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Neotoma stephensi.

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Neotoma stephensi Goldman, 1905

Stephens' Woodrat

Neotoma stephensi Goldman, 1905:32. Type locality "Hualapai Mountains, 6300 ft., Mohave County, Arizona."

CONTEXT AND CONTENT. Order Rodentia, Family Cricetidae. The genus *Neotoma* contains 19 species in North America (Honacki et al., 1982). Two subspecies of *N. stephensi* were recognized by Hoffmeister and de la Torre (1960):

N. s. relicta Goldman, 1932:66. Type locality "Keams Canyon, Navajo County, Arizona."
N. s. stephensi Goldman, 1905:32, see above.

DIAGNOSIS. This is a medium to small-sized *Neotoma* (Fig. 1), with a semi-bushy tail (bushier than in other species except *N. cinerea*). The baculum is slender, wedge-shaped, and smaller than in any other species of *Neotoma* found in the United States. The antero-medial fold of M1 is usually absent or shallow. The second loph of M3 is long and narrow, extending diagonally across the tooth. The postero-labial fold of M3 terminates posterior to the lingual fold and is directed postero-medially. The lingual fold of m3 is as deep as or deeper than the labial fold. The rostrum is narrow; nasals are truncate posteriorly, rarely sharply pointed. The posterior extensions of the premaxillaries rarely expand posteriorly. The supraorbital ridges remain lateral as they continue forward to the rostrum. In other species, the supraorbital ridges approach the midline terminating almost in line with the posterior extensions of the premaxillaries (Hoffmeister and de la Torre, 1960). Skull (Fig. 2), in general, resembling that of *N. lepida*, but differing in its most extreme development in being smaller, less angular; zygomata more squarely spreading; frontal region broader and more flattened; braincase more smoothly rounded (Hall, 1981).

GENERAL CHARACTERS. Measurements (in mm) of five adults are: total length, 274 to 312; length of tail, 115 to 149; length of hind foot, 28 to 30 (Goldman, 1932). Skull measurements (in mm) from an adult topotype are: basilar length, 33.8; zygomatic breadth, 22.0; interorbital breadth, 6.7; length of nasals, 16.5; length of incisive foramina, 8.9; length of palatal bridge, 7.5; alveolar length of upper molar series, 8.5 (Goldman, 1910). Upperparts yellowish to grayish buff, darkened dorsally by dusky hairs (Hall, 1981). Dusky color extends down the top of the foot one-third of the way below the ankle (Hoffmeister, 1971). Underparts are creamy or white, frequently washed with pinkish buff, fur plumbeous basally except on throat, pectoral and inguinal regions, and inner sides of forelegs (Hall, 1981). Feet generally white; tail pale gray to grayish brown above, paler beneath; semi-bushy (Goldman, 1905; Hall, 1981).

Males, especially adults, are larger than females in most features, however, females average larger than males in the length of the maxillary toothrow. Also, the skulls of adult females are characteristically short and broad in contrast to the relatively longer and narrower skulls of males. Specimens from areas with dark substrata exhibit corresponding darkening of the pelage (Hoffmeister and de la Torre, 1960).

DISTRIBUTION. The geographic distribution of the two named subspecies of *N. stephensi* (Fig. 3) includes western New Mexico from Grant County northward and from central Arizona northward to southern Utah and as far west as Mohave County south of the Colorado River. *Neotoma s. relicta* occurs north of the Little Colorado River and east of the Colorado River to southern Utah; *N. s. stephensi* ranges across central Arizona south of the Little Colorado and Colorado rivers (Cockrum, 1960; Findley et al., 1975; Hall, 1981; Hoffmeister, 1986).

FOSSIL RECORD. Remains of *N. stephensi* were reported from late Pleistocene deposits in the lower Grand Canyon of Arizona. In addition to materials from woodrat middens dated at 14,000 to 24,000 years before present, *N. stephensi* was identified in modern owl-pellet material from a rock shelter near Rampart Cave (Van Devender et al., 1977). However, these published records may be of *N. lepida* (Harris, 1985).

