MAMMALIAN SPECIES No. 85, pp. 1–6, 2 figs.

Peromyscus californicus.

By Joseph F. Merritt

Published 6 January 1978 by The American Society of Mammalogists

Peromyscus californicus (Gambel) 1848

California Mouse

Mus californicus Gambel, 1848:78. Type locality Monterey, California.

Peromyscus californicus, Thomas, 1894:364, first use of current name combination.

CONTEXT AND CONTENT. Order Rodentia, Family Muridae, Subfamily Cricetinae, Subgenus *Haplomylomys*. Five subspecies of *Peromyscus californicus* are recognized:

P. c. parasiticus (Baird, *ex* Cooper, MS, 1858:478.). Type locality Santa Clara Valley, Santa Clara Co., California.

P. c. californicus (Gambel, 1848:78). Type locality Monterey County, California.

P. c. benitoensis Grinnell and Orr, 1934:216. Type locality near Cook Post Office, 1300 feet, Bear Valley, San Benito Co., California.

P. c. mariposae Grinnell and Orr, 1934:217. Type locality El Portal, 2500 feet, Mariposa Co., California.

P. c. insignis Rhoads, 1895:33. Type locality Dulzura, San Diego Co., California.

For a detailed synopsis of the *californicus* group of *Peromyscus*, see Grinnell and Orr (1934).

DIAGNOSIS. *Peromyscus californicus* is the largest species of the genus in the United States. Total length is 220 to 285 mm; tail is longer than head and body, commonly indistinctly bicolored, and well-haired, but the annulations are not thoroughly concealed. Color is geographically variable, generally blackish brown above, sides ochraceous-tawny, venter pale olive gray to buffy brown (Osgood, 1909). Pelage is long and lax. For photographs and additional information, see Bond (1942), Eisenberg (1962), and Ingles (1965).

The skull is large and the braincase well-inflated; tympanic bullae are large and inflated (figure 1). Molars are robust, no accessory cusps are on M1; upper molars typically lack both lophs and styles, whereas lower molars may possess these structures; well-developed ectostylid is often present, and low ectolophid on m1; occasional subspecific variation of lophs and styles was reported by Hooper (1957:19). Dental formula is i 1/1, c 0/0, p 0/0, m 3/3, total 16.

Baculum is vase-shaped; its base is broad, flat, widest near middle, and has distal and proximal depressions; its shaft is relatively thick and has no protrusible tip; bacular length is 12.6 to 15.4 mm, mean 13.7 mm; width of base is 1.7 to 2.7 mm, mean 2.0 mm (Burt, 1960:51; for other details, description, and illustrations also see Blair, 1942:199 and Hooper, 1958:17). Ceratohyals are short, rectangular, and lacking terminal processes; unique among *Peromyscus*, but resembling *Reithrodontomys megalotis* (Sprague, 1941:305).

GENERAL CHARACTERS. Total length is 220 to 285 mm; length of tail, 117 to 156; hind foot, 24 to 31; ear from notch, 20 to 27; greatest length of skull, 28.1 to 32.1; basilar length, 21 to 25.8; zygomatic width, 13.5 to 16.2; interorbital constriction, 4.3 to 5.1; length of nasals, 10.2 to 12.4; shelf of bony palate, 3.9 to 5.1; length of palatine slits, 5.3 to 6.9; diastema, 7 to 8.4; postpalatal length, 10.2 to 12.6; and length of maxillary toothrow, 4 to 5.1 mm. Weight ranges from 33.2 to 54.4 g (Allen, 1896; Grinnell and Orr, 1934; Burt and Grossenheider, 1964; Ingles, 1965). External and cranial dimensions increase in a stepped cline from 30°29′ N to 38° N latitude (Grinnell and Orr, 1934).

DISTRIBUTION. *P. californicus* is restricted to California south of San Francisco Bay, occurring southward along the coastal ranges as far as San Quintín, Baja California (figure 2). It also occupies lower western slopes of the southern Sierra Nevada, from northwestern Mariposa County southward to Kern County, California.

Hooper (1944:74) considered San Francisco Bay a possible barrier to northward movement of *P. californicus*, suggesting that "unknown factors associated with latitude may define the northern limits of this species. . . ." Merritt (1974) studied local distribution near its northern limits, and indicated possible limiting factors (see section on Ecology). Altitudinal range is from sea level to 2440 m (8000 feet)——Grinnell and Swarth, 1913:344; Grinnell and Orr, 1934; Hall and Kelson, 1959.

