

*Sorex vagrans*. By Scott W. Gillihan and Kerry R. Foresman

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*Sorex vagrans* Baird, 1857

Vagrant Shrew

- Sorex vagrans* Baird, 1857:15. Type locality “Shoalwater Bay, W.T.” = Willapa Bay, Pacific Co., Washington.
- Sorex suckleyi* Baird, 1857:18. Type locality “Steilacoom, W.T.” Pierce Co., Washington.
- Sorex dobsoni* Merriam, 1891:33. Type locality “Saw Tooth or Alturas Lake, Saw Tooth Mountains [Blaine Co.], Idaho.”
- Sorex amoenus* Merriam, 1895:69. Type locality “Mammoth Pass, head of Owens River, east slope Sierra Nevada, California” = near Mammoth, not Mammoth Pass, Mono Co. (Jackson 1928).
- Sorex nevadensis* Merriam, 1895:71. Type locality “Reese River, Nevada” at the border between Lander and Nye counties.
- Sorex shastensis* Merriam, 1899:87. Type locality “Wagon Camp, Mt. Shasta,” Siskiyou Co., California.
- Sorex halicoetes* Grinnell, 1913:183. Type locality “near Palo Alto, Santa Clara County, California.”
- Sorex trigonirostris* Jackson, 1922:264. Type locality “Ashland, altitude 1,975 feet, Jackson County, Oregon.”
- Sorex ornatus trigonirostris* Bailey, 1936:366. New name for *S. trigonirostris* Jackson, 1922.

**CONTEXT AND CONTENT.** Order Insectivora, family Soricidae, subfamily Soricinae, tribe Soricini, genus *Sorex*, subgenus *Otisorex* (Findley 1955; Repenning 1967). Junge and Hoffmann (1981) provide a key to North American *Sorex*. Hennings and Hoffmann (1977) recognized 5 subspecies of *S. vagrans*, but George and Smith (1991) subsumed *S. v. vancouverensis* into *S. v. vagrans*.

- S. v. halicoetes* Grinnell, 1913:183, see above.
- S. v. orizabae* Merriam, 1895:71. Type locality “Mount Orizaba, State of Puebla, Mexico.”
- S. v. paludivagus* von Bloeker, 1939:93. Type locality “Elkhorn Slough, Moss Landing, Monterey County, California.”
- S. v. vagrans* Baird, 1857:15, see above, *amoenus* Merriam, *dobsoni* Merriam, *nevadensis* Merriam, *shastensis* Merriam, *suckleyi* Baird, *trigonirostris* Jackson, and *vancouverensis* Merriam are synonyms.

**DIAGNOSIS.** *Sorex vagrans* (Fig. 1) is separated from other North American *Sorex* species by the combination of condylobasal length usually 15.5–17.5 mm and the 3rd unicuspid noticeably smaller than the 4th, apparent in lateral view (Fig. 2). The latter characteristic is shared with *S. longirostris*, *S. monticolus*, and *S. trowbridgii*.

Compared to *S. monticolus*, *S. vagrans* is generally smaller, with a shorter tail and smaller skull and teeth (van Zyll de Jong 1983). Pigmentation on I1 of *S. vagrans* extends no further than to dorsal limit of medial accessory cuspules, whereas pigmentation of *S. monticolus* extends above cuspules (Junge and Hoffmann 1981). Digits 2 through 4 on hind feet of *S. vagrans* possess 4 or less paired friction pads, whereas those of *S. monticolus* possess 5 or more pairs (van Zyll de Jong 1982), although this character may not be usable on dried specimens. *S. monticolus* and *S. vagrans* can be differentiated by discriminant analysis of 4 cranial measurements: least interorbital breadth, palatal length, width across I1–I1, and width across U4–U4 (Woodward 1994). Specimens from the zone of overlap in southwestern British Columbia are separable with discriminant function analysis, with the greatest contribution of the variance coming from the width across M2–M2 and across U4–U4 (George and Smith 1991).

