
mustard, white	*Sinapis alba*	BRASSICACEAE
narcissus	*Narcissus* spp.	AMARYLLIDACEAE
nasturtium	*Tropaeolum* spp.	GERANIACEAE
nectarine	*Prunus persica*	ROSACEAE
nut, cob	*Corylus maxima*	CORYLACEAE
oats	*Avena sativa*	POACEAE
onion	*Allium cepa*	LILIACEAE
parsley	*Petroselinum crispum*	UMBELLIFERAE
parsnip	*Pastinaca sativa*	UMBELLIFERAE
pea	*Pisum sativum*	FABACEAE
peach	*Prunus persica*	ROSACEAE
pear	*Pyrus communis*	ROSACEAE
pepper, sweet	*Capsicum* spp.	SOLANACEAE
plum	*Prunus domestica* agg.	ROSACEAE
poinsettia	*Euphorbia pulcherrima*	EUPHORBIACEAE
poppy	*Papaver* spp.	PAPAVERACEAE
potato	*Solanum tuberosum*	SOLANACEAE
primrose	*Primula vulgaris*	PRIMULACEAE
quince	*Cydonia oblonga*	ROSACEAE
quinoa	*Chenopodium quinoa*	CHENOPODIACEAE
radish	*Raphanus sativus*	BRASSICACEAE
rape	e.g. *Brassica napus*	BRASSICACEAE
rape, oilseed	*Brassica napus*	BRASSICACEAE
raspberry	*Rubus idaeus*	ROSACEAE

Common name	*Scientific name*	*Family*
rhododendron	*Rhododendron* spp.	ERICACEAE
rhubarb	*Rheum rhabarbarum*	POLYGONACEAE
rose	*Rosa* spp.	ROSACEAE
rye	*Secale cereale*	POACEAE
rye-grass	*Lolium* spp.	POACEAE
rye-grass, Italian	*Lolium multiflorum*	POACEAE
rye-grass, perennial	*Lolium perenne*	POACEAE
sage	*Salvia officinalis*	LABIATAE
shallot	*Allium cepa*	LILIACEAE
spinach	*Spinacea oleracea*	CHENOPODIACEAE
spruce	*Picea* spp.	PINACEAE
stock	*Matthiola* spp.	BRASSICACEAE
strawberry	*Fragaria* x *ananassa*	ROSACEAE
sugar beet	*Beta vulgaris*	CHENOPODIACEAE
sunflower	*Helianthus annuus*	ASTERACEAE
swede	*Brassica napus*	BRASSICACEAE
tayberry	*Rubus idaeus* x *R. frutiocosus* "Aurora'	ROSACEAE
teasel	*Dipsacus sativus*	DIPSACACEAE
timothy grass	*Phleum pratense*	POACEAE
tomato	*Lycopersicon esculentum*	SOLANACEAE
trefoil	*Lotus* spp.	FABACEAE
tulip	*Tulipa* spp.	LILIACEAE
turnip	*Brassica rapa*	BRASSICACEAE
vetch	e.g. *Vicia sativa*	FABACEAE
violet, African	*Saintpaulia* spp.	GESNERIACEAE
wallflower	*Cheiranthus cheiri*	BRASSICACEAE
watercress	*Nasturtium officinale*	BRASSICACEAE
water-lilies	e.g. *Nymphaea* spp.	NYMPHAEACEAE
wheat	*Triticum* spp.	POACEAE

Wild Host Plants Cited in the Text Under Their Scientific Name

Scientific name	*Common name*	*Family*
Alnus	alder	BETULACEAE
Anthriscus sylvestris	cow parsley	UMBELLIFERAE
Artemisia vulgaris	mugwort	ASTERACEAE
Asparagus officinalis	asparagus	LILIACEAE
Atriplex littoralis	grass-leaved orache	CHENOPODIACEAE
Atrip lex pa tula	common orache	CHENOPODIACEAE
Bellis perennis	daisy	ASTERACEAE
Beta vulgaris	sea beet	CHENOPODIACEAE
Betula	birch	BETULACEAE
Capsella bursa-pastoris	shepherd's purse	BRASSICACEAE
Carduus	thistle	ASTERACEAE
Chenopodium	goosefoot	CHENOPODIACEAE
Chenopodium album	fat hen	CHENOPODIACEAE
Cirsium	thistle	ASTERACEAE
Corylus	hazel	CORYLACEAE
Crataegus	hawthorn	ROSACEAE
Crataegus monogyna	hawthorn	ROSACEAE
Crep is	hawk's-beard	ASTERACEAE
Dactylis glomerata	cocksfoot	POACEAE
Dipsacus	teasel	DIPSACACEAE
Dipsacus fullonum	common teasel	DIPSACACEAE
Elytrigia rep ens	couch grass	POACEAE
Epilobium	willowherb	ONAGRACEAE
Erysimum cheiranthoides	treacle mustard	BRASSICACEAE
Euonymus europaeus	spindle tree	CELASTRACEAE
Euphorbia	spurge	EUPHORBIACEAE
Galeobdolon luteum	yellow archangel	LABIATAE
Galeopsis	hemp nettle	LABIATAE
Galium	bedstraw	RUBIACEAE
Halimione portulacoides	sea purslane	CHENOPODIACEAE
Hedera helix	ivy	ARALIACEAE
Heracleum sphondylium	hogweed	UMBELLIFERAE
Hieracium	hawkweed	ASTERACEAE

