MAMMALIAN SPECIES No. 11, pp. 1-7, 3 figs.

Zapus hudsonius. By John O. Whitaker, Jr.

Published 16 June 1972 by The American Society of Mammalogists

Zapus Coues, 1876

Zapus Coues, 1876:253. Type species *Dipus hudsonius* Zimmermann.

CONTEXT AND CONTENT. Order Rodentia, Superfamily Dipodoidea, Family Zapodidae, Subfamily Zapodinae. The genus *Zapus* includes three living species, *Z. hudsonius*, *Z. princeps*, and *Z. trinotatus*.

1 First molariform tooth large, about 0.70 mm long and 0.75 wide, with crescentine fold on occlusal surface .... *Z. trinotatus*

First molariform tooth smaller (about 0.55 by 0.50 in *princeps* and 0.30 by 0.35 in *hudsonius*) 2

2 Incisive foramina shorter than 4.6 mm; palatal breadth at last molariform tooth less than 4.2; condylobasal length usually less than 20.3; maxillary toothrow usually 3.7 or less .... *Z. hudsonius*

Incisive foramina longer than 4.6 mm; palatal breadth at last molariform more than 4.4; condylobasal length usually 20.3 or more; maxillary toothrow usually greater than 3.7 .... *Z. princeps*

Zapus hudsonius Zimmermann, 1780
Meadow Jumping Mouse

Dipus hudsonius Zimmermann, 1780:358. Type locality Hudson Bay, Canada; restricted by Anderson (1942) to Fort Severn, Ontario.

Dipus labradorius Kerr, 1792:276. Type locality. Preble (1899: 11) states that the type specimen came from Hudson Bay.

Dipus canadensis Davies, 1798:157. Type locality near Quebec City, Province of Quebec, Canada.

Dipus americanus Barton, 1799:115. Type locality near Philadelphia, Pennsylvania.

Meriones microcephalus Harlan, 1839:1. Type locality Becks Farm, a few miles NE Philadelphia, Pennsylvania.

Meriones acadicus Dawson, 1856:2. Type locality Nova Scotia, Canada.

Zapus tenellus Merriam, 1897:103. Type locality Kamloops, British Columbia, Canada.

CONTEXT AND CONTENT. Context noted in generic summary above. The group has been monographed by Preble (1899) and Krutzsch (1954), who recognized the 11 living subspecies listed below.

Z. h. hudsonius (Zimmermann, 1780:358), see above (*labradorius* Kerr a synonym).

Z. h. canadensis (Davies, 1798:167), see above (*ontarioensis* Anderson a synonym).

Z. h. americanus (Barton, 1799:115), see above (*microcephalus* Harlan, *brevipes* Bole and Moulthrop, and *rafinesquei* Bole and Moulthrop are synonyms).

Z. h. acadicus (Dawson, 1856:2), see above (*hardyi* Batchelder a synonym).

Z. h. alascensis Merriam, 1897:223. Type locality Yakutat Bay, Alaska.

Z. h. tenellus Merriam, 1897:103, see above.

Z. h. campestris Preble, 1899:20. Type locality Bear Lodge Mountains, Crook Co., Wyoming.

Z. h. ladas Preble, 1899:10. Type locality Rigoulette, Hamilton Inlet, Labrador.

Z. h. pallidus Cockrum and Baker, 1950:1. Type locality NW corner sec. 4, T. 12 S, R. 20 E, 5½ mi. N, 1¾ mi. E Lawrence, Douglas Co., Kansas.

Z. h. intermedius Krutzsch, 1954:447. Type locality Ridgeway, Winneshiek Co., Iowa.

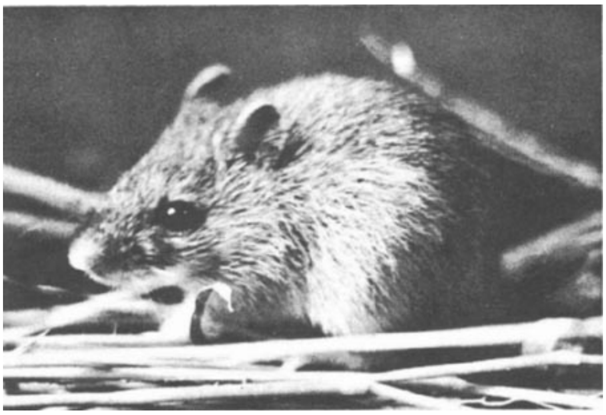

FIGURE 1. Photograph of *Zapus hudsonius* taken at Terre Haute, Vigo Co., Indiana, by Dennis Clark.

Z. h. preblei Krutzsch, 1954:452. Type locality Loveland, Larimer Co., Colorado.

†*Z. h. adamsi* Hibbard, 1955:217. Type locality, XI Ranch Meade County, Kansas, late Sangamon interglacial (Pleistocene, Kingsdown formation, Jinglebob local fauna).

†*Z. h. transitionalis* Klingener, 1963:257. Type locality, base of Mt. Scott, Big Springs Ranch, SE¼, sec. 18, T. 32 S, R. 28 W, Meade Co., Kansas, late Illinoian glacial (Pleistocene, Kingsdown formation, Mt. Scott local fauna).

DIAGNOSIS. *Zapus* is a long-tailed, yellowish mouse with four upper molariform teeth, the first much smaller than the others. *Napaeozapus* differs in having a white-tipped tail and only three molariform teeth; *Eozapus* differs in having a white-tipped tail and a dark longitudinal stripe down the abdomen. *Z. hudsonius* is smaller (187 to 230 mm, 108 to 139, 28 to 31), has a narrower skull in proportion to its length, smaller premolars (0.30 by 0.35), and a shorter toothrow (usually less than 3.7) than other species of *Zapus*.

GENERAL CHARACTERS. *Zapus* has the hind legs much longer than forelegs; tail attenuate, subcylindrical and longer than body; eyes small and midway between nose and ear; ear dark with narrow pale edge and somewhat longer than surrounding hair; upper lip with median groove; vibrissae conspicuous; teats 8, with 2 pectoral, 4 abdominal, and 2 inguinal; total length of baculum 4.5 to 4.9 mm, width 0.64 to 0.72; general pelage coarse with broad dorsal band of brown or yellowish brown darkened with brownish black hairs; sides paler; underparts white or sometimes suffused with yellowish, but usually separated from sides by band of clear yellowish color; backs of forefeet and hind feet grayish white; tail distinctly bicolor, dark brown above and yellowish white below (Figure 1). Total length is 187 to 255 mm, tail length 108 to 155, and hind foot 28 to 35. Skull with preorbital foramen large and oval; ends of nasals project noticeably beyond incisors; four upper molariform teeth with first reduced in size (illustrated in MAMMALIAN SPECIES No. 14 on *Napaeozapus*); upper incisors strongly grooved; upper and lower incisors deep orange or yellow; enamel pattern complicated, consisting of one re-entrant fold lingually and four labially; three lower molariform teeth, dentition i 1/1, c 0/0, p 1/0, m 3/3.