On upper incisors, an unpigmented or lightly pigmented line often separates the cuspule from the body of the tooth; this line is absent in *S. longirostris* (Junge and Hoffman 1981). Compared to

that of *S. trowbridgii*, I1 of *S. vagrans* is straighter, with less divergence along medial edge, when viewed anteriorly. Least interorbital breadth is  $\geq 3.5$  mm in *S. trowbridgii* and  $< 3.5$  mm in *S. vagrans* (Carraway 1987). Tail of *S. trowbridgii* is distinctly bicolored, whereas that of adult *S. vagrans* is not.

**GENERAL CHARACTERS.** Dorsal pelage is gray to dark brown in interior populations, nearly black in some coastal populations. Ventral pelage is white to brown or gray. Tail of juveniles is distinctly bicolored, dark brown above and white below. Tail of adults is indistinctly bicolored, light to medium brown above and white below (Carraway 1990; Nagorsen 1996).

Of 20 measured characters of skull and body, 8 were significantly greater in males than females: greatest length of skull, cranial breadth, maxillary breadth, width across I1–I1, breadth of zygomatic plate, length of mandible, greatest condylar depth, and length of tail (Carraway 1990). However, least interorbital breadth and palatal length of females from British Columbia were significantly greater than for males (Woodward 1994).

Mean (and range) in millimeters of external and cranial measurements of 357 male and 401 female specimens, respectively, from California, Oregon, and Washington (Carraway 1990) are total length, 99.69 (83–128), 98.64 (80–130); length of tail, 40.52 (25–58), 39.68 (23–55); length of hind foot, 12.23 (10–18), 12.15 (10–18); greatest length of skull, 16.46 (15.46–19.34), 16.35 (14.93–19.50); cranial breadth, 8.16 (7.55–9.41), 8.08 (7.36–9.69); maxillary breadth, 4.68 (4.15–5.81), 4.64 (3.97–5.99); least interorbital breadth, 3.14 (2.81–4.12), 3.12 (2.67–3.91); length of mandible, 7.08 (6.43–8.43), 7.03 (6.29–8.81); and height of coronoid process, 3.66 (3.22–5.13), 3.64 (3.03–4.97). Mean mass (and range) in grams of *S. vagrans* from Oregon: subadult males 4.6 (3.5–6.1;  $n = 73$ ), adult males 6.3 (4.9–7.8;  $n = 42$ ), subadult females 4.4 (3.4–5.7;  $n = 64$ ), and adult females 5.5 (4.2–7.7;  $n = 48$ —Hooven et al. 1975).

**DISTRIBUTION.** *Sorex vagrans* ranges from southern British Columbia including Vancouver Island, east to southwestern Alberta (Smith 1988), south along the Pacific coast to central coastal California, throughout Oregon and Washington, western Montana, western and southern Idaho, northern and east-central Nevada, northern and extreme west-central Utah, and extreme western Wyoming (Fig. 3). *S. v. orizabae* occurs as an isolated relict at the southern end of the Mexican Plateau (Hennings and Hoffmann 1977).

**FOSSIL RECORD.** Middle Pleistocene fossils classified as *S. vagrans* have been recovered from Arkansas, New Mexico, and Texas (Kurtén and Anderson 1980), all outside the species' current range. Holocene fossils have come from Yellowstone National Park, Wyoming (Santucci 1998), just outside the current range. As paleontologists cannot distinguish among fossil remains from the sister



FIG. 1. Photograph of an adult *Sorex vagrans* from 50 km southwest of Missoula, Montana. Photograph by K. R. Foresman.