Scientific name	*Common name*	*Family*
Hydrocharis morsus-ranae	frog-bit	HYDROCHARITACEAE
Tactuca	lettuce	ASTERACEAE
Lamium	dead-nettle	LABIATAE
Lolium	rye-grass	POACEAE
Lonicera	honeysuckle	CAPRIFOLIACEAE
Lysimachia vulgaris	yellow loosestrife	PRIMULACEAE
Malus	apple	ROSACEAE
Mentha	mint	LABIATAE
Mercurialis perennis	dog's mercury	EUPHORBIACEAE
Pastinaca sativa	wild parsnip	EUPHORBIACEAE
Phragmites communis	reed	POACEAE
Pistacia lentiscus	mastic tree	ANACARDIACEAE
Plant ago	plantain	PLANTAGINACEAE
Plantago lanceolata	ribwort plantain	PLANTAGINACEAE
Poa annua	annual meadow-grass	POACEAE
Poa pratensis	smooth meadow-grass	POACEAE
Polygonum	bistort, persicaria, etc.	POLYGONACEAE
Polygonum aviculare	knotgrass	POLYGONACEAE
Populus	poplar	SALICACEAE
Populus nigra 'Italica'	Lombardy poplar	SALICACEAE
Prunus	cherry, plum, etc.	ROSACEAE
Primus avium	wild cherry	ROSACEAE
Prunus padus	bird cherry	ROSACEAE
Prunus spinosa	blackthorn	ROSACEAE
Ranunculus	buttercup	RANUNCULACEAE
Rhamnus	buckthorn	RHAMNACEAE
Ribes	currant, gooseberry	GROSSULARIACEAE
Rubus	blackberry, raspberry, etc.	ROSACEAE
Rubus fruticosus	blackberry	ROSACEAE
Rumex	dock, sorrel	POLYGONACEAE
Salix	osier, sallow, willow	SALICACEAE
Salix alba	white willow	SALICACEAE
Salix fragilis	crack willow	SALICACEAE
Senecio jacobaea	common ragwort	ASTERACEAE
Sinapis arvensis	charlock	BRASSICACEAE
Sisymbrium officinale	hedge mustard	BRASSICACEAE
Solanum dulcamara	bittersweet	SOLANACEAE
Solanum nigrum	black nightshade	SOLANACEAE
Sonchus	sow thistle	ASTERACEAE
Sorbus	rowan, whitebeam	ROSACEAE
Stachys	woundwort	LABIATAE
Stachys sylvatica	hedge woundwort	LABIATAE
Taraxacum officinale	dandelion	ASTERACEAE
Ulmus	elm	ULMACEAE
Urtica	nettle	URTICACEAE
Veronica	speedwell	SCROPHULARIACEAE

Glossary

Abdomen The third of the three main divisions of the body of an insect.
Aculeate Pointed; also, a member of the order Hymenoptera which possesses a sting.
Aestivation Summer diapause.
Alate *(pi.* alatae, alates) A winged insect - applied usually to an aphid.
Ambulacrum The terminal part of the leg of a mite in regular contact with the substratum, consisting mainly of the apotele (q.v.) but also sometimes a pretarsus (q.v.) and a pulvillus (q.v.).
Amphitoky Parthenogenetic reproduction in which both male and female offspring are produced from unfertilized eggs.
Anal claspers The pair of prolegs on the last abdominal segment of an insect larva.
Anal plate A dorsal plate often present on the last abdominal segment of an insect larva.
Anchor process *(see* Sternal spatula).
Anholocyclic As in aphids, breeding parthenogenetically and viviparously.
Annulate With ring-like markings.
Annulus *(pi.* annuli) A small ring.
Antenna *(pi.* antennae) One of the pair of sensory 'feelers' on the head of an insect.
Antennomeres The individual components ('segments') of an insect antenna.
Anterior At or towards the front.
Apical At or towards the tip (apex) of a structure, e.g. that part furthest from the body.
Apodous Without legs, legless.
Apotele The articulating sixth segment arising from the tarsal segment of the pedipalp of certain mites.
Appendage An outgrowth, such as a leg or wing, attached to the body by a joint.
Aptera *(pi.* apterae) A wingless insect - applied usually to an aphid.
Apterous Without wings, wingless.
Arboviral disease A disease caused by an arbovirus (q.v.).
Arbovirus A virus spread by an arthropod vector ('arbo' standing for arthropod-borne).
Arista A bristle-like outgrowth, as on the antennae of certain insects.
Aristate Bearing an arista.
Arolium *(pi.* arolia) A usually very small pad or sac-like structure located between the claws of the foot of an insect.
Arrhenotoky Parthenogenetic reproduction in which only male offspring are produced from unfertilized eggs.
Atraceate Lacking spiracles and a tracheal system.
Basal At or towards the base of a structure, e.g. that part nearest the body.
Basitarsus The basal (and often the largest) segment of the tarsus.
Bidentate With two teeth.
Biordinal Of two sizes.
Bipectinate Feather-like (cf. Pectinate).
Birefringent Showing characters of double refraction.
Bivoltine Having two generations annually.
Brachypterous Having shortened wings.
Breast bone *(see* Sternal spatula).
Calypter *(see* Squama).
Campodeiform larva An elongate, dorsoventrally flattened larva with well-developed antennae and thoracic legs, as in larvae of many lacewings and beetles.
Capitate With a distinct head.
Caste One of several distinct forms found amongst populations of social insects.
Caterpillar An eruciform larva of a butterfly, moth or sawfly.
Cauda A tail, including the tail-like structure of an aphid.
Caudal At or towards the tail (anal) end.
Cell As in insect wing venation, a discrete area enclosed by veins.
Cement glands *(see* Colleterial glands).
Cenchri Wing-coupling tubercules found in certain sawflies.