FOSSIL RECORD. A brief review of the fossil record of *P. californicus* was provided by Hibbard (1968). The earliest record is from the McKittrick local fauna (late Quaternary), Kern County, California (Schultz, 1938:208). Approximately 100 left lower jaws and nearly 90 right lower jaws were examined; identification was provisional. Wolff (1971, 1973) reported remains of *P. californicus* from the late Pleistocene (Rancholabrean) Montezuma formation at Rodeo, California. Paleoecological data sug-

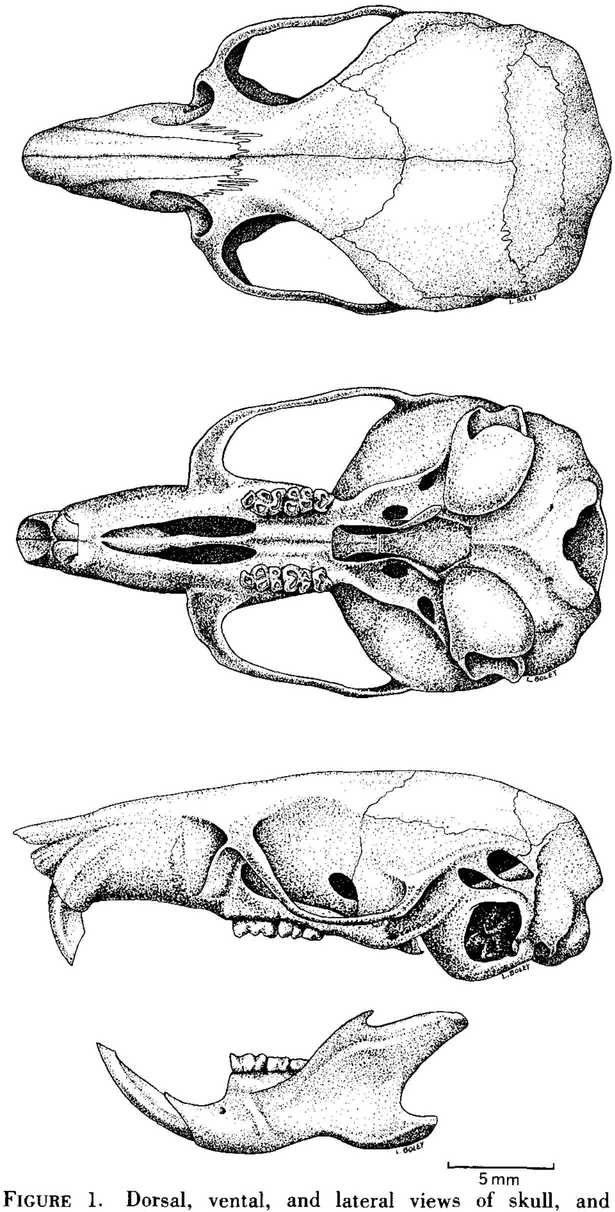

FIGURE 1. Dorsal, vental, and lateral views of skull, and lateral view of lower jaw of *Peromyscus californicus insignis*, CU 9393, female, from Pasadena, California. Collected by J. Grinnell, 1904.

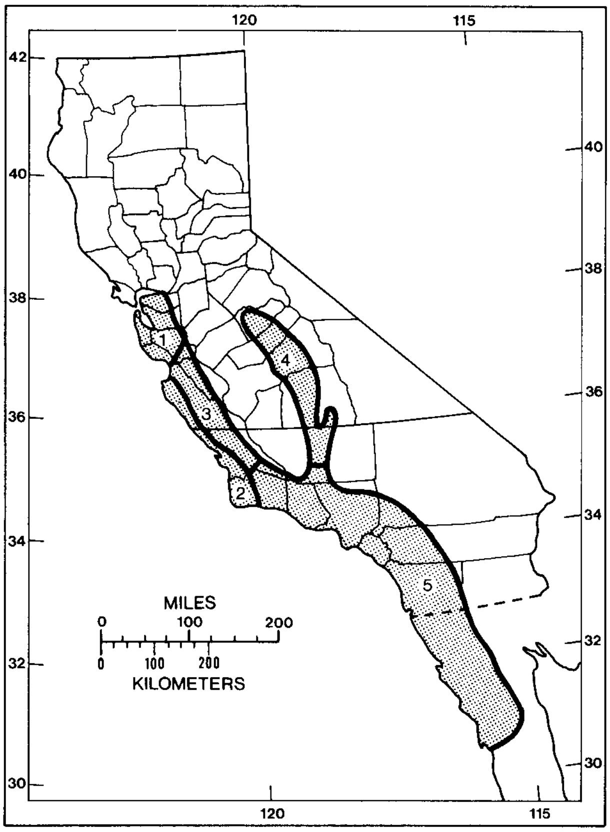

FIGURE 2. Geographic distribution of *Peromyscus californicus* in California and Baja California. 1, *P. c. parasiticus*; 2, *P. c. californicus*; 3, *P. c. benitoensis*; 4, *P. c. mariposae*; 5, *P. c. insignis*.

gested that *P. californicus* inhabited the margins of the chaparral. The California mouse is not yet known from Rancho La Brea, but some rodents from the deposit remain unidentified.