Specific characters: *Zapus hudsonius* has the back ochraceous to dark brown; sides pale; lateral line ochraceous-buff, indistinct, or absent; belly white or sometimes suffused with ochraceous; additional descriptive data may be found in Krutzsh (1954), Klingener (1963, 1964), and Whitaker (1963, 1966). The skull is illustrated in Figure 2. Whitaker (1963)

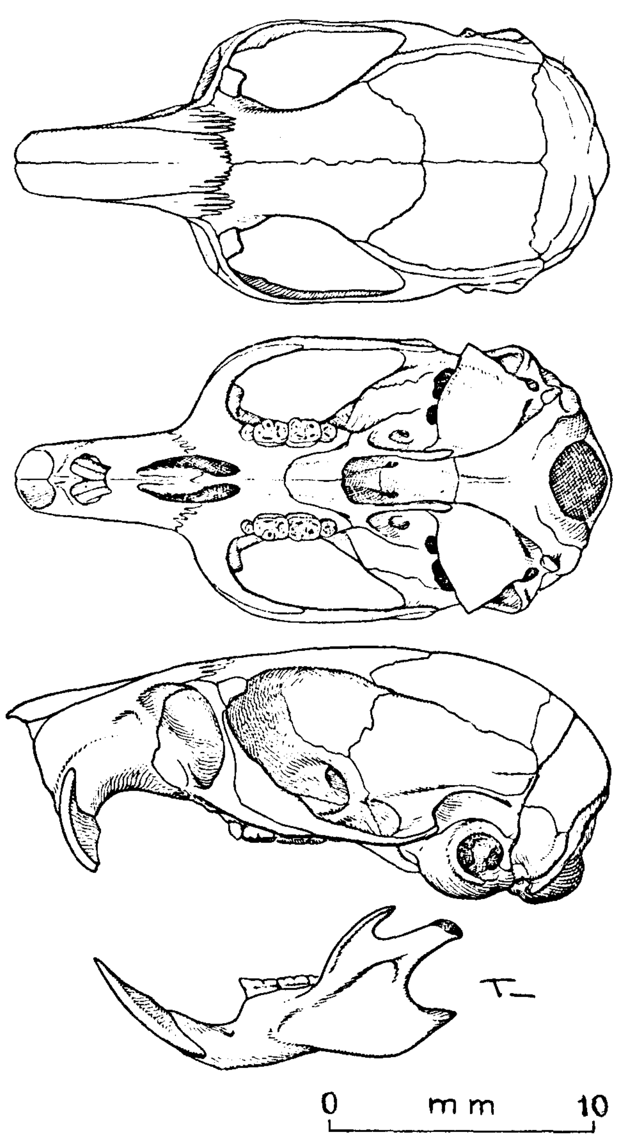

FIGURE 2. Skull and jaw of *Zapus hudsonius*, A. dorsal view, B. ventral view, C. lateral view of cranium and jaw. From Ellerman, 1940:571.

gave information on variability within the species in central New York, including means, ranges, standard errors, and coefficients of variability. Also males and females were compared.

DISTRIBUTION. Eleven living and 2 fossil subspecies of *Zapus hudsonius* have been described (Figure 3). All known extinct taxa of *Zapus* were described from Meade County, Kansas, and *Z. h. transitionalis* has also been taken in Harper County, Oklahoma. These localities are well beyond the present range of *Z. hudsonius* and about 270 miles (450 km) east of the nearest *Z. princeps* localities. *Zapus hudsonius* occurs primarily in abandoned fields, moist abandoned fields, and brushy fields but is sometimes taken in wooded areas when herbaceous ground cover is adequate.

FOSSIL RECORDS. Fossil taxa, *Z. rinkeri* Hibbard, 1951, *Z. s. sandersi* Hibbard, 1956, *Z. s. rexroadensis* Klingener, 1963, *Z. burti* Hibbard, 1941, and two fossil subspecies of *Z. hudsonius*, listed above, have been described. Klingener (1963) studied 32 *Zapus* fossils from seven localities in Meade County, Kansas, and from one locality in Harper County, Oklahoma. It is not clear where *Z. burti* fits into the phylogeny of *Zapus*, but the Pliocene taxon, *Z. sandersi rexroadensis*, appears to be a logical ancestral stock for *Zapus hudsonius*. *Zapus rinkeri* appears to have evolved from *Z. s. rexroadensis* by late Pliocene, but then to have died out. *Z. s. rexroadensis* appears to have given rise to *Z. s. sandersi*, *Z. hudsonius transitionalis*, *Z. h. adamsi*, and the living *Z. hudsonius*, in a progressive series.

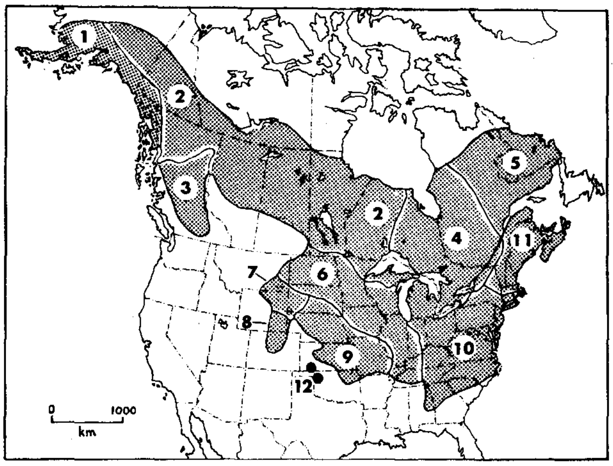

FIGURE 3. Range of *Zapus hudsonius* and its subspecies (Modified from Hall and Kelson, 1959). Subspecies are: 1) *Z. h. acadicus*; 2) *Z. h. alascensis*; 3) *Z. h. americanus*; 4) *Z. h. campestris*; 5) *Z. h. canadensis*; 6) *Z. h. hudsonius*; 7) *Z. h. intermedius*; 8) *Z. h. ladas*; 9) *Z. h. pallidus*; 10) *Z. h. preblei*; 11) *Z. h. tenellus*; 12) fossil sites mentioned in text on distribution.

Guilday *et al.* (1969) found *Zapus hudsonius* in a late Pleistocene cave deposit in Robinson Cave, Overton Co., Tennessee.