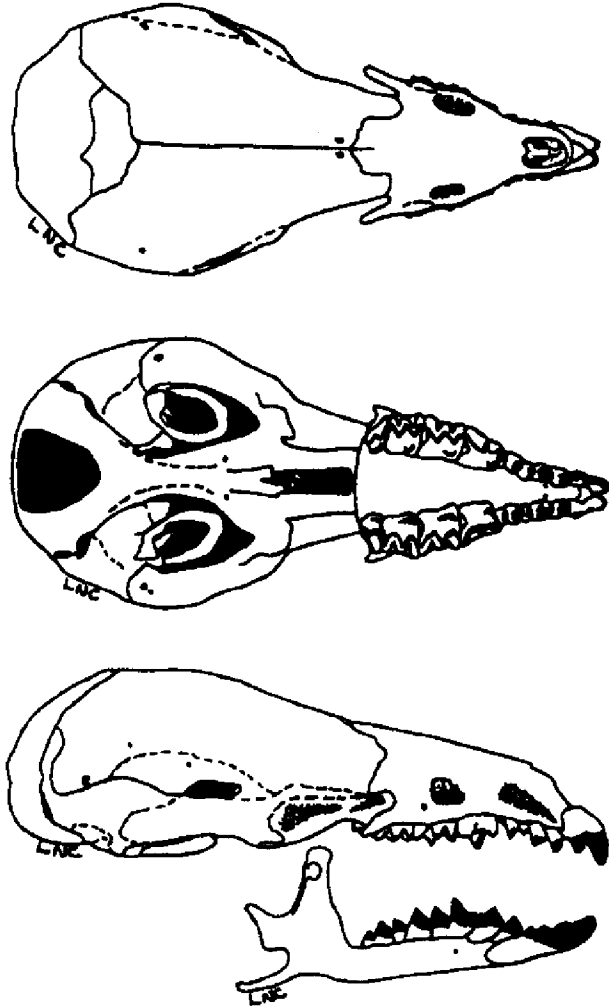


FIG. 2. Dorsal, ventral, and lateral views of cranium and lateral view of mandible of *Sorex vagrans* (OSUFW [Oregon State University Department of Fisheries and Wildlife] 8510). Reprinted with permission from Verts and Carraway (1998).

species *S. monticolus* and *S. pacificus* and *S. vagrans*, the fossils could represent any of these species (George 1988).

**FORM AND FUNCTION.** Individuals molt in fall, acquiring winter pelage late September to early October. Fall molt begins on the rump and progresses anteriorly, while a separate molt begins on snout and progresses posteriorly (Dalquest 1944). Overwintered adults molt in spring, with the molt beginning on the shoulder region and progressing outward. Dates for onset of spring molt are variable, with individuals in winter, summer, and intermediate pelages present in local populations concurrently (Dalquest 1944). A midsummer molt progresses in the same pattern as the spring molt (Dalquest 1944), although this may actually be the spring molt occurring late in the season (Findley 1955).

Bite force is less than expected by mandibular morphology (Carraway and Verts 1994) and increases with age due to increased masticatory muscle mass (Carraway et al. 1996). Dental formula is  $i\ 3/1, c\ 1/1, p\ 3/1, m\ 3/3$ , total 32 (Jackson 1928).

The basal metabolic rate of *Sorex vagrans* is  $5.41\ \text{ml O}_2\ \text{g}^{-1}\ \text{h}^{-1} \pm 0.19\ \text{SE}$  (Tomasi 1985). No evidence of torpor was found in winter-acclimatized individuals under energetic stress (Gillihan 1992).

**ONTOGENY AND REPRODUCTION.** *Sorex vagrans* may reproduce during its 1st summer (Foresman and Long 1998; Hooven et al. 1975). First-year animals that breed are born early in the season. Reproduction more typically occurs among overwintered adults, at 7–10 months. Occasionally, individuals may survive a 2nd winter and breed in their 2nd spring (Newman 1976). Re-