FORM AND FUNCTION. There is a size difference between males and females, especially in adult animals. Although it often occupies arid and semi-arid areas, *N. stephensi* seemingly is not good at conserving water (Vaughan, 1982); water balance is maintained by consistently consuming succulent plant materials. Members of this species neither hibernate nor estivate. Animals forage out from the nests during all times of the year. Stephens' woodrat is a dietary specialist that depends mostly on juniper, *Juniperus* (Vaughan, 1982). Survival of captive animals appeared to improve when juniper cuttings were provided (R. J. Howe, personal communication). Details of how these woodrats deal with the digestion of cellulose and the defensive chemical compounds in junipers are not known.

ONTOGENY AND REPRODUCTION. The major reproductive period occurs from February through July, however, pregnant and lactating females have been taken in other months. Females attain reproductive maturity late (usually at 9 to 10 months) and after a gestation period of approximately 31 days, usually one young is born. Twin births have been recorded, but their survival is probably low. Females suffer a severe loss in mass during a lactation period of approximately 35 days. The young grow slow and are weaned late. In 18 laboratory-born woodrats, major developmental events averaged as follows: opening of the ear canal, 12 days of age; opening of the eyes, 14 days; loss of the divergent nursing tips of the incisors, 19 days; climbing ability, 18 days. Young began to eat juniper between day 10 and 24. Weaning occurs at approximately 35 days of age. Most young do not forage outside the den until at least 42 days of age. Females may have one to five litters/year, however, they do not enter estrus again until they recover from lactation. The average time between litters is 130 days (Vaughan and Czaplewski, 1985).

ECOLOGY. In New Mexico, this woodrat was found inhabiting rock accumulations in the pinon-juniper zone (*Pinus edulis-Juniperus monosperma*); nests usually were at the bases of junipers, but some were constructed 1.6 to 2 m above the ground in juniper

FIG. 1. Photograph of *Neotoma stephensi* from Wupatki National Monument, Arizona. Photograph courtesy of K. P. Dial and T. A. Vaughan.

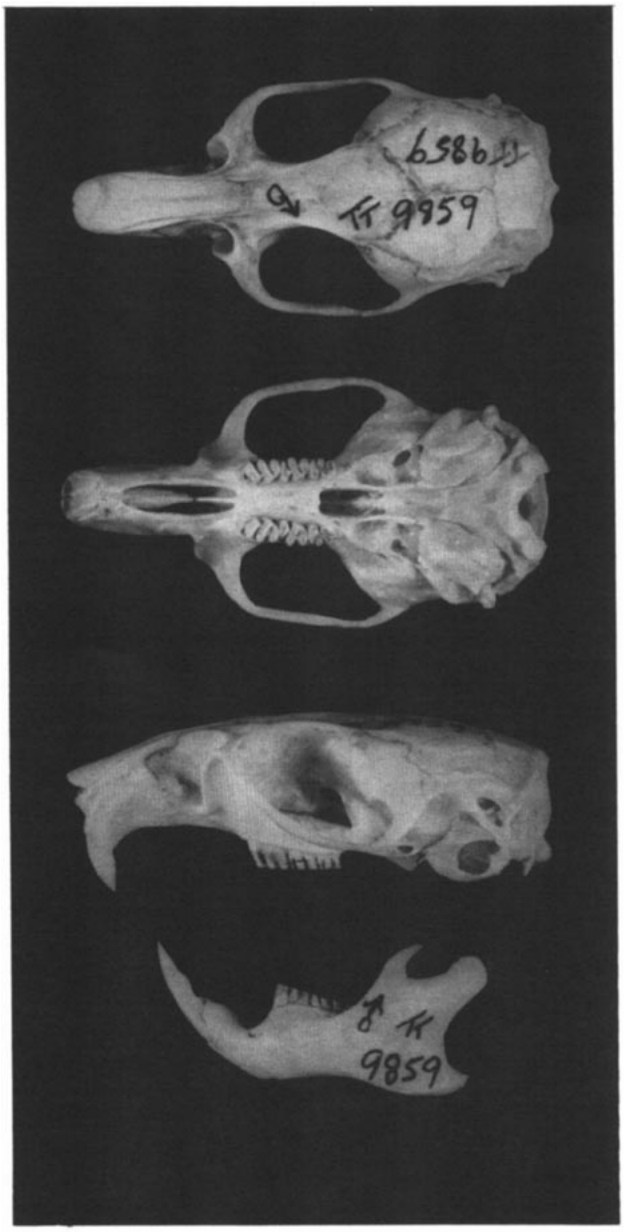

FIG. 2. Dorsal, ventral, and lateral view of cranium and lateral view of mandible of *Neotoma stephensi* (Texas Tech Univ. 9859, male, 15 mi. NE Flagstaff, Coconino Co. Arizona). Greatest length of skull is 42.3 mm. Photograph by N. Olson.