FORM AND FUNCTION. A brief review of some aspects of gross anatomy was provided by Klingener (1968). The following pelage changes have been described: Osgood (1909:236) suggested that two molts occur per year, one in early summer and another in late autumn. Collins (1923) indicated that three pelage phases were typical of *P. californicus*, juvenal, postjuvenal or subadult, and adult; these phases agree with those outlined by McCabe and Blanchard (1950). Layne (1968) reviewed developmental molt in *P. californicus*.

Doty and Kart (1972:94) reported only slight development of midventral sebaceous glands; two females, 201 days of age, had glands about 13 by 1 mm. Eight males showed no evidence of these glands. Rinker (1960:276) reported the presence of an entepicondylar foramen. Cranial foramina were studied by Hill (1935: 121). Body, brain, and lens weights of *P. c. parasiticus* were compared by King (1965:180) with these weights for other species of *Peromyscus*. McCabe and Blanchard (1950:29) supplied data on weights of gonads and accessory sexual glands.

In stomach morphology, Vorontsov (1957) described an incipient three-chambered stomach in *P. californicus*, whereas Carleton (1973:20) found a typical bilocular arrangement. The difference may have been due to contraction of the antrum at the time of preservation in Vorontsov's study. Functional implications of stomach morphology were discussed by both authors.

The structure of spermatozoa of *P. californicus* includes a short and wide sperm head with the recurved hook extending about halfway down the side of the head, a wide base, and a very short midpiece attached on the side of the head on which the hook is located. The sperm was the shortest of any of the 27 species and seven subgenera of *Peromyscus* studied; the mean length was 72.0 microns (Linzey and Layne, 1974:19; illustrations and measurements were given also by Hirth, 1960). Linzey and Layne (1969) also described the male reproductive tract. A full complement of accessory glands is present. The proportions and size of genital organs of *P. californicus* are similar to those of other species of the genus *Peromyscus*, but the *ductus deferens* is short. The bulb of the penis is not bifurcate, and the vesiculars are not as recurved as in *P. eremicus*. Two pairs of ventral prostates are of the same size, with medial members having two ducts, and lateral, four. Preputial glands are very large, measuring 10 by 2 mm; these glands may function in marking objects and conserving water (Eisenberg, 1962).

Brown and Welser (1968:423) determined albumin mobility by starch-gel electrophoresis, and suggested that, "there is no apparent relationship between the serum albumin mobilities of those species of *Peromyscus* studied and accepted phylogenetic arrangements of the species within the genus. . . ." Peterson (1968:146) examined blood-serum proteins by disc-electrophoresis using mice from the same vicinity as the above study. He concluded that blood-serum patterns generally supported existing taxonomic arrangements (Osgood, 1909; Hooper and Musser, 1964) based on other morphological criteria. Brand and Ryckman (1969:508) examined blood serum proteins of *P. c. insignis* by cellulose acetate strip electrophoresis. The pattern was distinctive among the species of *Peromyscus* studied. High concentrations of plasma 11-hydroxycorticosteroid following electrical shock were found in the California mouse by Treiman and Levine (1969). Further work with adrenal steroid biosynthesis was conducted by Ogunsua *et al.* (1971), who found that adrenals from *P. californicus* formed corticosterone as a major endogenous end product *in vitro* and no cortisol was detected.