Cephalopharyngeal skeleton In certain dipterous larvae, the skeletal structure formed from the reduced, retracted head and the mouthparts.

Cephalothorax *(see* Prododosoma).

Cercus *(pi.* cerci) One of a pair of appendages arising from abdominal segment 11.

Chaetotaxy The arrangement (disposition and number) of bristles or setae on the body and appendages - of particular importance in the classification of Diptera and mites.

Cheek *(see* Gena).

Chela The distal, pincer-like part of the chelicera (q.v.).

Chelate Grasping, prehensile.

Chelicera *(pi.* chelicerae) One of a pair of much modified structures at the tip of the pedipalp, formed or dervived from three segments: a basal trochanter, a fixed main section and an articulating terminal apotele - the main section and the apotele often form the chela (q.v.).

Chitin A polysaccharide, which is the main chemical component of the cuticle.

Chorion The outer skin of an egg.

'Chrysalis' *(pi.* 'chrysalids') A usually inappropriate term for 'pupa' and one to be avoided (although, arguably, acceptable for pupae of certain nymphyalid butterflies); its use in acarology to designate resting stages (viz. 'protochrysalis'. 'deutochrysalis' and "teliochrysalis") should also be avoided.

Claspers *(see* Anal claspers).

Clavate Club-shaped.

Clavus The posterior part of the forewing of a heteropteran bug.

Club The swollen terminal segments of a clavate antenna.

Clypeus The lowest part of the face, immediately above the labrum.

Colleterial glands A pair of glands, associated with the female genitalia, which produce a secretion for cementing eggs to the substratum.

Collophore The ventral tube on the first abdominal segment of a springtail.

Compound eye The multi-faceted eye of an insect. formed from a collection of ommatidia.

Corbiculum *(pi.* corbicula) The so-called "pollen-basket' of a bee.

Corium The main (usually leathery) part of the forewing of a heteropteran bug.

Cornicle *(see* Siphunculus).

Cornu *(pi.* cornua) An elongated "arm' on the pharyngeal sclerite of the mouthparts (cephalopharyngeal skeleton) of certain dipterous larvae.

Costa One of the main longitudinal veins of the wing, which usually forms the costal margin.

Costal margin The front margin of the wing.

Costal vein *(see* Costa).

Coxa *(pi.* **coxae)** The basal segment of the leg.

Crawler The highly mobile first-instar nymph of a scale insect.

Cremastal Pertaining to the cremaster.

Cremaster A small cluster of hooks or spines at the tip of the pupa of a butterfly or moth, often borne on a distinctive outgrowth.

Crochets Sclerotized hooks found on the abdominal prolegs of most lepidopterous larvae.

Cross-vein A transverse vein that links the longitudinal veins in an insect wing.

Cuneus The more or less triangular part of the forewing of a heteropteran bug, separated from the corium (q.v.) by a groove or suture.

Cuticle The three-layered 'skin' of an insect or mite.

Dectious pupa A pupa with sclerotized, articulated mandibles.

Deflexed Bent downwards.

Dentate Toothed.

Deuterogenous Pertaining to deuterogeny.

Deuterogeny Having distinct winter and summer forms.

Deuterotoky *(see* Amphitoky).

Deutogyne The "winter' female in a species of mite exhibing deuterogeny (q.v.).

Deutonymph The second nymphal stage of a mite.

Dorsal On or pertaining to the upper surface.

Dorsal cornu *(pi.* cornua) One of a pair of often very long, posteriorly directed dorsal processes of the cephalopharyngeal skeleton (q.v.).

Dorsal shield *(see* Prodorsal shield).

Dorsum The upper surface of the body.

Ecdysis The process of moulting during which the 'old' skin is cast off and replaced by another.

Ectognathous Mouthparts exposed (external) (cf. Endognathous).

Ectoparasite A parasite which lives on the outside of the body of its host.

Ectoparasitoid A parasitoid which lives on the outside of the body of its host.

Egg-tooth A caudal appendage which enables a larva to burst the chorion of the egg when hatching.

Elytron *(pi.* elytra) The hardened, horny forewing of a beetle and certain other insects *(see also* Hemelytron).

Emarginate With a distinct indentation or notch.

Embolium A narrow section along the costal margin of the forewing of a heteropteran bug.

Empodium *(see* Ambulacrum).

Endognathous Mouthparts hidden - located in a pocket (cf. Ectognathous).

Endoparasite A parasite living within the body of its host.

Endoparasitoid A parasitoid which develops within the body of its host.