FORM. Krutzsch (1954) studied the teeth, baculum, ear ossicles, and hair. In addition to sensory hairs, facial vibrissae, nasal hairs, and carpal vibrissae, three kinds of hairs (guard hairs, overhairs, and underfur) are normally present in *Zapus*. Guard hairs are gray at the base with increased pigmentation (black or brown) at the tips. They are elliptical in cross section, taper at both ends, and range from .096 to .140 mm in diameter (average .115 in *Z. hudsonius*). This is significantly narrower than in *Z. princeps* or *Z. trinotatus*. Individual hairs of the underfur are cylindrical, taper abruptly at each end, are grayish or white proximally, and are yellowish brown distally. The dark dorsal stripe of *Zapus* is caused by the large number of black hairs there. Black hairs are less abundant on the paler sides and essentially absent in the lateral yellow band. Krutzsch (1954) found six individuals with abnormal coloring among 1261 specimens of *Z. hudsonius* examined, four had white spots, one was black, and one lacked any black. Schorger (1951) caught six meadow jumping mice in Dane County, Wisconsin, with white-tipped tails and Whitaker (1963) found five of 1049 that had white tail tips, and one each with a small white spot on the rump and crown, respectively.

Krutzsch (1954) presented data on the length and transverse diameter at the base and tip of the baculum (os penis). Whitaker (1966) figured an os clitoridis bone of *Zapus*, which was 1.7 mm long. Krutzsch (1954) studied geographic variation in *Z. hudsonius*. The subspecies vary mainly in coloration, relative proportions of the tail, hind feet, and body, and size and shape of parts of the skull. Individuals generally have paler backs, brighter sides, and smaller skulls in the southern parts of the range.

Klingener (1964) published on the comparative myology of *Zapus*, *Napaeozapus*, and related taxa, and also (1963) on the evolutionary development of the dentition of *Zapus*. Lyon (1901) compared the osteology of jerboas and jumping mice. Guthrie (1963) studied a specimen of *Napaeozapus* injected with latex and skulls of *Zapus* and *Sicista*, and concluded that the carotid arterial pattern in this group (Zapodidae) is basically the same as in *Microtus*. He discussed the minor differences. Most of the anatomical systems, however, have not been studied at all in *Zapus hudsonius*, even in general terms.

FUNCTION. Most of the work on physiology of *Zapus hudsonius* pertains to hibernation. Waters and Stockley (1965) timed the breathing rate of *Zapus* in hibernation by observing thoracic movements for 25 minutes on 16 January 1963. There were 29 intervals between thoracic movements with long and short intervals interspersed. Sixteen intervals were less than 5 seconds, four were from 6 to 15, and the nine longer than 15 seconds were 63, 70, 95, 95, 100, 107, 109, 115, and 141.

Morrison and Ryser (1962) found the average body temperature for 163 values on nine *Z. hudsonius* to be 37.27° C with a range of 35.1 to 40.1° (s.d. 1.00). They found a rhythmic daily cycle in this species, with highest readings at night (mean of 38.0°C) and lowest readings during the day (mean of 36.9°C), thus reflecting the nocturnal behavior pattern of the species. During exposure to temperatures of 0 to 10°C, body temperature was unstable. Morrison and Ryser concluded that this did not represent an inability to regulate body temperature, because at ambient temperatures below zero, the body temperature again increased to normal nighttime active temperature of about 38°C. This, of course, would be beneficial in keeping the animal from freezing. This response to subzero environmental temperatures has been found in other hibernating mammals and is apparently caused by an increase in metabolic activity (Lyman, 1963).

Waters and Stockley (1965) took rectal temperatures of a *Zapus hudsonius* as it entered, emerged, and finally re-entered hibernation; this sequence occurred from the hour 1920 through noon the next day. Ambient temperatures outside the nest box were below 0°C. The animal remained in hibernation after the probe was inserted until about 2020 whereupon its temperature started to rise. At 2030 it was about 5°C and by 2040 it was about 15° and the animal was emerging from dormancy. By 2050 it had reached 25°, but then fluctuated between 25° and 33° until 2140, when it leveled off at about 33°, and remained there until about midnight. It then became irregular, dropped to around 26°, and between 0200 and 0220 dropped to about 2° and the animal again became dormant. Its temperature rose to about 15° for about 3 hours then dropped to about 7° for several hours. Rectal temperatures exceeded ambient temperatures by at least 3° during nearly all of the observation period. In another mouse in a refrigerator, skin temperatures varied rather directly about 6° to 7° above the refrigerator temperature, until the refrigerator temperature decreased to about –3° to –4°. The skin temperatures of the animal then rose from about 3° to 4° to about 10°.

Morrison and Ryser (1962) studied the relation between temperature and oxygen consumption in nonhibernating animals, although some individuals entered hibernation during the trial. At an ambient temperature of 29°C, oxygen consumption ran slightly more than 2000 mm^3/hr/g of body weight in one individual. At 10°, oxygen consumption rose to the vicinity of 5000 and 6000 mm^3. After an hour, the metabolic response dropped slightly, and after another half hour, it dropped to 200 mm^3, and finally in another 4 hours reached a minimum of 40 mm^3. The animal then woke spontaneously and within an hour was utilizing 5000 mm^3 necessary for maintenance at 10°C. Pearson (1947) reported a basal level of 3100 mm^3 in an 18 g *Z. hudsonius*, and of 3200 mm^3 in a 22 g jumping mouse. During 24 hours, oxygen consumption ranged from about 3500 to 5500 mm^3/hr/g of body weight, with the maximum occurring at hours 1830, 2230, 0030, and 0730.

Neumann and Cade (1964) found that jumping mice (eight *Napaeozapus* and two *Z. hudsonius*) on short days fattened before hibernation and hibernated for longer periods than did their counterparts on long days (See MAMMALIAN SPECIES No. 14 on *Napaeozapus*). The average weights of the short-day mice decreased rapidly just after the mice entered hibernation, then leveled off, whereas weights of the long-day mice decreased rapidly and continually throughout their sporadic periods of hibernation until death occurred. Quimby (1951) and Hamilton (1935) also noted rapid weight loss in the first days after entrance into hibernation.

Morrison and Ryser (1962) found rapid weight increases up to slightly more than 100% of original body weight. The adult weight before fattening averaged about 19 g, with an increase in one case to 37 g. These workers also found that the rapid and massive increase in weight was not synchronized in the various individuals. One individual began its increase on 18 August, whereas another did not begin until 20 September. This supports the hypothesis of Whitaker (1963) that individuals of this species enter hibernation a few at a time after they have had time to accumulate ample fat and that this occurs over an extended period. The maximum daily increases in weight found by Morrison and Ryser were as high as 1.9 to 2.0 g per day, or 6 to 8% of body weight per day in some individuals over three day periods. The rate was lower over longer periods since the progression in weight is stepwise, with periods of increase interspersed with periods of nonincrease. However, there was one average value of 0.94 g per day over 16 days (3.2% per day).