Metabolism of a laboratory stock of *P. californicus* was studied by McNab (1963) and McNab and Morrison (1963), and reviewed by Hock (1969) and Hart (1971:29,79). Mean basal metabolic rate in *P. c. parasiticus* is 1170 ± 30 mm^3 (1.17 ± 0.03 cc) O$_2$/g/hr; in *P. c. insignis* it is 1030 ± 20 mm^3 (1.03 ± 0.02 cc) O$_2$/g/hr (McNab and Morrison, 1963:66). The California mouse was compared to other species of *Peromyscus* inhabiting different habitats in roughly the same climatic zone. Of the species examined, *P. californicus* demonstrated the lowest basal metabolic rate and lowest thermal conductance, both attributable to its large size. Also, surface-to-mass ratio was lowest and pelage thickest. Body temperature increased when ambient temperature was high. The thermoneutral zone showed the lowest lower critical temperature and a high upper critical temperature. The lower and upper critical temperatures for *P. c. parasiticus* and *P. c. insignis* are 27.0 to 34.5°C and 28.0 to 34.5°C, respectively (McNab and Morrison, 1963:74). McNab (1963) outlined an energy budget for the California mouse. Morhardt and Morhardt (1971) correlated heart rate, via radiotelemetry, and oxygen consumption, via a paramagnetic oxygen analyzer. MacMillen (1964) and Merritt (1974) investigated water relations in the California mouse. Mean water consumption by *P. c. insignis* was approximately 120 mm^3 (0.12 ml)/g/day (calculated by King, 1968:39 from data graphed by MacMillen, 1964:39). This rate corresponds closely with that determined by Merritt (1974:109) for *P. c. parasiticus*, 110 mm^3 (0.11 ml)/g/day. Compared with other rodents studied, the California mouse has relatively poor physiologic mechanisms for maintaining internal water balance (MacMillen, 1964).

Hatton and Johnson (1970) and Hatton *et al.* (1972) compared quantitative relationships of supraoptic cells in *P. californicus* from a mesic habitat and *P. eremicus* from a desert habitat. The latter species had a greater number of supraoptic cells than the former. These cells produce anti-diuretic hormone (ADH), which aids in water conservation.

ONTOGENY AND REPRODUCTION. Svihla (1932) and McCabe and Blanchard (1950) have contributed much to our knowledge of reproduction in the California mouse, and Layne (1968) and Terman (1968) have reviewed these and other studies. The gestation period for laboratory stock of *P. californicus* ranges from 21 to 25 days (mean, 23.6, according to Svihla, 1932). Data on litter size and other reproductive strategies for laboratory stock and wild-conceived animals were given by the above authors and also by MacMillen (1964), Rood (1966), and Drickamer and Vestal (1973). Means ranged from 1.87 to 2.5 young per litter (table 1). Unusual fecundity and longevity records were reported by Egoscue *et al.* (1970) for laboratory stock. From examination of 506 litters, a maximum of 87 young per lifetime was determined.

McCabe and Blanchard (1950) suggested that *P. californicus* breeds seasonally near Berkeley. Studies by Drickamer and Vestal (1973) in the laboratory, however, indicated no seasonality and reproduction was not correlated with day length. Mean litter size showed a gradual increase through the reproductive life span, changing from 1.8 to 2.3 young per litter. Svihla (1932) and McCabe and Blanchard (1950) suggested that this mouse is polyestrous and has no postpartum heat, differing from most other species of *Peromyscus* in this respect. Svihla (1932:31) found that *P. californicus* commonly has as many as six litters per year, the usual number of young per litter being two, and the total young per year being about 12. McCabe and Blanchard (1950) reported that the average number of litters per year is 3.25, and the mean young per litter is about 1.9 (combined laboratory and field data); therefore, approximately 6.2 young are produced annually. By contrast, Rood (1966) studied repro-

TABLE 1. Litter sizes of *Peromyscus californicus*.

Taxon	N (liters)	Litter size Mean	Litter size Range	Source
P. c. californicus	15	1.8	1 to 3	Svihla, 1932
P. c. parasiticus	34	1.79	—	McCabe and Blanchard, 1950
P. c. parasiticus	19	2.11*	—	McCabe and Blanchard, 1950
P. c. parasiticus	27	1.99	1 to 3	Rood, 1966
P. c. parasiticus	493	1.9	—	Drickamer and Vestal, 1973
P. c. insignis	6	2.5*	2 to 4	MacMillen, 1964

* wild-conceived

ductive performance in the laboratory. He suggested (assuming lactation anestrus) that a postpartum estrus must occur in some females of *P. californicus* and that the average number of young born per year to breeding females is 15 (Rood, 1966: 502), which approximates Svihla's (1932) findings. Preliminary data (Dewsbury, 1974) indicate that *P. californicus* has a short estrous cycle of about seven days. Smith and McGinnis (1968) described relationships between mean litter size, mean production of offspring, latitude, altitude and body size (data from McCabe and Blanchard, 1950). Summarizing reproductive patterns in *Peromyscus*, Rood (1966) contended that species with a low reproductive potential (for example, *P. floridanus* and *P. californicus*) ". . . may maintain their numbers when exposed to invasions of the subgenus *Peromyscus* in part because they tend to be highly specialized to a particular ecological niche." Specialization in food habits has been shown by Meserve (1972) and more recently by Merritt (1974). McCabe and Blanchard (1950) showed that the lower reproductive capacity of this mouse is offset by its greater longevity. McCabe and Blanchard (1950: 113) estimated average ecological life-span as about nine months, although Merritt (unpublished data) recaptured animals after 18 months, suggesting a longer ecological life-span than published data indicate. Egoscue *et al.* (1970) found the maximum age of females at birth of the last litter to be 42 months in a laboratory stock of *P. c. insignis*.