Epidermis The unicellular integument which secretes the cuticle.
Epipharynx In the mouthparts of an insect, a usually small lobe attached to the ventral surface of the labrum.
Eruciform larva A larva with a cylindrical body, three pairs of thoracic legs and several pairs of stumpy abdominal prolegs - body sometimes sac-like and with a distinct pseudopod. as in certain chrysomelid larvae.
Exarate pupa Most if not all appendages free, as in various Hymenoptera (cf. Obtect pupa).
Exoskeleton The hardened external skeleton to which the muscles are attached.
Exuviae The cast-off skin (cuticle) after moulting.
Eye-cap A hood-like structure at the base of the antenna of certain moths, which partly covers the eye.
Falcate Sickle-shaped.
Fat body The collection of often densely aggregated cells (large trophocytes and small oenocytes) found in the haemocel and functioning as an organ of excretion and, notably, storage of, for example, fat and glycogen.
Feather-claw A feather-like ambulacrum (q.v.) on the leg of an eriophyid mite, composed of a central shaft and a series of lateral branches or rays which may themselves be branched - a divided feather-claw has the shaft subdivided into two.
Femur *(pi* **femora)** The third, and frequently the largest, segment of the leg of an insect, located between the trochanter and the tibia; also, the third segment of the leg of a mite (and the second segment of the pedipalp), located between the trochanter and the genu.
Filiform Thread-like.
Flagellomeres The individual components ('segments') of the flagellum (q.v.).
Flagellum The third (distal) part of the antenna, beyond the pedicel.
Fore At or towards the anterior end.
Forelegs The pair of legs arising from the prothorax.
Forewings The pair of wings arising from the mesothorax.
Fossorial Adapted for digging.
Frass The solid excreta of an insect, especially that produced by a caterpillar.
Frenulum The bristle-like wing-coupling mechanism found on the hindwing of certain moths and some other insects, which links to the retinaculum (q.v.) which is located on the forewing.
Furcula The forked saltatory appendage on the fourth abdominal segment of a springtail.
Fusiform Cigar-shaped or spindle-shaped.
Gallicola ***(pi.*** **gallicolae)** A female that initiates and breeds with a gall, as in many aphids.
Gaster In certain Hymenoptera (Apocrita), that part of the abdomen behind the petiole.
Gena *(pi.* **genae)** That part of the head ('cheek') above the mandible below and behind the compound eye.
Genal cones The pair of anteriorly directed processes on the head of a psyllid.
Geniculate Abruptly bent, elbowed.
Genital flap In a female eriophyid mite, the characteristic flap which conceals the reproductive organs.
Genu The fourth segment of the leg (or the third segment of the pedipalp) of a mite, located between the femur and the tibia.
Glabrous Without hairs, hairless.
Gnathosoma The anterior-most of the two main sections of the body of a mite, constituting the mouthparts and bearing two pair of appendances: the chelicerae and the pedipalps (cf. Idiosoma).
Grub A colloquial name for an insect larva, as in 'chafer grub'.
Gynopara *(pi.* **gynoparae)** A female aphid that gives rise sexually (i.e. after mating) to a generation of oviparae (q.v.).
Haemocoel The main body cavity of many invertebrates, such as insects and mites.
Haemolymph The fluid ("blood") filling the haemocoel (q.v.).
Haltere The club-shaped or drumstick-like balancing organ on the metathorax of a fly, formed from the modified hindwing.
Hamula *(see* Retinaculum).
Hamuli The small wing-coupling hooks on the hindwings of Hymenoptera.
Head The anterior-most of the three main subdivisions of the body of an insect body, bearing (for example) the antennae and mouthparts.
Hemelytron ***(pi.*** **hemelytra)** The mainly leathery forewing of a heteropteran bug - unlike the elytron of, for example, a beetle, the distal part of the hemelytron is membranous.
Hemimetabolous insect An insect with incomplete metamorphosis, i.e. no pupal stage in the life-cycle (cf. Holometabolous insect).
Hemi-pupa ***(pi.*** **hemi-pupae)** A modified pupa which, instead of producing an adult, gives rise directly to several so-called 'daughter' larvae, as in certain gall midges.
Heteroecious Species whose 'summer' and 'winter' host plants are different, as in certain aphids.
Heteromerous beetle A beetle with an unequal number of tarsal segments on the three pairs of legs.
Hibernaculum ***(pi.*** **hibernacula)** The structure (e.g. a cocoon) in which an insect hibernates.
Hind At or towards the posterior end.
Hindlegs The pair of legs arising from the

metathorax; also, in a mite the fourth pair of legs.

Hindwings The pair of wings arising from the metathorax.

Holometabolous insect An insect with complete metamorphosis, i.e. with a pupal stage in the life-cycle (cf. Hemimetabolous insect).

Honeydew A sugary fluid excreted through the anus of certain phytophagous Hemiptera, notably aphids, mealybugs, psyllids and scale insects.

Horn A term of convenience to describe a spinose outgrowth arising from the eighth abdominal segment of certain caterpillars.

Hyaline Clear and colourless, as in the wings of certain insects.

Hypermetamorphosis A kind of life-cycle which includes two or more distinct types of larvae.

Hyperparasitoid A parasitoid whose host is itself a parasitoid.

Hypognathous With a vertically directed head and the mouthparts directed ventrally.

Hypopal Pertaining to the hypopus.

Hypopharynx Part of the insect mouthparts. arising behind the mouth but just in front of the labium. Typically short and tongue-like in insects with biting mouthparts but often enlongated and tube-like in insects with sucking mouthparts.

Hypopleural bristles A distinctive curved row of bristles present on each side of the thorax of certain flies.

Hypopus The morphologically distinct, often phoretic, dispersal stage of a mite.

Hypostome The beak-like part of the mouthparts of a mite.

Hysterosoma That part of the idiosoma of a mite lying beyond (posterior to) the sejugal furrow and bearing the third and fourth pairs of legs.

Idiosoma The hinder-most of the two main sections of the body of a mite, bearing the legs (cf. Gnathosoma).

Imago *{pi.* **imagines, imagos)** The adult stage of an insect.

'Imago' larva In cecid midges, a larva which will eventually develop via a pupal stage into an adult (cf. Paedogenic larva).

Inquiline An animal living in the "home' (e.g. a gall or a nest) of another and sharing its food.