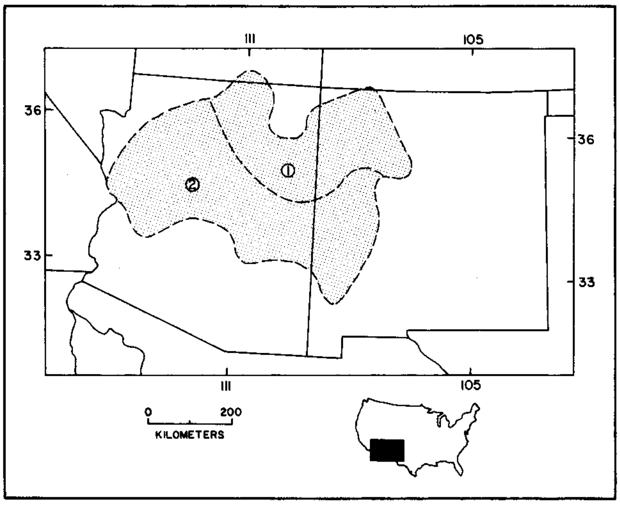

FIG. 3. Distribution of *Neotoma stephensi* in western North America: 1, *N. s. relicta*; 2, *N. s. stephensi*.

trees (Harris, 1963; Findley et al., 1975). In Arizona, *N. stephensi* usually is most closely associated with junipers and pinons, but sometimes it is found among yellow pines (*Pinus ponderosa*), as well as cacti (*Opuntia*) and agave (*Agave*; Hoffmeister, 1986). The species also seems closely associated with piles of rocks, rock walls, and crevices (Findley et al., 1975; Hoffmeister, 1986). Throughout its geographic range, Stephens' woodrat lives in association with junipers (*Juniperus monosperma*, *J. osteosperma*, *J. californica*), and depends on these plants for food, water, and shelter. As noted earlier, this woodrat is a dietary specialist; juniper occurred in 100% of the samples of fecal materials examined (Vaughan, 1980, 1982), indicating that Stephens' woodrats eat juniper consistently, probably each day. Of nests of these woodrats examined by Vaughan (1980), 63% were beneath either living or dead junipers. Nests not directly beneath junipers were not far away; distances from such dens to the nearest living junipers averaged 5.1 m. In addition to providing materials for construction of nests, junipers probably serve as barriers to predators and provide advantageous thermal microenvironmental conditions for these woodrats. The consistent cropping of junipers by *N. stephensi* contributes to the growth form of some of these trees and may have been an important force in the evolution of junipers in parts of the Southwest (Vaughan, 1980).

Some ecological associations have been observed between *N. stephensi*, *N. albigula*, *N. cinerea*, *N. mexicana*, and *N. lepida* (Hoffmeister, 1986). In east-central Arizona, *N. stephensi* coexists with *Peromyscus maniculatus* and *P. boylii* (Holbrook, 1979*a*, 1979*b*); the woodrats utilize a broader selection of habitats and vegetation types than the other rodents.

Parasites reported from *N. stephensi* include a coccidium, *Eimeria operculata*, a nematode, *Aspiculuris*, and an intranasal chigger, *Otorhinophila parvisola* (Kruidenier and Mehra, 1958; Levine et al., 1957; Loomis and Wrenn, 1973).

BEHAVIOR. Male *N. stephensi* exhibit resource defense polygyny, however, the spacing of females may limit the degree of polygyny (Ward, 1984). Vaughan (1982) reported that *N. stephensi* demonstrates central place foraging. This is, the woodrat clips a spray of juniper foliage from the tip of a twig, returns to the den, and eats it at a midden within the den entrance. Juniper cuttings are cached frequently at the den entrance (R. J. Howe, personal communication). Scent marking by males with the ventral sebaceous gland is associated with agonistic behavior in confrontations with other males, with dominant animals doing most of the marking (Howe, 1977; Ward, 1984). In a laboratory experiment, Howe (1977), observed woodrats scent marking sticks, rocks, shelters, and the substrate of the test arenas with both perineal drag and ventral rub behaviors. Another pattern resembled sandbathing where the animal wriggled and rolled on its back for several seconds (Howe, 1977). Within parts of its range, *N. stephensi* competes for den sites with *N. albigula*, but not for food (Howe, 1978). Dial (1984) concluded from a laboratory experiment that woodrats exhibit a social hierarchy. He paired *N. cinerea*, *N. albigula*, and *N. devia* with *N. stephensi*. *Neotoma cinerea* dominated 90% ($n = 11$) of the bouts with *N. stephensi*; *N. albigula* dominated 92% ($n = 13$) of the bouts with *N. stephensi*; and *N. stephensi* dominated 100% ($n = 6$) of the bouts with *N. devia*.