No information is available on embryonic development of the California mouse, but postnatal development and growth were described by Svihla (1932) and McCabe and Blanchard (1950), and reviewed by Layne (1968). Postnatal development was followed closely by McCabe and Blanchard (1950) in *P. californicus*, *P. truei*, and *P. maniculatus*. Young *P. californicus* are more precocial than the young of other species of *Peromyscus* studied. Neonates were heavily pigmented dorsally (most *Peromyscus* are pinkish or flesh-colored above and below—Layne, 1968:173). Vibrissae of newborn were the longest (4.25 mm) of the three species studied by McCabe and Blanchard (1950). Pinnae opened as early as hour 6 after birth, and were erect by hour 24; most species of *Peromyscus* exhibit eruption of pinnae at hours 72 to 96. In addition, the California mouse attained almost fully separated front and hind digits at day 7, and was more advanced in development of pelage and also in motor coordination than other species. The opening of the eyes occurs on day 13 or 14 (Svihla, 1932); this also is somewhat precocial (Layne, 1968:177). However, at week 3, *P. californicus* begins to fall behind other species (McCabe and Blanchard, 1950). Layne (1968:244) summarized data on selected characteristics of growth and suggested that the precocity of *P. californicus* is an adaptation to conserve water and energy, advantageous in a xeric habitat where favorable conditions for reproduction are dependent on highly variable rainfall and food production.

Lactation is prolonged. Svihla (1932) found one litter of *P. californicus* that was not weaned until day 44 and McCabe and Blanchard (1950) reported young weaned at about week 5. The growth curve is similar to that of other species of *Peromyscus*, but weights are 40% greater (Layne, 1968:221). Sexual development is slow; females first show slightly perforate vulva at week 11 (McCabe and Blanchard, 1950).

BEHAVIOR. Excellent reviews of various aspects of comparative behavior in *Peromyscus* are found in King (1968). Within this source Layne (p. 148) discussed behavioral development, Eisenberg (p. 451) presented an ethogram as an analysis of behavior and King (p. 496) provided quantitative analyses of particular behavioral patterns. For comprehensive behavioral studies of this species, see McCabe and Blanchard (1950), Eisenberg (1962, 1963), and King *et al.* (1968).

Eisenberg (1962, 1963) combined his laboratory data with field and laboratory data from Svihla (1932) and McCabe and Blanchard (1950) to provide a picture of the social organization of *P. californicus*. Males are aggressive toward one another, and employ a unique fighting technique characterized by much jumping and avoidance, accompanied by a mewing cry thought to inhibit aggressive behavior of another individual. This behavior may be of selective advantage in forming bisexual groups of adults with minimal injury to participants. *Peromyscus californicus* is more strongly territorial than *P. maniculatus* and both males and females defend the nest site. MacMillen (1964) found *P. californicus* socially compatible in intraspecific encounters in the laboratory, but intolerant in encounters with *Dipodomys agilis*. Intraspecific behavior of *P. californicus* was contrasted with that of three other species of *Peromyscus* by Eisenberg (1963). He showed that females of *P. californicus* exhibit a pronounced nest site attachment and defense, but other agonistic behavior was confined to males.

Various motor patterns have been studied in a comparative fashion: geotactic orientation (Clark, 1936); locomotion, activity in the nest, washing, elimination, nest building, feeding and hoarding (Eisenberg, 1962); and swimming, running, climbing, digging and gnawing (Clark, 1936; McCabe and Blanchard, 1950; King *et al.*, 1968). McCabe and Blanchard (1950) suggested that, of the three species of *Peromyscus* studied, *P. truei* was the best climber, *P. californicus* was next, and *P. maniculatus* did not climb at all. The California mouse was categorized as semi-arboreal by Clark (1936). King *et al.* (1968) indicated that it is advanced in gnawing ability, but McCabe and Blanchard reported that it could enlarge holes or cracks in hollow logs, but was unable to start a hole in solid material. King *et al.* (1968) found it to be an inept digger and it has never been observed entering holes in the ground (McCabe and Blanchard, 1950:20).