Instar The stage in the development between two moults or stages - a first-instar larva or nymph is that which emerges from the egg.

Integument The outer covering (cuticle plus epidermis) of an insect or mite.

Intersegmental Located between two segments.

Juguin A narrow lobe at the base of the forewing of Certain Lepidoptera which overlaps the hindwing and serves to couple the wings together.

Knee A term of convenience to describe, in certain flies (e.g. Agromyzidae), the differentially coloured section at the base of the tibia which demarcates the point of articulation with the femur.

Labial palp One of the pair of palps arising from the labium.

Labium The lower lip' of the mouth.

Labrum The 'upper lip' of the mouth.

Lamella *{pi,* **lamellae)** A thin leaf-like flap or plate.

Lamellate Composed of several lamellae.

Larva The immature growth stage of a holometabolors insect, which is very different in appearance to the adult into which it metamorphoses during a pupal stage; the first (typically six-legged) juvenile stage of a mite between the egg and first eight-legged nymphal stage.

Larval paedogenesis Parthenogenetic reproduction in which the adult and pupal stages are omitted from the life-cycle and the larva gives rise directly to a 'new' generation of larvae.

Larviform An adult with larva-like body features.

Lateral At or close to the sides.

Lateral penellipse A penellipse with the 'missing sector' directed mesally.

Macropterous Wings fully developed.

Maggot A colloquial term, often applied to the larva of a fly.

Malpighian tubules The thin, blind-ending tubules that arise between the mid-gut and hindgut of an insect, and which are concerned with the regulation of nitrogenous waste, salt and water.

Mandible Jaw.

Mandibulate With mandibles suitable for biting or chewing.

Maxilla *{pi.* **maxillae)** One of two parts of the mouthparts of an insect, located just behind the mandibles.

Maxillary palp One of the pair of palps arising from the maxillae.

Meconium The excreta produced by a fully-developed insect larva which does not defaecate during its development; also, the excreta discharged by an adult insect on emerging from the pupa.

Melanin A collective term for various black, brown or yellow pigments which may be incorporated into the skin.

Mesal At or pertaining to the mid-line of the body.

Mesal penellipse A penellipse with the 'missing sector' directed laterally.

Mesonotum The dorsal surface of the second thoracic segment.

Mesoseries A series lying mesally.

Mesothorax The second of the three main sections of the thorax of an insect.

Metasternum The ventral surface of the metathorax.

Metathorax The third of the three main sections of the thorax of a insect.
Micropyle A small pore in the chorion of an insect egg, through which sperm may enter.
Microtrichia Small, spine-like hairs.
Microtubercle A minute tubercle (q.v.).
Mid-legs The pair of legs arising from the mesothorax.
Moniliform Bead-like.
Mouth-hooks That part of the cephalopharyngeal skeleton (q.v.) formed from the mandibles.
Multiordinal Of several different sizes.
Multiserial circle Arranged in several concentric circles.
Multivoltine Having several generations annually.
Nymph The immature growth stage of a hemimetabolous insect, usually similar in general appearance to the adult and often sharing similar feeding habits.
Obtect pupa Appendages firmly fastened to the body, as in Lepidoptera (cf. Exarate pupa).
Ocellar triangle A usually distinctly separate, triangular part of the head of certain Diptera which bears the ocelli.
Ocellus *(pi.* ocelli) A light-sensitive simple eye with a lens but without an image-forming capability *(see also* Stemma); also, a pigmented spot on the wing of certain Lepidoptera.
Ommatidium *(pi.* ommatidia) One of the units forming a compound eye.
Omnivorous Feeding on both animal and plant material.
Ootheca *(pi.* oothecae) The purse-like, egg-containing case produced by cockroaches and other Dictyoptera.
Operculum *(pi.* opercula) A lid-like structure.
Oral vibrissae The pair of long bristles arising from just above the mouth of certain flies.
Ovipara *(pi.* oviparae) A female aphid that lays eggs.
Oviparous Reproducing by laying eggs.
Ovipositor The egg-laying structure of an insect.
Ovisac A typically silken, cocoon-like sac containing eggs.
Oviscapt An egg-laying tube formed from the terminal segments of the abdomen.
Ovoviviparous Producing an egg which has a definite shell and hatches within the maternal body.
Paedogenesis Parthenogenetic reproduction in which the adult stage is omitted *(see* Larval paedogenesis; Pupal paedogenesis).
Paedogenetic larva A larva which gives rise to further larvae by the process of paedogenesis (q.v.) *(see* Larval paedogenesis).
Palp *(pi.* palpi, palps) A segmented, sometimes leg-like, sensory structure arising from the maxilla or the labium of an insect *(see also* Pedipalp).
Palpus *(see* Palp).
Papilla *(pi.* papillae) A small, often finger-like, projection.
Parasite A species which lives in or on another (the host), obtaining food from it but giving nothing in return.
Parasitoid Typically, a parasite in which only the larval stage is parasitic and the adult free-living - a parasitoid usually kills its host.
Paratergal plates Small sclerotized plates on the tergites, as in certain lice.
Parthenogenesis Reproduction which does not involve fertilization.
Parthenogenetic Pertaining to parthenogenesis (q.v.).
Patella *(see* Genu).
Pecten A comb-like tuft of hair, present on the base of the antennae of some insects.
Pectinate Comb-like (cf. Bipectinate).
Pedicel The second segment of an antenna, between the scape and the flagellum; also, in ants, an alternative name for the petiole (q.v.).
Pedipalp One of a pair of sensory, leg-like structures arising from the gnathosoma of a mite.
Pedunculate Stalked.
Penellipse An incomplete (open) ellipse.
Petiolate Attached by a narrow stalk.
Petiole The narrow 'waist" found in certain Hymenoptera.
Pheromone A semiochemical (q.v.) produced by an organism and used to communicate with, and usually eliciting a predetermined response in, a receiving individual of the same species - alarm pheromones and sex attractants are examples.
Phoresy The involuntary transportation of one organism by another, without involving parasitism.
Phoretic Pertaining to phoresy (q.v.).
Phytophagous Plant-eating, herbivorous.
Pilose Hairy.
Pinaculum *(pi.* pinacula) A small chitinized plate on the body of a larva.
Pleuron *(pi.* pleura) A plate forming the side wall of a thoracic segment.
Plumose With numerous feathery branches.
Polyembryony The embryo of a single egg subdividing to give rise, on hatching, to two or more larvae (all of which will be of the same sex).
Polyphagous Feeding on a range of different kinds of food or host plant, such as plants belonging to more than one family.
Porrect Extended forward horizontally.
Posterior At or towards the rear.
Postscutellum A small, usually poorly developed section of the mesonotum, located immediately behind the scutellum - well developed in certain flies.
Prepupa *(pi.* prepupae) The non-feeding develop-