Other patterns of social behavior exhibited by *N. stephensi* include attack, approach, chase, flee, foot stomping, locked fighting, rush, sidling, sparring, tail twitching, trembling, tooth chattering, threatening, defeat posturing, and turning away (Howe, 1978). Ward (1984) reported that before *N. stephensi* crossed open areas in the wild they would spend long periods of time remaining still, and some animals exhibited false starts where they would dart out and then turn back under cover.

GENETICS. The diploid number of chromosomes is 52. A female with a total of 53 chromosomes was reported by Baker and Mascarello (1969). There are 10 submetacentric autosomes and 40 acrocentric autosomes (Fig. 4). The X chromosome is submetacentric and the Y chromosome is subtelocentric (Hsu and Benirschke, 1975). In females, there are four pairs of medium to small biarmed elements and one pair of large subtelocentric elements in the somatic cells (Baker and Mascarello, 1969). Large biarmed autosomes are lacking;

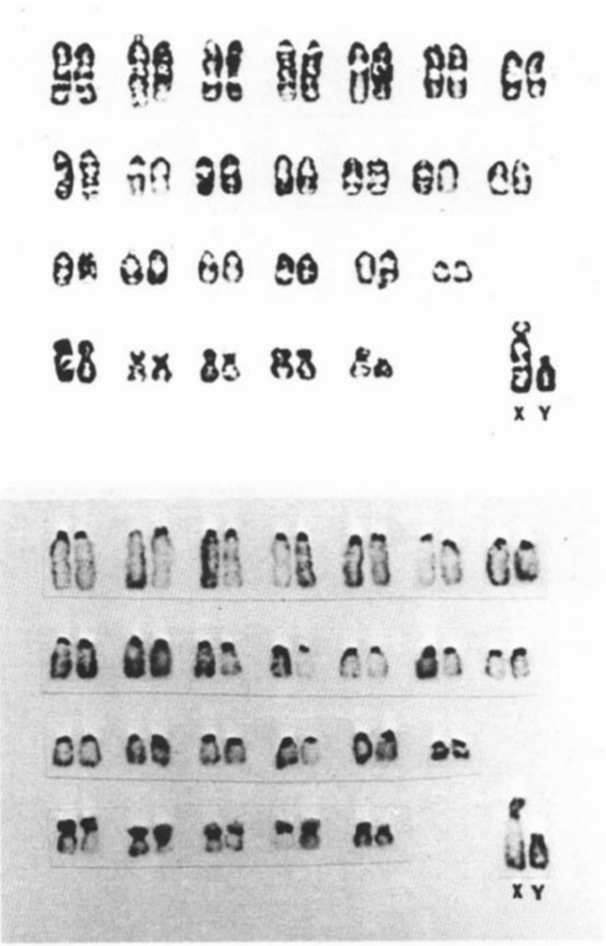

FIG. 4. Karyotypes (top, C-banding; bottom, G-banding) of *Neotoma stephensi* (Hsu and Benirschke, 1975).

there are five pairs of small biarmed chromosomes. The second arm of the X chromosome is relatively short. The G-banding patterns of the eight largest autosomes of *N. micropus* and *N. albigula* (Mascarello and Hsu, 1976).

REMARKS. Stephens' woodrat is the accepted vernacular name for this species (Jones et al., 1986). We are grateful to T. A. Vaughan and K. P. Dial for providing us with a photograph, as well as with sources of information about *N. stephensi.* N. J. Czaplewski and R. J. Howe also contributed information for preparation of this account. N. L. Olson provided the photographs of the skull. S. Burgeson typed the manuscript.

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