Speed of predatory attack was studied in the laboratory by Thomas and Fried (1971). They reported that *P. californicus* was slower and more variable than *Mus musculus* and *Onychomys torridus* in attacking and consuming live house crickets and would leave a partly eaten cricket for several minutes before returning to it.

Dewsbury (1972, 1974) described copulatory behavior in *P. californicus*, unique among muroids studied. Maternal behavior was studied by McCabe and Blanchard (1950) and Eisenberg (1962) and was reviewed by King (1963) and Layne (1968). Suckling young tend to cling to nipples continuously and can be dislodged only with much difficulty.

The presence and importance of paternal care in the California mouse was studied by Dudley (1973, 1974*a*, 1974*b*). Parental behavior was observed in the laboratory and the male and female were shown to spend equal amounts of time with pups, indicating a male role in the caring for young. McCabe and Blanchard (1950), Eisenberg (1962), and Dudley (1973) have shown that this species lives in pairs in nature, even during parturition and lactation. Eisenberg (1963:245) found prolonged pair bonds. Dudley (1974*a*) showed that the male provided additional heat, promoting weight gain in pups.

Aspects of communication in the California mouse have been studied by various workers (McCabe and Blanchard, 1950; Eisenberg, 1962, 1968; Smith, 1965; Rahmann *et al.*, 1968; Huff, 1973). Newborn mice have a versatile vocal repertoire consisting of ". . . minute shrieks, chirpings, chucklings made with convulsive efforts" (McCabe and Blanchard, 1950:31).

Eisenberg (1968) analyzed the physical characteristics of two types of abandoned (distress) cries. More recently, Huff (1973) analyzed the "distress" cry of infant *P. californicus*, suggesting that these cries act to draw attention to the pup while carrying information on species identity, age, and location. Eisenberg (1962:204) indicated that complex vocal communication exists in *P. californicus*, a correlate of highly developed social organization.

Smith (1965) tested behavioral discrimination in *P. californicus* in the laboratory, suggesting that olfactory and auditory stimuli, not visual cues, permit recognition of species, sex, and reproductive condition. Visual range and acuity was studied by Rahmann *et al.* (1968:311). Contrasted with five other species of *Peromyscus*, *P. californicus* exhibited the greatest maximum visual range (VR = 0.11 m) and a small minimum visual angle (VA = 38′).

Few studies have considered activity patterns of the California mouse. Behavioral rhythmicity has been shown in male *P. californicus* in the laboratory by Kavanau and Rischer (1968). Owings and Lockard (1971) studied activity patterns of *P. californicus* and *P. eremicus* in terms of a possible temporal dimension to competitive exclusion. The amount of nightly wheel-running of *P. californicus* was correlated negatively with duration of simulated moonlight; conversely, *P. eremicus* was most active on moonlit nights. However, they suggested that temporal exclusion alone is not sufficient to eliminate competition.

Recent studies by Marten (1970, 1972, 1973) correlated weather and patterns of activity near Berkeley. *P. californicus* was shown to be active periodically throughout the night, but exhibited a burst of activity shortly before dawn. Fluctuations occured night-to-night with a prominent periodicity of about four days. Peak activity of *P. californicus* did not correspond to weather patterns.

The nest of *P. californicus* is complex, commonly found under debris such as fallen logs. Nests are composed of coarse dry grasses, weeds and sticks and may ". . . consist of masses up to a bushel in bulk, though usually of less than half that size . . ." (McCabe and Blanchard, 1950:22). The center is a chamber lined with fine grasses. The nest is defended actively and is occupied for prolonged periods of time. Caching behavior was observed by Streator (1931).

ECOLOGY. Early accounts of habitats and habits (Gambel, 1848; Baird, 1857; Thomas, 1894; Rhoads, 1895; Allen, 1896; Elliot, 1903; Stephens, 1906; Grinnell and Swarth, 1913; Taylor, 1919) provided valuable baseline data for understanding the ecology of *P. californicus*. Other studies have detailed ecological distribution. It has been reported from chaparral and oak woodland near Berkeley (McCabe and Blanchard, 1950; Cook, 1959; Marten, 1970, 1972, 1973), mesic laurel and redwood forests of the Santa Cruz Mountains (Streator, 1931; Rudd, 1948; Merritt, 1974), and chaparral of Monterey County (Linsdale and Tevis, 1951) and the Sierra Nevada foothills (Lawrence, 1966). It also occurs in chaparral and coastal sage scrub communities of southern California (Vaughan, 1954; Murray, 1957*a*; MacMillen, 1964; M'Closkey, 1970, 1972; Meserve, 1972, 1974), and was trapped in coniferous woodland and chaparral situations by Pequegnat (1951) and Ryan (1968). At its southern limit in Baja California, it is found on brush-covered slopes (Huey, 1964).