mental (often resting) stage between a larva and a pupa.

Prescutum The anterior-most (first) of the three main dorsal components of each of the three sections of the thorax, usually obvious only on the mesothorax (cf. Scutum, Scutellum).

Prespiracular plate In an insect larva, a plate lying anterior to a spiracle.

Pretarsus In certain mites the terminal (distal) part of the tarsus, forming part of the ambulacrum (q.v.).

Proboscis The elongated, often curled, 'tongue' of an insect, as in many adult butterflies and moths.

Prodorsal shield The more-or-less triangular shield-like part of an eriophyid mite, anterior to the annulated hysterosoma, which overlies the propodosoma.

Prognathous With a more or less horizontal head and the mouthparts located anteriorly.

Proleg One of a pair of unsegmented 'false' legs arising from the abdominal segment of a larva.

Pronotum The often enlarged, shield-like dorsal surface of the prothorax (q.v.).

Propodeum The first abdominal segment in certain Hymenoptera (Apocrita), located in front of the pedicel and thus appearing to be part of the thorax.

Propodosoma That part of the idiosoma of a mite lying anterior to the sejugal furrow and bearing the first and second pairs of legs.

Propodosomal shield *(see* Prodorsal shield).

Propupa *(pi.* propupae) In thrips, the resting developmental stage between the nymph and the pupa.

Prothoracic plate A dorsal plate, often present on the first thoracic segment of a larva.

Prothorax The first (of three) main sections of the thorax of an insect.

Protogyne The 'summer' female in a species of mite exhibing deuterogeny (q.v.).

Protonymph The first nymphal stage of a mite.

Pseudocellus *(pi.* pseudocelli) A light-sensitive receptor on the abdomen of a springtail.

Pseudo-gall An often distinctly coloured gall-like deformation of part of a host plant (e.g. a leaf), induced by a pest such as an aphid.

Pseudopod A false leg, applied especially to that present on the anal segment of certain larvae.

Pseudo-pupa The resting stage of certain hemimetabolous insects in which moulting to the adult occurs, as in whiteflies.

Pteromorphae Wing-like or ridge-like expansions to the idiosoma of an oribatid mite.

Pterostigma A small pigmented area present towards the tip of an otherwise 'clear' wing of an insect (sometimes also called a 'stigma').

Ptilinum A small balloon-like structure which is projected temporarily from the front of the head of a young fly to aid its emergence from the puparium.

Pubescent Covered in short, soft hairs.

Pulvillus *(pi.* pulvilli) A pad at the tip of the tarsus (foot); also, in mites, a small cushion-like structure at the tip of the ambulacrum (q.v.).

Punctate Covered in small pits or depressions.

Pupa *(pi.* pupae) The pre-adult stage of a holometabolous insect, in which metamorphosis occurs; also, the pre-adult 'resting' stage of certain mites.

Pupal paedogenesis Parthenogenetic reproduction in which the adult stage is omitted from the life-cycle and the 'pupa' (= hemi-pupa) (q.v.) gives rise directly to a 'new' generation of larvae.

Puparium *(pi.* puparia) In higher Diptera: the barrel-shaped structure, formed from the cast-off skin of the fmal-instar larva (exuvium), within which the pupa is formed.

Pupate To turn into a pupa (the act of pupation).

Pygidium The dorsal surface of the last visible abdominal segment.

Pyriform Pear-shaped.

Radicicola *(pi.* radicicolae) A member of a root-inhabiting generation, as in grape phylloxera.

Raptorial Grasping, prehensile.

Reniform Kidney-shaped.

Reticulate With a net-like pattern.

Retinaculum The retaining hook on the third abdominal segment of springtails which possess a furcula (q.v.); also, a hook or group of bristles located on the forewing of certain insects which possess a frenulum (q.v.).

Rickettsia *(pi.* rickettsiae) A bacterium- or virus-like blood parasite which can reproduce only in an animal cell.

Rickettsial disease A disease caused by a rickettsia (q.v.).

Rostrum The beak of a heteropteran bug; also, the snout of a beetle or weevil *(see also* Gnathosoma).

Saltatory Jumping.

Saprophagous Feeding on dead or decaying organic material.

Scape The basal (first) segment of an antenna.