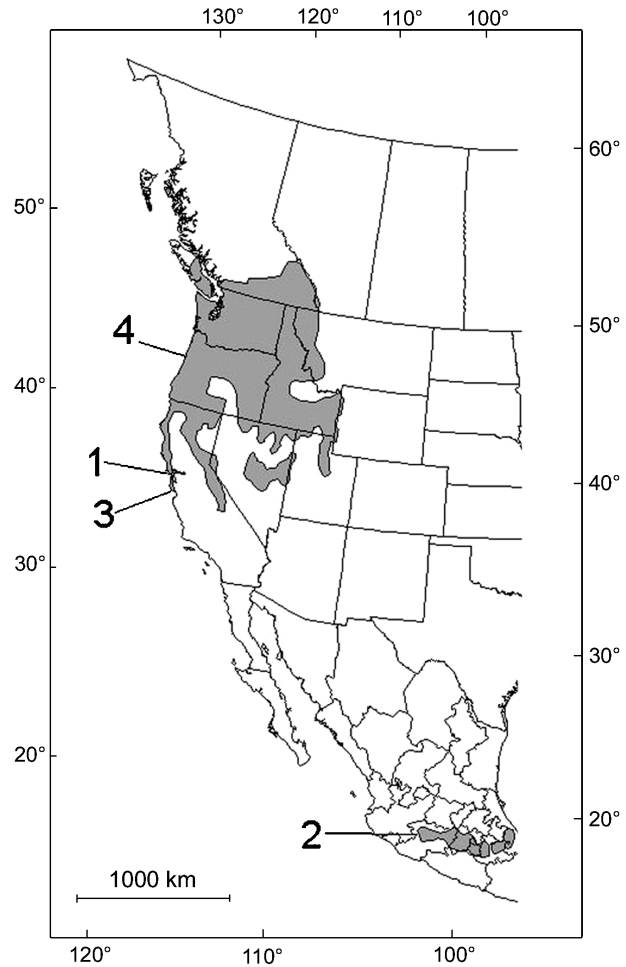


FIG. 3. Geographic distribution of *Sorex vagrans*: 1, *S. v. halicoetes*; 2, *S. v. orizabae*; 3, *S. v. paludivagus*; 4, *S. v. vagrans*. Redrawn from Hennings and Hoffmann (1977) and Junge and Hoffmann (1981), with modifications.

productive development in females, marked by increasing width of the uterine horns, begins in January (Hooven et al. 1975). In males, testicular enlargement begins in February and is complete by March, accompanied by development of scent glands on the flanks. Testes remain enlarged until at least August–September (Foresman and Long 1998). Conceptions and births are highest during April–June, declining markedly thereafter; births may occur as late as September (Foresman and Long 1998). Gestation is ca. 20 days (Johnston and Rudd 1957). Detailed embryological patterns have been described for *S. v. vagrans* demonstrating their very altricial state at birth (Foresman 1994). Births of *S. v. halicoetes* begin in February and continue until June, with most occurring in April, although a few occur as late as September (Johnston and Rudd 1957). Mean number of embryos in Montana was 6.5 (no range given;  $n = 15$ —Foresman and Long 1998), 6 in Oregon (range, 2–8;  $n = 18$ —Hooven et al. 1975), and 5.55 in California (no range or sample size given—Johnston and Rudd 1957). Mean litter size for young 1–2 weeks old was 4.74 (no sample size given—Johnston and Rudd 1957). Survival of young in 16 litters followed from shortly after birth to 3 weeks of age was 55–60% (Johnston and Rudd 1957). Among 17 litters produced in captivity, 17% of young died in the first 2 days; survival after 25 days was 49% (Hooven et al. 1975). Livetrapping of marked animals indicates that females may produce 3 litters per season (Hawes 1975). Advanced age does not preclude breeding, and females may produce litters until the end of their lives (Carraway and Verts 1999).

Young are born hairless, with eyes closed; by 2 weeks, dorsal pelage is present. Eyes open at 2–3 weeks; heavy pelage is present, and teeth have erupted by 3 weeks (Hooven et al. 1975; Johnston and Rudd 1957). Young are weaned at 16–25 days and stay in the

nest until as late as the 5th week after birth (Johnston and Rudd 1957).

Young vagrant shrews weigh ca. 0.35–0.50 g at birth, rapidly gaining mass until ca. 4 weeks of age, when they reach 5–6 g. By ca. 8 weeks of age, mass has dropped slightly to 4–5 g (Johnston and Rudd 1957). This mass is maintained until December–January in California (Rudd 1955). In other parts of the species' range, mass declines again during late summer and autumn, reaching its lowest point in December–January (Gillihan 1992). By February, rapid weight gain commences in concert with sexual maturation and onset of breeding (Gillihan 1992).