ONTOGENY AND REPRODUCTION. Whitaker (1963) presented information on 19 newborn young (neonates) *Zapus hudsonius* as follows: total length, mean 34.4, range 30 to 39 mm; tail, mean 9.3, range 7 to 11; hind foot, mean 4.7, range 3 to 6. The average weight of 14 neonates from three litters was 0.8 g (0.7 to 1.0 g). Quimby (1951) found that neonates had minute vibrissae, but otherwise were naked and pink. Their eyes were closed but appeared as dark spots. The ear pinnae were folded over the external ear openings. During the first week, the vibrissae became visible to the naked eye, the tail became bicolor, and pinnae of the ears unfolded and were tipped with black, and the claws appeared. Yellowish hairs appeared about the ninth day dorsally, and spread to include the sides about day 13. By then the vibrissae had became prominent and were about 8 mm long. The eyes were still closed, but a crack down the center was visible by about day 13, when the incisors erupted. They were white. Sparse, pale-colored hairs were visible on the belly back of the feet and on the outer surfaces of the legs. During the third week the hair covering was completed and the external auditory meatus began to open. By this time the young were readily identifiable as jumping mice. During the fourth week the adult pelage replaced the juvenile pelage and the eyes opened. The incisors changed from white to the yellowish orange of the adult and by day 23 all but the third molars had erupted. After the fourth week, growth of the young mice slowed considerably. By this time they were 4.6 times their length at birth, whereas at the end of the 13th week they had increased only to 5.8 times this length. Tail length had increased 10 times in the first four weeks and 12 times in the first 13 weeks. At four weeks the hind foot was 5.6 times longer than at birth and at 13 weeks it was 5.9 times longer. The young weighed about 2 to 4 g at day 10, about 4 to 8 g at day 20, about 8 to 11 g at day 30, and reached a minimum adult weight of about 14 or 15 g at about day 60. By about day 90 they attained a weight of about 20 g.

Quimby (1951) presented information on gestation in four meadow jumping mice. The periods (in days) were 17 or 18, 17 to 19, at least 20 to 21, and 12 to 20. Data for the first two litters were for nonlactating *Z. hudsonius*, the time increased to 20 or 21 days if the female was lactating, as the third was. Quimby concluded that most births take place between 15 June and 30 August in Minnesota, but that three peaks occur, one in late June, a second in mid- and late July and a third in mid-August. Townsend (1935) and Whitaker (1963) reported pregnancies throughout the summer in New York, and Whitaker presented data on estimated birthdates for 78 potential litters. Mice apparently breed soon after emerging from hibernation with dates of emergence influencing breeding dates. Some litters were produced in every 10-day period between 11 May and 20 September. However, only three of the 78 litters would have been produced in May, and only three in September. The greatest numbers of litters were produced in the first 3 weeks in June and the first 3 weeks in August. Quimby (1951) found that many mice have two litters during the year at Minnesota, but that some may have three, and Hamilton (1935) believed two litters per year were produced. Whitaker (1963) found that many mice have at least two litters per year since 67% of the adult females taken in the first major breeding period (21 May to 20 June) were pregnant, or had given birth recently, and 84% of the adult females taken in the period 21 July to 20 August were pregnant or had recently given birth.

Quimby (1951) found an average of 5.7 young per litter in Minnesota (17 litters, range 4 to 7), and Townsend (1935) found a mean of 4.5 in New York (17 litters range 3 to 7). Krutzsch (1954) got a mean of 4.5 by averaging embryo counts from museum labels of 62 individuals; the range was 2 to 8. Whitaker (1963) presented other embryo and litter counts from the literature, and also data concerning numbers of embryos from 78 snap-trapped females taken at Ithaca, New York. The mean number of embryos was 5.5 (range 2 to 9).

Whitaker (1963) studied seasonal changes in the male reproductive tract and found that the length of the seminal vesicles was a more sensitive indicator of breeding behavior than the testis measurements.

ECOLOGY. *Zapus hudsonius* may live in a variety of habitats (Getz, 1961; Quimby, 1951; Whitaker, 1963). The species is widespread in abandoned grassy fields, but is often more abundant in thick vegetation along ponds, streams, and marshes or in rank herbaceous vegetation of wooded areas. Stands of touch-me-not, *Impatiens*, provide particularly good habitat for *Zapus hudsonius*. Ross *et al.* (1968) found *Zapus* to be more abundant on low mounds (Mima mounds) of Minnesota than on the surrounding prairie. They hypothesized the mounds might be used as hibernation sites.

Whitaker (1963) concluded that adequate herbaceous ground cover was necessary for maintenance of populations of *Zapus*, but that soil moisture seemed to have little or no direct effect except as it influenced other factors, and that distance to major bodies of water was of little importance. Getz (1961), however, concluded that there was a definite relationship between the species and moisture, but that the species avoided sparse vegetation. Whitaker (1963) found that grassy vegetation favored populations of *Zapus*, but the species of plants present (including food plants) were of little consequence. There appeared to be enough food in most of the habitats studied to support populations of *Zapus*. Other species of mammals, if they competed, did not limit the distribution or abundance of *Zapus*. Bider (1968) found that the activity of zapodids increased with rainfall.

Information concerning predation on *Zapus* has been summarized (Whitaker, 1963). In addition, *Zapus hudsonius* was preyed upon by red tailed hawks in Alberta (Luttich *et al.*, 1970), and by barn and long-eared owls in New York (Eaton and Grzybowski, 1969).

Zapus hudsonius harbors few parasites (for some, associates might be a better term) in comparison to many other species of small mammals of comparable size (Hamilton, 1935; Whitaker, 1963). Among bacteria, *Escherichia coli*, *Bacillus mycoides*, *Klebsiella* sp., and *Bacteriodes* sp. have been reported from the cecum (Whitaker, 1963). *Bacteriodes* occurs in low numbers in spring but becomes abundant in late summer and autumn. Two species of *Hexamita* and one of *Eimeria* (protozoans), were found in the cecum of *Zapus*, also at Ithaca.

Of the trematodes, *Notocotylus hassali* was reported from Michigan (Erickson, 1938), and *Plagiorchis proximus* and *Quinqueserialis quinqueserialis* were reported from Labrador and Quebec (Schad, 1954). Whitaker (1963) found trematodes in 26 of the 956 mice examined for larger internal parasites. *Plagiorchis* sp. was the most common, being found in 16 mice. Other trematodes found were *Schistosomatium douthitti*, *Quinqueserialis* sp., and *Echinostoma* sp. Cestodes reported are *Mesocestoides* sp. (Schad, 1954), larval *Taenia mustelae* (Freeman, 1956), and *Choanotaenia* sp. (Lubinsky, 1957). Only five of the 956 mice examined by Whitaker yielded cestodes, one of which was *Hymenolepis* sp. Reported nematodes are *Subulura ungulatus* and *Spirocerca zapi* (Erickson, 1938), and *Mastophorus muris* in one mouse from Labrador (Schad, 1954). Whitaker (1963) found nematodes in the intestines of only two of 956 examined, these worms were *Citellinoides zapodis* and *Rictularia* sp. Lichtenfels and Haley (1968) found *Longistriata dalrymplei* and *Citellinoides zapodis* in mice from Maryland.