Scarabaeiform larva A larva with a thick, fleshy (often C-shaped) body and a well-developed head and thoracic legs - exemplified by chafer larvae.

Sclerite One of any of the hardened (sclerotized) plates which form the body wall.

Sclerotization The process by which the cuticle is hardened and tanned by the formation of the protein sclerotin.

Scopa The pollen-collecting apparatus of a bee.

Scutellum The third of the main dorsal components of each of the three sections of the thorax, usually obvious only on the mesothorax and often very large in certain bugs (cf. Prescutum, Scutum).

Scutum The second of the main dorsal components of each of the three sections of the thorax, usually obvious only on the mesothorax (cf. Prescutum, Scutellum); also, a roof-like shield over the gnathosoma of a mite.

Segmental Pertaining to a segment or segments.

Sejugal furrow A suture or groove which divides the idiosoma of a mite into the propodosoma and the hysterosoma (q.v.).

Semiochemical A chemical used in interspecific or intraspecific communication.

Serrate Toothed like a saw.

Seta *(pi.* **setae)** A small bristle.

Setose Covered with setae.

Shield A term of convenience for a large sclerotized plate on the body of an insect or mite.

Siphunculus *(pi.* siphunculi) One of a pair of pores or tube-like structures on the abdomen of an aphid which discharge, for example, alarm pheromones and other defensive secretions.

Spatulate Spade-like.

Spinneret A silk-producing structure containing silk glands.

Spinose Spiny.

Spinule A small spine.

Spiracle A breathing pore - an opening of the tracheal system.

Spiracular line A line on the body surface of a larva, passing through the row of spiracles.

Squama *(pi.* squamae) A membranous flap at the base of the wing of certain flies.

Stemma *(pi.* **stemmata)** In holometabolous insects, the 'simple' eye (ocellus) of a larva, which is sometimes capable of forming a relatively clear image.

Sternal spatula A ventrally placed structure present in third-instar larvae of most midges (Cecidomyiidae), formed from the remains of the head capsule and used to burrow into the soil prior to pupation.

Sternite A ventral sclerite; also, one of the annulated subdivisions on the ventral part of the hysterosoma of an eriophyid mite.

Sternum The ventral surface of a segment.

Stigma *(pi.* stigmata) A distinctive, often reniform, mark on the forewing of certain moths; also, in certain mites, an external opening of the respiratory (tracheal) system *(see also* Pterostigma).

Striae Grooves running across or along the body cuticle (such as those on the elytra of beetles).

Strigulae A series of short dash-like markings arising from the costal margin of the forewings of certain Lepidoptera (e.g. Tortricidae).

Style A slender bristle present at the apex of some antennae.

Stylet A needle-like structure - often applied to parts of the probing mouthparts of certain insects and mites, and to parts of the sting of certain bees and wasps.

Styliform Needle-like.

Stylophore The needle-like piercing mouthparts of a mite, formed from the coalesced chelicerae.

Subdorsal Pertaining to or at the side of the dorsum.

Subspiracular line A line on the body surface of a larva, passing just below the row of spiracles.

Suture A groove on the body surface which usually divides one sclerite (plate) from another; also, the division between the paired elytra of a beetle.

Tarsal formula In certain beetles, the specified number of tarsal segments on the foreleg, mid-leg and hindleg.

Tarsus *(pi.* **tarsi)** The distal part ('foot') of the leg of an insect, usually subdivided into several segments; also, the fifth segment of the pedipalp of a mite; also, the fifth (usually terminal) segment of the leg of a mite.

Tegmen *(pi.* **tegmina)** The hardened, leathery forewing of a cockroach, grasshopper, etc. *(see also* Elytron).

Tegula *(pi.* **tegulae)** A small lobe covering the base of the forewing.

Tergal Pertaining to the tergum.

Tergite A dorsal sclerite; also, one of the annulated subdivisions on the dorsal part of the hysterosoma of an eriophyid mite.

Tergum The dorsal surface of a body segment.

Thelytoky Parthenogenetic reproduction in which only female offspring are produced.

Thorax The second of the three main divisions of the body of an insect, bearing the legs and the wings.

Thumb-claw In certain mites, a prehensile structure on the pedipalps, formed from the tibial seta (which forms the claw) and the palpal tarsus (which forms the 'thumb').

Tibia *(pi.* **tibiae)** One of the segments of a leg, located between the femur and the tarsus of an insect or a mite; also, the penultimate segment of the pedipalp of a mite, located between the genu and the tarsus.

Triordinal Of three sizes.

Tritonymph The third nymphal stage of a mite.

Trochanter An often small and inconspicuous segment of the leg of an insect, located between the coxa and the femur; also, the second segment of the leg of a mite, located between the coxa and the femur; also, the basal (first) segment of the pedipalp of a mite.

True legs Thoracic legs.

Tubercle A small, rounded projection.

Tuberculate With tubercles (q.v.).

Tympanum The auditory membrane or 'ear' of an insect.

Uniordinal Of one size.

Uniserial circle Arranged in a single circle (cf. Multiserial circle).
Univoltine Having one generation annually.
Ventral On or pertaining to the lower surface.
Ventriculus The main digestive (usually tubular) section of the mid-gut.
Ventrum The lower surface of the body.
Vermiform Worm-like, i.e. long and thin.
Verruca *(pi.* verrucae) A wart-like projection, often bearing several bristles or setae.
Vibrissae *(see* Oral vibrissae).
Viviparous Producing live young (nymphs or larvae) as opposed to eggs.
Waist *(see* Petiole).
Wing pad The sac-like structure in an insect nymph that is the developing precursor of the adult wing.
Wing venation The arrangement of veins on the wing of an insect.