Throughout much of its range the California mouse is associated with the large surface dens of *Neotoma fuscipes* (Baird, 1857; Elliot, 1903; Gander, 1919; Vestal, 1937, 1938; Rudd, 1948; Linsdale and Tevis, 1951; Pequegnat, 1951; Merritt, 1974). Baird (1857:479) reported that *P. californicus* inhabited nests of *N. fuscipes* in Santa Clara Valley, and found that ". . . on setting fire to these nests both species rush out together." Later, Gander (1929:54) examined approximately 100 dens of *N. fuscipes* in southern California and found California mice frequently in abandoned dens. Pequegnat (1951) studied *P. californicus* in the Santa Ana Mountains of southern California, and suggested that *P. californicus* is associated closely with woodrats, even occupying the same houses (Pequegnat, 1951: 54). Density estimates of *P. c. insignis* averaged 10.75 animals per acre (26.55 per ha) in the chaparral and only 3.75 animals per acre (9.26 per ha) in other communities; these trends paralleled closely the densities of *Neotoma* (Pequegnat, 1951: 83). More recently, Merritt (1974) encountered high densities (42 animals per acre, or 104 per ha) of the California mouse in a mesic study area in the Santa Cruz Mountains predominated by California laurel (*Umbellularia californica*). Densities correlated well with the frequency of *Umbellularia* and the dens of *N. fuscipes*. His data suggested a positive relationship between *P. californicus* and dens of *Neotoma*, and indicated that the former may utilize the periphery of the den.

There is a paucity of information on population dynamics of the California mouse. Most work is from the coastal sage scrub community of southern California (Pequegnat, 1951; MacMillen, 1964; M'Closkey, 1970, 1972; Meserve, 1972, 1974; Glanz, personal communication); McCabe and Blanchard (1950) and Merritt (1974) provided data from areas near the northern limit of the range. Pequegnat (1951:83) indicated that the peak breeding period is in spring, but some young are produced year-round. He contended that "it is the most abundant rodent on this range."

Monthly population estimates for *P. c. insignis* (derived from mark-recapture studies) showed a high of 0.8 animals per acre (1.9 per ha) in January to a low of zero in June and July (MacMillen, 1964:36) on a 6.7 acre (2.7 ha) quadrat. *P. californicus* was the least abundant small mammal with the exception of *N. fuscipes*. M'Closkey (1972:666) calculated population trends by Jolly's stochastic model and trap-revealed census which indicated that *P. c. insignis* was ". . . not a usual inhabitant of the *Eriogonum-Artemisia* scrub community." Eight California mice were trapped in his 3.08 ha study plot—an estimated density of 2.59 per ha—and displayed a mean duration of residence of 1.8 months. He suggested that the transient status of this mouse was attributable to immigration. Meserve (1972, 1974) studied the ecology of the California mouse on the same site as M'Closkey (1972) in an effort to elucidate aspects of resource and habitat utilization, employing a six-acre (2.4 ha) live-trapping grid and methods of censusing similar to M'Closkey's. Meserve (1972, 1974) found a trend from one animal in February to a maximum of 28 individuals during July, and estimated density from 0.4 to 11.7 per ha (Meserve, 1974:837). Immigration occurred in two separate groups during his 13 month study; mean duration of residence was 3.2 months. He attributed increased numbers in spring to immigration of *P. californicus* from an adjacent canyon where they were found year-round. Differing opinions were presented by M'Closkey (1972:666) and Meserve (1974:839) to account for immigration; the former contended that unusually heavy seasonal rain, causing damage to nests located in washes, precipitated movement into the well-drained study plot, whereas the latter attributed immigration to "population pressures generated by year-around reproduction in the canyons."

Additional data on demography were supplied by McCabe and Blanchard (1950:105), who captured 23 animals within one year in an area of some 26 acres (an estimated density of 0.9 animals per acre, 2.2 per ha). Glanz (personal communication) estimated populations of *P. californicus* from live- and snap-trapping data in southern California. Numbers ranged from a low of 1.5 per ha in summer to a high of 24 per ha in spring. Trapping was performed over a period of two years.

Data on home ranges in the California mouse are scarce, available for southern California only. MacMillen (1964:26) determined home range employing the exclusive boundary strip method (Stickel, 1954), for six individuals (four males, two females). Mean home ranges for both sexes was 0.37 acres (0.15 ha); those of males were slightly larger than home ranges of females. Meserve (1972) examined the vertical component in spacial distribution. Tracking data revealed considerable arboreal behavior, primarily on three shrubs in the coastal sage scrub community; this behavior may be important in preventing competition with other cricetids.