The tick, *Dermacentor variabilis*, was reported from Minnesota (Quimby, 1951) and Nova Scotia (Dodds *et al.*, 1969). Whitaker (1963) found 36 of 864 meadow jumping mice examined for external parasites to harbor *Ixodes muris* in New York, and Martell *et al.* (1969) found the same tick from Nova Scotia. The chigger mites, *Trombicula microti* and *T. subsignata* were taken by Brennan and Wharton (1950), and Farrell (1956) reported *Euschongastia diversa acuta*. Strandtmann (1949) reported *Androlaelaps fahrenholzi* (= *Haemolaelaps glasgowi*) and Judd (1950) reported *Haemogamasus hirsutus*.

The most abundant external parasite of the meadow jumping mouse in New York (Whitaker, 1963) and in Indiana (Rupes and Whitaker, 1968) is the hypopus (transport form) of *Dermacarus hypudaei*. This form does not feed on the mouse, and adults of this species have not been found in North America, even though it was found on over half of the specimens examined from New York and Indiana, often in great numbers. No other mites were found with any regularity by Whitaker (1963) or Whitaker and Wilson (1968), but species reported were the chiggers *Neotrombicula subsignata*, *Eutrombicula alfreddugesi*, and *Neoschongastia* sp. Other mites were: *Eulaelaps stabularis*, *Laelaps kochi*, *Haemogamasus alaskensis*, and a few free-living mites considered as accidentals. See remarks at end also.

Flea records summarized by Whitaker (1963) include *Orchopeas leucopus*, *Megabothris asio*, *M. wagneri*, *M. quirini*, *Stenopomia americana*, and *Corrodopsylla curvata*. Only 13 of 864 mice examined by Whitaker harbored fleas (one flea each). Included were *Ctenopthalmus pseudagyrtes*, *Orchopeas leucopus*, and *Megathris asio*. Holland and Benton (1968) recently reported *Ctenopthalmus pseudagyrtes* and *Orchopeas leucopus* from Pennsylvania.

Larval botflies, *Cuterebra*, often have been found on *Zapus hudsonius* (Whitaker, 1963). Hamilton (1935) reported seeing one louse on a *Zapus hudsonius*, and Whitaker (1963) found one, probably *Neohaematopinus* sp., among 864 *Z. hudsonius* examined.

Quimby (1951) found that the home range in *Z. hudsonius* varied from 0.19 to 0.87 acres (0.08 to 0.35 hectares) in females, with a mean of 0.38 (.15 hectares), and male home ranges varied from 0.14 to 1.10 acres, with a mean of 0.43 (.17 hectares) in one area in Minnesota. In another area in Minnesota he found that nine males had significantly larger home ranges (2.70 acres, 1.1 hectares) than did 17 females (average 1.57 ± 0.22 s.d. acres, or 0.63 hectares). Blair (1940) calculated home ranges of 26 males (Michigan) as 0.89 ± 0.11 and of 24 females as 0.92 ± 0.11 acres, the difference not significant.

Quimby (1951) figured some home ranges and suggested that the environment plays a major role in determining the size, and that the shape of home ranges is determined by terrain. Home ranges shift, in one case an adult moved more than a half mile.

Townsend (1935) and Sheldon (1938) suggested that *Z. hudsonius* tends to wander, and Townsend believed that the movement may be associated with the animals seeking moist spots during the dry part of summer. Quimby (1951) found them to have essentially no homing tendencies on the basis of releases of 13 individuals 0.2 to 0.5 miles (0.3 to 0.8 km) from their original home ranges. Only two returned, and both of these appeared to Quimby to have returned by chance wandering. The evidence is not conclusive but suggests that *Zapus* may move about more than is the case with other small mammals.

Quimby (1951) estimated that there were 11.91 mice per acre (48.3/hectare) in one Minnesota study area, and gave monthly averages ranging from 1.81 to 3.57 mice per acre (7.4 to 14.4/hectare) for the second. Quimby (1951) and Blair (1940) agreed that the number of jumping mice in an area may vary considerably from year to year.

FOOD. Quimby (1951) studied food preference in caged *Z. hudsonius*, by making many insects and plants available to them. Of 32 insects tried, all but adult silphid and coccinelid beetles and larval papillionid caterpillars were eaten. Entire plants were made available, but only the fruits and seeds were utilized to any great extent, including several grass seeds and fruits of various shrubs (*Rubus*, *Ribes*, *Cornus*, *Vaccinium*, *Fragaria*, and others). The fruits of 15 plants, including *Typha*, *Cyperus*, *Scirpus*, *Salix*, *Corylus*, *Alnus*, *Chenopodium*, *Trifolium*, *Rhus*, *Cicuta*, *Asclepias*, *Phlox*, *Plantago*, and *Rudbeckia* were not eaten. Hamilton (1935) concluded that seeds are the main food of the species, but that berries, nuts, fruits, and insects are also eaten.

Whitaker (1963) examined the stomach contents of 796 mice of this species. He found that when *Zapus* emerges from hibernation in late April and May it feeds on a variety of foods. Animal material is about half the food and seeds are about 20%. As the season progresses, more seeds and less animal materials are consumed, and the fungus, *Endogone*, becomes important. Seeds, particularly grass seeds, are the basic food in general. The different grasses are used in sequence as they progressively ripen and disappear in the field. Some of the more important seeds eaten were those of *Phleum*, *Anthoxanthum*, *Poa*, *Cerastium*, *Rumex acetosello*, *Dactylus*, *Potentilla*, *Oxalis*, *Echinochloa*, *Ulmus*, and *Asclepias*. The most important of the animal foods were lepidopterous larvae and beetles of the families Carabidae and Curculionidae. It has been suggested that the fungus *Endogone* is taken incidentally with other foods. Whitaker concluded that the fungus is actively sought since the percentages of this food were so high in individual stomachs, since particles of dirt including *Endogone* spores were sometimes found on the cervical and pectoral regions of the animals, and since there was no likely food source with which *Endogone* might be taken incidentally. Available evidence (Quimby, 1951; Whitaker, 1963) indicates that *Zapus hudsonius* does not store food.

BEHAVIOR. The young, at birth, are naked and helpless, but emit a high-pitched squeaking sound, audible for several feet (Quimby, 1951). During the first week of life the young are able to crawl, but are unable to support themselves on their legs. A "suckling note" is made during the first week.