**ECOLOGY.** *Sorex vagrans* has been trapped in alpine tundra, bunchgrass, wet meadows, grassy meadows, riparian zones, swamps, bogs, forest openings, and coniferous forests including coastal Douglas-fir, coastal western hemlock, Engelmann spruce–subalpine fir, western red cedar, interior cedar–hemlock, interior Douglas-fir, mountain hemlock, montane spruce, or ponderosa pine. Preferred habitat may be moist, grassy areas; they are rarely found in closed forest (Nagorsen 1996). *S. v. halicoetes* inhabits salt marshes, where vegetation reaches 5–10 cm in height and driftwood is common, providing refugia for shrews and their prey during warm, dry weather (Johnston and Rudd 1957). In British Columbia, *S. vagrans* is generally found below 400 m elevation, although records exist for sites as high as 2,133 m (Nagorsen 1996).

*Sorex vagrans* was more common in clear-cut and burned deciduous forest than on control sites that were not cut or burned (Cole et al. 1998) but less common in clear-cut and burned coniferous forest than in either unburned clear-cut or untreated control sites (Hooven and Black 1976). *S. vagrans* was found more often in clear-cuts (<10 years old) and closed-canopy stands (30–80 years) than in either mature (80–195 years) or old-growth (195–450 years) stands; abundance was negatively correlated with number of logs in decay classes 4 and 5, moss cover, and litter depth (Corn et al. 1988). In coastal Washington, *S. vagrans* was significantly more abundant in areas with low amounts of coarse woody debris (Lee 1995). *S. vagrans* populations also fluctuated significantly more in areas with low amounts of coarse woody debris (Lee 1995). However, sites in Montana with *S. vagrans* contained significantly higher densities of fallen logs than sites with either *S. cinereus* or *S. monticolus*. Phosphorescent powder tracking revealed that *S. vagrans* makes extensive use of fallen logs as cover (McCracken 1990).

*Sorex vagrans* is more likely to be found in open, grassy areas than *S. monticolus* (Terry 1981) or *S. trowbridgii* (Hooven et al. 1975). *S. vagrans* may prefer less acidic soils than *S. monticolus* (Hawes 1977).

Average life expectancy in Washington was estimated as 6.6 months (Newman 1976); most individuals live a maximum of 16–17 months (Hawes 1977; Rudd 1955). Occasionally, individuals may survive a 2nd winter and reach at least 24 months. Mortality is highest among juveniles 2–4 months old and adults 12–15 months old (Newman 1976).

Diet of *S. vagrans* in grassy meadows in Oregon included (in declining order, by volume) earthworms, spiders, crickets, caterpillars, moths, slugs, snails, June beetles and larvae, ladybird beetles, centipedes, ants, *Endogone* fungi, flower parts, seeds, other vegetation, craneflies, harvestmen, aphids, moth cocoons, Hemipterans, grasshoppers, bees, wasps, and unidentified insects and insect larvae (Whitaker et al. 1983). In meadows subject to livestock grazing, *S. vagrans* consumed more flying invertebrates than in ungrazed meadows (Whitaker et al. 1983).

Captive individuals in feeding trials accepted tree seeds, including those of *Abies amabilis*, *A. procera*, *Picea sitchensis*, *Pinus monticola*, and *Pseudotsuga menziesii*; seeds of the *Abies* were not as readily eaten as seeds of other species (Hooven and Black 1976). Seeds and fruits of herbs and shrubs were also accepted. *S. vagrans* did not consume ripe fresh berries but did consume the same species when the berries had dried and shriveled. Mushrooms were sampled but not consumed. Other food items included lepidopteran pupae, maggots, other insect larvae, slug eggs (*Arion ater*), and sowbugs. Live-trapped individuals ate 15% of *P. menziesii* seed bait but could not be kept alive on those seeds alone in captivity (Hooven and Black 1976). A captive vagrant shrew (6.5 g) ate an average of 10.95 g of food per day (range, 4.2–12.3), equivalent to 1.68 times its body weight (Broadbooks 1939). Vagrant shrews have been maintained in captivity on a diet of com-

mercial canned baby food (meat varieties, without vegetables—Hooven et al. 1975), a mixture of commercial canned dog food and raw beef liver (Eisenberg 1964), and a 1:2 mixture of commercial canned and dried cat food, moistened with water and homogenized (Gillihan 1992). Supplemental foods included earthworms, mealworms, other invertebrates, and carcasses of small rodents and birds. Water can be supplied by spraying a fine mist on plants and other surfaces in the enclosure or by offering it in open dishes (Broadbooks 1939).