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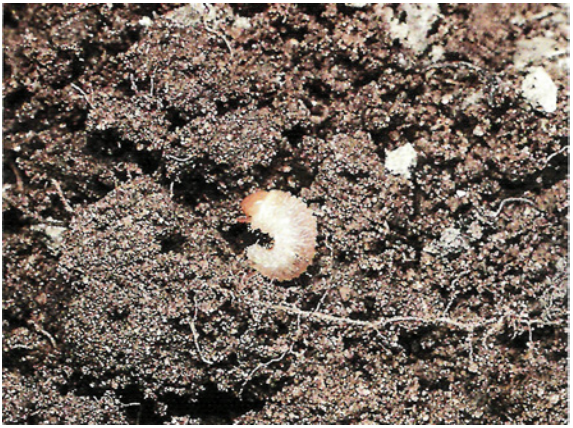

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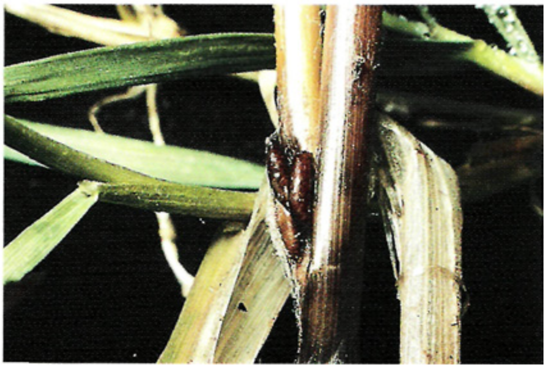

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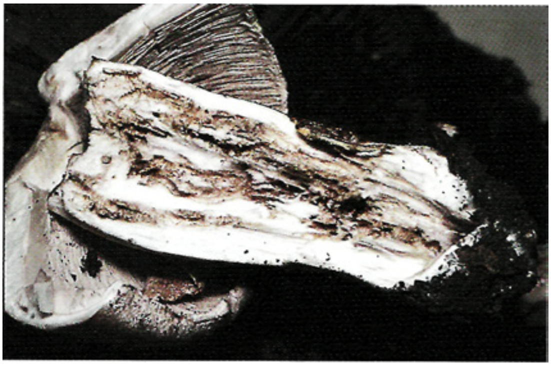

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Plate 10c Female ghost swift moth *(Hepialus humuli)*

Plate lOd Larva of ghost swift moth *(Hepialus humuli)*

Plate lOe Larva of garden swift moth *(Hepialus lupulinus)*

Plate lOf Larva of leopard moth *(Zeuzera pyrina).*

Plate 9a Larva of gout fly *(Chlorops pumilionis).*

Plate 9b Puparium of gout fly *(Chlorops pumilionis).*

Plate 9c Larva of frit fly (*Oscinella frit*).

Plate 9d Larva of onion fly (*Delia antiqua*).

Plate 9e Wheat bulb fly *(Delia coarctata).*

Plate 9f Larva of wheat bulb fly *(Delia coarctata).*

Plate 12a Male fruit tree tortrix moth *(Archips podana).*

Plate 12b Larva of fruit tree tortrix moth *{Archips podana).*

Plate 12c Larva and larval habitation of flax tortrix moth *(Cnephasia asseclana).*

Plate 12d Omnivorous leaf tier *(Cnephasia longana).*

Plate 12e Larva of pea moth *(Cydia nigricana).*

Plate 12f Pea moth *(Cydia nigricana).*

Plate 11a Pupa and pupal cocoon of leek moth *(Acrolepiopsis assectella).*

Plate lib Leek moth *(Acrolepiopsis assectella).*

Plate lie Larva and larval web of *Epermenia chaerophyllella* on parsnip.

Plate lid Adult of *Epermenia chaerophyllella.*

Plate lie Parsnip moth *(Depressaria pastinacella).*

Plate llf Larva of parsnip moth *(Depressaria pastinacella).*

Plate 14a Larva of *Pyrausta aurata.*

Plate 14b Larvae of large white butterfly *(Pieris brassicae).*

Plate 14c Larva of small white butterfly *{Pieris rapae).*

Plate 14d Larva of brown-tail moth *(Euproctis chrysorrhoea).*

Plate 14e Larva of turnip moth *(Agrotis segetum)* damaging a potato tuber.

Plate 14f Shark moth *(Cucullia umbratica).*

Plate 13a Garden grass veneer moth {*Chrysoteiichia culmella*).

Plate 13b Larva of garden grass veneer moth (*Chrysoteiichia culmella*).

Plate 13c Garden pebble moth (*Evergestis forficalis*).

Plate 13d Larva of a garden pebble moth (*Evergestis forficalis*).

Plate 13e European corn borer (*Ostrinia nubilalis*)

Plate 13f Adult of *Pyrausta aurata*.

Plate 15a Larva of bordered straw moth *(Heliothis peltigera).*

Plate 15b Larva of rosy rustic moth *{Hydraecia micacea)* boring within a wheat stem.

Plate 15c Larva of tomato moth *(Lacanobia oleracea).*

Plate 15d Eggs and first-instar larvae of cabbage moth *{Mamestra brassicae).* and typical 'windowing' damage on a cabbage leaf.

Plate 15e Larva of common rustic moth *(Mesapamea secalis).*

Plate 15f Mediterranean brocade moth *{Spodoptera littoralis).*

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