These patterns continue through the second week of life and the young first react to sound about day 20, after the external auditory meatus opens. About this time the young are able to support themselves on their legs, walk, and make short "hops" of an inch or so, although the movements appear awkward because of the hind feet, which appear very large for the size of the animal. The eyes open about day 25, and the behavior patterns then change considerably; the young begin to venture from the nest for the first time, and begin to eat solid food, but nursing does not necessarily end at this time. The young of one litter continued to suckle for the 7 days they were allowed to remain with the female. By the end of the fourth week, the young have the appearance of the adult and are fully able to fend for themselves.

Jumping mice, except when young, are usually silent, but a few sounds have been recorded. York (1945) heard captives utter series of short chirps similar to the sounds of night migrating birds, and another sound which sounded like a cloth being rubbed across damp glass, "cho, cho, cho . . . . . cho." Quimby (1951) kept many live animals but heard only one vocalization, a clucking noise made when individuals were excited. DeKay (1842) reported a sparrowlike chirping sound. Whitaker (1963) heard the squeaks and suckling notes described by Quimby, and also a drumming noise produced by vibrating the tail rapidly against a surface. This noise was also reported by Sheldon (1938) and Svihla and Svihla (1933).

Meadow jumping mice are docile creatures, seldom attempting to bite even when handled roughly. When startled, they usually take a few jumps of about a meter or so, then a series of shorter hops, or more commonly they may stop abruptly and remain motionless. If one does not know exactly where they have stopped it is difficult to locate them. Quimby (1951) and Sheldon (1934) both felt that this motionless state was their chief means of protection. Whitaker (1963) hypothesized that the dark dorsal stripe might be of benefit in helping to conceal them when motionless, and also that they might produce less odor than other small mammals.

Meadow jumping mice are essentially solitary but when together are generally not antagonistic toward one another. Whitaker (1963) recorded that when a *Zapus* was introduced into a cage in which one was already present, the second usually wandered about the cage, not seeming to smell or notice the first, until the two happened to come face to face. The first mouse would remain motionless and pressed against the floor of the cage in a high state of excitement, with the tail out straight and sometimes quivering slightly. When the second found the first it too would enter this same stance. Quimby recorded that in one case a *Zapus* became imprisoned with a meadow mouse, *Microtus pennsylvanicus*. The *Zapus* attempted to defend itself and inflicted a severe gash on the upper lip of the meadow mouse, but the jumping mouse was killed in the process. These mice would be able to offer little resistance to a predator, and appear to protect themselves by remaining perfectly still. Neither Quimby (1951) nor Whitaker (1963) found any evidence that *Zapus* used burrows or runways extensively, other than the burrow leading directly to nests or hibernacula, although Eadie (1939), Whitaker (1963), and Sheldon (1934) have found *Zapus* occasionally using burrows.

Quimby (1951) and Whitaker (1963) reported that *Zapus* often washed their feet, faces, and especially their long tails. The tail was grasped in the forepaws, and passed completely through the mouth, whereas the hands and feet were washed by means of the forepaws.

Hamilton (1935) reported that the mice can and do dig. Captive mice dig in loose dirt by scooping it back under their bodies. The mice apparently forage mostly on the surface and in the herbaceous vegetation above the ground, but the fungal foods extensively eaten are probably obtained by scratching the ground (Whitaker, 1963).

Quimby (1951) described a caged mouse feeding on grass seeds. It sat on its haunches and fed by means of the front feet. First the fruiting head of the grass was cut off, then all parts were stripped beginning at one end. Only the seeds were eaten, but many of these dropped to the ground, and no effort was made to retrieve them. Similar observations were made by Whitaker (1963). Bailey (1926) found that *Zapus* would reach as high as it could on grass stems, bite them off and pull them to the ground, repeating the procedure until the head was reached and eaten. This process would result in a pile of pieces of grass stem, often with the rachis and glumes on top. Whitaker (1963) found evidence that the same procedure is used in New York at least in the case of timothy, *Phleum pratense*, and that in some cases the mouse may climb the stem, cut off the head and bring this to the ground and then consume it.

Mice in captivity regularly drink water, but it is not known whether *Zapus* in the field drink or get their water from green vegetation or from dew, or both.

Zapus hudsonius was often seen during the daytime by Whitaker (1963), who initiated a trapping program during two 5-day periods to determine the daily activity periods of the species. Traps were checked just before and just after dawn and dusk, and at noon. Of 31 *Z. hudsonius*, 27 were taken at night, two at dusk, one in the morning, and one in the afternoon.

Summer nests of *Zapus* have not often been found. Sheldon (1938) described a nest on a hummock of grass and Hamilton (1943) recorded nests of young in open fields under planks. Quimby (1951) found a nest under an overhanging clump of sedge, one in the center of a rotten willow log, and one in a living but hollow red oak under the debris at ground level. Other nests were about 150 mm below ground level. Most of the nests were of grass, but one was a pile of wood pulp and oak and grass leaves in a hollow root, located about 45 mm from the end of a "mouse sized entrance." Quimby (1951) concluded that the "nest is generally located in a protected spot such as a hollow log, hollow tree, under some protecting object, or underground."

The common name of this mouse is a misnomer. Mice of the species do not normally progress by jumping; they more often move slowly through the grass or else take little hops of 1 to 6 inches (Quimby, 1951). They frequently crawl through the grass or under the grass, sometimes flattening their bodies to the ground and proceeding on all fours. When startled, however, a jumping mouse often will take several long leaps of up to a meter, then stop or remain motionless or proceed by means of shorter hops. A jumping mouse in full retreat progresses by means of .3 m hops. Quimby and Whitaker both felt that records of long leaps (over 1 or 1.3 m) are probably errors. Likely these records refer to *Napaeozapus*.

Zapus hudsonius is a good swimmer both on the surface and underwater as has been observed by several workers (Hamilton, 1935; Stone and Cram, 1910; Sheldon, 1938); Jones, 1950; Sutton, 1939; and Quimby, 1951).

Hamilton (1935) and Sheldon (1934) found that *Zapus hudsonius* was able to climb with ease over brush placed in its cage, and Whitaker (1963) found that it was able to climb grass stems.

HIBERNATION. *Zapus hudsonius* is one of the most profound of hibernators, and remains in hibernation as long or longer than most other mammals. Quimby (1951) found that eight of 19 mice entered hibernation between 17 September and 1 October, whereas the remainder had shown no sign of hibernating by this date. The average weight of the hibernating group was 26.44 g, and that of the nonhibernating group was 16.06 g. All of the early hibernating individuals were adults. Seven that had shown no tendency to hibernate by 1 October, had entered hibernation by 16 October. Their average weight was 23.44 just prior to hibernation, whereas the average weight of the four remaining mice was 19.42 g. In both groups of mice the greatest weight gains were during the 2-week period just prior to hibernation. The four remaining mice were removed from the cold room, but they entered hibernation in the heated room.