Food habits have been examined by fecal analysis (Meserve, 1972) and stomach analysis (Merritt, 1974); both augmented by laboratory feeding experiments. Meserve (1972) found the California mouse to be a strong specialist on shrub fruits, seeds, and flowers. A large portion of the diet constituted *Rhus integrifolia*, *Lotus scoparius*, and *Salva apiana* during months of availability. Other foods found periodically were grasses, forbs, fungi, and arthropods. Merritt (1974:108) showed that seeds of California laurel constituted a principal staple in the diet of *P. c. parasiticus*. Other important food items were unidentified leaf fragments, fungi, endosperm, and smaller quantities of berries, arthropods, and herbaceous stems. Similarly, Glanz (personal communication) found seeds a major food of *P. californicus* taken in southern California.

Ecologists have studied water relations, food requirements, and relationships of *P. californicus* to the dens of *N. fuscipes* to elucidate habitat requirements of this mouse. Population estimates coupled with data on habitat preference for moist situations (Merritt, 1974; Meserve, 1974) and critical nutritional and shelter requirements have partially delimited the range of tolerance of the California mouse.

Two studies have addressed themselves to the subject of fire and its effect on distributions of *P. californicus* (Cook, 1959; Lawrence, 1966). Data show a species shift from brush-inhabiting *P. californicus* and *P. truei* to grassland-inhabiting *P. maniculatus* following a fire.

There are few accounts of predation on the California mouse. Vestal (1937) noted weasel predation on a group of *Neotoma* dens near Berkeley. Within these dens he found remains of *P. californicus* as well as *Neotoma*. Barn owl pellets from San Benito County contained skeletal remains of six *P. c. benitoensis* (Von Bloeker, 1937). McCabe and Blanchard (1950) thought predation not to contribute greatly to population changes in *P. californicus*.

An excellent review of parasites of the California mouse was published by Whitaker (1968), and a more recent paper discussed parasitic and phoretic mites (Whitaker and Wilson, 1974). Murray (1957*b*) discussed the relationship of fleas and the California mouse in a zone of epizootic plague in San Mateo County. Two intestinal protozoan parasites (Eimeriidae) were described by Davis (1967) from *P. californicus* taken in Monterey County. Additional work on protozoan parasites was conducted in southern California by Van Peenen and Duncan (1968), who found piroplasms (Protozoa: Sarcodina) in the blood of *P. californicus* and other small mammals on various military reservations. More recently, Wrenn and Loomis (1973) described a new species of *Euschoengastia* (Acarina: Trombiculidae) from *P. californicus* in San Diego County.

GENETICS. The first published data on chromosomes of *P. californicus* were provided by Cross (1938). Two subspecies (*P. c. insignis*, *P. c. californicus*) were studied and assigned the diploid number of 48. Cross (1938:410) diagrammed karyotypes for *P. c. insignis*, and stated that "pairs of large V- and J-shaped elements are always found" and the remaining ones are ". . . rod-like forming a graded series as to length."

More recently, Hsu and Arrighi (1968:422) provided karyotypes and descriptions of chromosomes of *P. c. insignis* and *P. c. parasiticus*. The karyotype consisted ". . . of pairs A_1, A_2, B_1 and B_2 and 19 pairs of acrocentrics"; the X chromosome was submetacentric and the Y was about the same length as the X, but its centromere was more medially located.

Avise *et al.* (1974:233) described allozymic variation in proteins encoded by 25 loci in nine species of *Peromyscus* (subgenus *Haplomylomys*) from mainland and insular populations of western United States and Mexico. Three samples of *P. c. insignis* from southern California were genetically indistinguishable; biochemically, *P. californicus* could be distinguished readily from *P. eremicus*. A small laboratory stock of *P. c. parasiticus* showed a distinctive monomorphism at one locus.

REMARKS. The California mouse possesses several ecological and behavioral peculiarities. It is generally slow and passive with a decreased tendency to bite. In addition, it has long, dense, fine fur effective against cold, but ineffective in shedding water. Live-trapping studies of McCabe and Blanchard (1950) and Merritt (unpublished data) have found *P. californicus* to be completely soaked which resulted in high trap mortality.

I thank Dr. David M. Armstrong of the University of Colorado for reviewing this manuscript for publication.

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Principal editor of this account was SYDNEY ANDERSON.

J. F. MERRITT, DEPARTMENT OF BIOLOGICAL SCIENCES, OLD DOMINION UNIVERSITY, NORFOLK, VIRGINIA 23508.