About 67% of a New York population studied disappeared during the winter, and the average weight of the individuals taken in spring was actually greater than those taken in autumn (Whitaker, 1963). Apparently the smaller animals perished during hibernation. A relatively small proportion of the population had accumulated extensive amounts of fat in the autumn. The animals that reach adult size and have adequate time to accumulate fat are the animals that survive hibernation. Fat production starts in central New York around 1 September, and continues until all animals have disappeared from the active population (by about 20 October). The animals accumulate fat in about 2 weeks, and immediately enter their hibernating quarters. This explains the small number of animals with fat among those caught in traps.

Whitaker (1963) found that nearly all animals had disappeared (presumably entered hibernation) by 20 October, at Ithaca, New York, but there are several later records as follows: 13 and 18 November (New York, Hamilton, 1935); 24 October (Minnesota, Bailey, 1923), and 25 October and 2 November (Washington, D. C.; Bailey, 1929), 26 October, 15 November (Pennsylvania, Richmond and Roslund, 1949);

and 22 October, 1 November (2), and 3 November (Whitaker, 1963).

Kile R. Barbehenn took a specimen of *Z. hudsonius* in an old apple orchard in Montgomery County, Maryland, on 11 February 1960, and Manville (1956) trapped one on 12 February 1955, in Michigan.

Zapus hudsonius apparently emerges from hibernation in the last week in April or the first week in May (Whitaker, 1963; Quimby, 1951; Hamilton, 1935; Bailey, 1929). Males generally precede females.

Several hibernation nests of *Zapus* have been found. Earlier records were summarized by Whitaker (1963). Most reports were of single jumping mice underground or under logs in nests of leaves or grass. Sometimes there was an entrance, sometimes not. Dilger (1948) reported two huddled close together in a layer of compacted wood ash. Linzey and Linzey (1968) found several hibernating individuals in a loose clay bank, each in a separate compartment lined with dry leaves, and approximately 0.5 m below ground level. Another was found 100 to 150 mm below a "clean road fill." Waters and Stockley (1965) found three dormant meadow jumping mice on 11 November 1962 during archaeological excavation on Nantucket Island. The three were in separate nests of bayberry leaves .30, .51, and .56 m below the surface, along with several unoccupied nests in the same area, a sandy knoll.

GENETICS. *Zapus hudsonius* has a diploid number of 72 chromosomes (Meylan, 1968).

REMARKS. The mite referred to as *Dermacarus hypudaei* above and by Whitaker and Mumford (1971) was described as *Dermacarus newyorkensis* by Fain (1969).

LITERATURE CITED

Anderson, R. M. 1942. Six additions to the list of Quebec mammals with descriptions of four new forms. Ann. Rept. for 1941, Provanch. Soc. Nat. Hist., Quebec, pp. 31–43.

Bailey, B. 1929. Mammals of Sherburne County, Minnesota. Jour. Mammal. 10:153–164.

Bailey, V. 1923. Mammals of the District of Columbia. Proc. Biol. Soc. Washington 36:103–138.

— 1926. A biological survey of North Dakota. N. Amer. Fauna. 49:1–226.

Barton, B. S. 1799. Some account of an American species of *Dipus*, or Jerboa. Trans. Amer. Philos. Soc. 4:114–124.

Bider, J. R. 1968. Animal activity in uncontrolled terrestrial communities as determined by a sand transect technique. Ecol. Monogr. 38:269–308.

Blair, W. F. 1940. Home ranges and populations of the jumping mouse. Amer. Midland Nat. 23:244–250.

Brennen, J. M., and G. W. Wharton. 1950. Studies on North American Chiggers, the subgenus *Neotrombicula*. Amer. Midland Nat. 44:153–197.

Cockrum, E. L., and R. H. Baker. 1950. A new jumping mouse (genus *Zapus*) from Kansas. Proc. Biol. Soc. Washington 63:1–4.

Davies, T. 1798. An account of the jumping mouse of Canada. Trans. Linn. Soc. London. 4:155–157.

Dawson, J. W. 1856. Notice of the species of *Meriones* and *Arvicola* found in Nova Scotia. Edinburgh New Philos. Jour., n.s. 3:2.

DeKay, J. E. 1842. Zoology of New York. Part I. Mammalia. White and Visscher. Albany. 146 pp.

Dilger, W. C. 1948. Hibernation site of the meadow jumping mouse. Jour. Mammal. 29:299–300.

Dodds, D. G., A. M. Martell, and R. E. Yescott. 1969. Ecology of the American dog tick, *Dermacentor variabilis* (Say), in Nova Scotia. Canadian Jour. Zool. 47:171–182.

Eadie, W. R. 1939. A contribution to the biology of *Parascalops breweri*. Jour. Mammal. 20:150–173.

Eaton, S. W., and J. A. Grzybowski. 1969. Food habits of owls on the Niagara frontier. Kingbird 19:135–138.

Ellerman, J. R. 1940. The families and genera of living rodents. . . . British Museum (Nat. Hist.), London. 1: xxvi + 1–689.

Erickson, A. B. 1938. Parasites of some Minnesota Cricetidae and Zapodidae, and a host catalogue of helminth parasites of native American mice. Amer. Midland Nat. 20:575–589.

Fain, A. 1969. Les deutonymphs hypopiales vivant en association phoretique sur les mammiferes (Acarina: Sarcoptiformes). Bull. Inst. Royal Sci. Nat. 45(33):1–262.

Farrell, C. E. 1956. Chiggers of the genus *Euschongastia* (Acarina: Trombiculidae) in North America. Proc. U. S. Nat. Mus. 106:85–235.

Freeman, R. S. 1956. Studies on *Taenia mustelae* Gmelin, 1790 and the taxonomy of certain taenioid cestodes from Mustelidae. Canadian Jour. Zool. 34:219–242.

Getz, L. L. 1961. Notes on the local distribution of *Peromyscus leucopus* and *Zapus hudsonius*. Amer. Midland Nat. 65:486–500.

Guilday, J. E., H. W. Hamilton, and A. D. McCrady. 1969. The pleistocene vertebrate fauna of Robinson Cave, Overton County, Tennessee. Palaeovertebrata 2:25–75.

Guthrie, D. A. 1963. The carotid circulation in the rodentia. Bull. Mus. Comp. Zool. 128:457–481.

Hall, E. R., and K. R. Kelson. 1959. The mammals of North American. Ronald Press Co. New York. 2:viii + 547–1083 + 79.

Hamilton, W. J., Jr. 1935. Habits of jumping mice. Amer. Midland Nat. 16:187–200.

— 1943. The mammals of eastern United States. Comstock. Ithaca. 432 pp.

Harlan, R. 1839. On a new species of *Meriones*. Proc. Zool. Soc. London 8:1.

Hibbard, C. W. 1941. The Borchers fauna, a new Pleistocene interglacial fauna from Meade County. Univ. Kansas Publ., Bull. State Geol. Surv. 38:197–220.

— 1951. A new jumping mouse from the upper Pliocene of Kansas. Jour. Mammal. 32:351–352.

— 1955. The Jinglebob interglacial (Sangamon?) fauna from Kansas and its climatic significance. Contrib. Mus. Paleontol. Univ. Michigan 12:179–228.

— 1956. Vertebrate fossils from the Meade formation of southwestern Kansas. Papers Michigan Acad. Sci. 41: 145–203.

Holland, G. P., and A. H. Benton. 1968. Siphonaptera from Pennsylvania mammals. Amer. Midland Nat. 80:252–261.

Jones, J. K., Jr. 1950. Another record of a swimming jumping mouse. Jour. Mammal. 31:453.

Judd, W. W. 1950. Mammal host records of Acarina and Insecta from the vicinity of Hamilton, Ontario. Jour. Mammal. 31:357–358.

Kerr, R. 1792. The Animal Kingdom . . . of Linnaeus. (Class I. Mammalia, Class II. The Birds) . . . , London. 644 pp.

Klingener, D. 1963. Dental evolution of *Zapus*. Jour. Mammal. 44:248–260.

— 1964. The comparative myology of four dipodoid rodents (genera *Zapus*, *Napaeozapus*, *Sicista*, and *Jaculus*). Misc. Publ. Mus. Zool., Univ. Michigan 124:1–100.

Krutzsch, P. H. 1954. North American jumping mice (genus *Zapus*). Univ. Kansas Publ., Mus. Nat. Hist. 7:349–472.

Lichtenfels, J. R., and A. J. Haley. 1968. New host records of intestinal nematodes of Maryland rodents and suppression of *Capillaria bonnevillei* Grundmann and Frandsen, 1960 as a synonym of *C. americana* Read, 1949. Proc. Helminth. Soc. Washington 35:206–211.

Linzey, D. W., and A. V. Linzey. 1968. Mammals of the Great Smoky Mountains National Park. Jour. Elisha Mitchell Sci. Soc. 84:384–414.

Lubinsky, G. 1957. List of helminths from Alberta rodents. Canadian Jour. Zool. 35:623–627.

Luttich, S., D. H. Rusch, E. C. Meslow, and L. B. Keith. 1970. Ecology of red-tailed hawk predation in Alberta. Ecology 51:190–203.

Lyman, C. P. 1963. Hibernation in mammals and birds. Amer. Scientist 1963:127–138.

Lyon, M. W., Jr. 1901. A comparison of the osteology of the jerboas and jumping mice. Proc. U. S. Nat. Mus. 23:659–668.

Manville, R. H. 1956. Hibernation of meadow jumping mouse. Jour. Mammal. 37:122.

Martell, A. M., R. E. Yescott, and D. G. Dodds. 1969. Some records for Ixodidae of Nova Scotia. Canadian Jour. Zool. 47:183–184.

Merriam, C. H. 1897. Three new jumping mice from the northwest. Proc. Biol. Soc. Washington 11:103–104.

Meylan, A. 1968. Formules chromosomiques de quelques petits mammifères nord-américains. Rev. Suisse Zool. 75: 691–696.

Morrison, P., and F. A. Ryser. 1962. Metabolism and body temperature in a small hibernator, the meadow jumping mouse, *Zapus hudsonius*. Jour. Cell. Physiol. 60:169–180.

Neumann, R., and T. J. Cade. 1964. Photoperiodic influence on the hibernation of Jumping mice. Ecology 45:382–384.

Pearson, O. P. 1947. The rate of metabolism of some small mammals. Ecology 28:127–145.

Preble, E. A. 1899. Revision of the jumping mice of the genus *Zapus*. North. Amer. Fauna 15:1–43.

Quimby, D. C. 1951. The life history and ecology of the jumping mouse, *Zapus hudsonius*. Ecol. Monogr. 21:61–95.

Richmond, N. D., and H. R. Roslund. 1940. Mammal survey of northwestern Pennsylvania. Pennsylvania Game Commission, Harrisburg. 67 pp.

Ross, B. A., J. R. Tester, and W. J. Breckenridge. 1968. Ecology of mima-type mounds in northwestern Minnesota. Ecology 49:172–177.

Rupes, V., and J. O. Whitaker, Jr. 1968. Mites of the subfamily Labidophorinae (Acaridae, Acarina) in North America. Acarologia 10:493–499.

Schad, G. A. 1954. Helminth Parasites of mice in northeastern Quebec and the coast of Labrador. Canadian Jour. Zool. 32:215–224.

Schorger, A. W. 1951. *Zapus* with white tail tip. Jour. Mammal. 32:362.

Sheldon, C. 1934. Studies on the life histories of *Zapus* and *Napaeozapus* in Nova Scotia. Jour. Mammal. 15:290–300.

— 1938. Vermont jumping mice of the genus *Zapus*. Jour. Mammal. 19:324–332.

Stone, W., and W. E. Cram. 1910. American animals. Doubleday, Page and Co., Garden City. 318 pp.

Strandtmann, R. W. 1949. The blood-sucking mites of the genus *Haemolaelaps* (Acarina: Laelaptidae) in the United States. Jour. Parasitol. 35:325–352.

Sutton, R. W. 1956. Aquatic tendencies in the jumping mouse. Jour. Mammal. 37:299.

Townsend, M. T. 1935. Studies on some of the small mammals of central New York. Roosevelt Wildl. Ann. 4:1–120.

Waters, J. H., and B. H. Stockley. 1965. Hibernating meadow jumping mouse on Nantucket Island, Massachusetts. Jour. Mammal. 46:67–76.

Whitaker, J. O., Jr. 1963. A study of the meadow jumping mouse, *Zapus hudsonius* (Zimmermann), in central New York. Ecol. Monogr. 33:215–254.

— 1966. Clitoris bones of *Zapus hudsonius* and *Napaeozapus insignis*. J. Mamm. 47:127.

Whitaker, J. O., Jr., and R. E. Mumford. 1971. Jumping mice (Zapodidae) in Indiana. Proc. Indiana Acad. Sci. 80:201–209.

Whitaker, J. O., Jr., and N. Wilson. 1968. Mites of small mammals of Vigo County, Indiana. Amer. Midland Nat. 80:537–542.

York, E. R. 1945. Notes on two captive meadow jumping mice (*Zapus hudsonius*). Canadian Field Nat. 59:47–50.

Zimmermann, E. A. W. 1780. Geographische Geschichte der Menschen und der Vierfussiger Thiere. 2, 432 pp.

Editor for this account was S. ANDERSON.

JOHN O. WHITAKER, JR., DEPARTMENT OF LIFE SCIENCES, INDIANA STATE UNIVERSITY, TERRE HAUTE, INDIANA 47809.