Predators of *S. vagrans* include barn owls (*Tyto alba*—Dawe et al. 1978), barred owls (*Strix varia*—Leder and Walters 1980), great gray owls (*Strix nebulosa*—Bull et al. 1989), great horned owls (*Bubo virginianus*—Martí and Kochert 1996), northern pygmy-owls (*Glucidium gnoma*—Holt and Leroux 1996), northern saw-whet owls (*Aegolius acadicus*—Holt and Leroux 1996), and bobcats (*Lynx rufus*—Toweill and Anthony 1988).

Endoparasites collected from *S. vagrans* include the intestinal fluke *Neoglyphe soricis* (Hendricks 1973) and tapeworms, including species of *Hymenolepis* and *Protogynella* (Vogel and Rausch 1955). Ectoparasites include fleas of the genera *Catallagia*, *Corrodopsylla*, *Corypsylla*, *Epitedia*, *Hystrichopsylla*, *Malariaeus*, *Megabothris*, *Nearctopsylla*, and *Peromyscopsylla* (Lewis et al. 1988) and mites of the genera *Alphalaelaps*, *Amorphacarus*, *Androlaelaps*, *Cyrtolaelaps*, *Eulaelaps*, *Euryparasitus*, *Haemogamasus*, *Hirstionyssus*, *Laelaps*, and *Protomyobia* (Whitaker et al. 1980). Heaviest ectoparasite loads occur in late summer (Newman 1976).

*Sorex vagrans* has been captured with pitfall traps (Foresman and Long 1998), snap traps (Carey and Johnson 1995), Sherman live-traps (Newman 1976), and Longworth live-traps (Hawes 1977). Individuals in live-traps or pitfalls can survive up to 2 h without bait but longer if food, such as mealworms, is provided. Live-trapped individuals can be marked by toe clipping (Hawes 1977).

**BEHAVIOR.** Home ranges are largest during the breeding season. Using an elliptical model, home range in British Columbia during the breeding season averaged 4,343 m<sup>2</sup> for males (no range given,  $n = 17$ ) and 2,233 m<sup>2</sup> for females (no range given,  $n = 18$ ); home range during the nonbreeding season (male and female combined) averaged 1,039 m<sup>2</sup> (no range given,  $n = 40$ —Hawes 1977). Using a minimum area method, home range (male and female combined) in western Washington averaged 316 m<sup>2</sup> (range, 55–678;  $n = 7$ ) in April and May, 235 m<sup>2</sup> (range, 29–580;  $n = 7$ ) in July and August, and 130 m<sup>2</sup> (range 27–203,  $n = 4$ ) in November (Newman 1976). Also, mean distance between captures of marked individuals on a trapping grid was greatest during spring (Newman 1976). Population densities range from 25.8 individuals/ha in late fall to early winter to 58.2/ha in summer (Newman 1976). First-year animals establish territories and defend them against conspecifics, possibly to enhance overwinter survival. Territories break down when spring breeding commences (Hawes 1977). Among captive individuals, onset of agonistic behavior toward conspecifics does not develop until the animals are ca. 3 months old, at which point individuals lead a solitary existence, coming together only briefly for mating (Eisenberg 1964).

Captive *S. vagrans* generally avoid one another. Nest defense occurs, in which intruders are driven away with a series of vocalizations and short charges. Physical battles are rare. Dominance ranks of subadults and adults vary (Eisenberg 1964; Hooven et al. 1975).

Captive individuals under simulated natural photoperiods are active throughout the 24-h cycle, with no clear peaks in activity, although nocturnal activity periods are longer (Gillihan 1992). Typical activity periods last 5–10 min, followed by slightly longer rest periods (Eisenberg 1964). Based on trapping results for free-ranging individuals, spring activity peaks shortly after nightfall, around dawn, and in late afternoon; summer activity peaks around midnight (Newman 1976).

*Sorex vagrans* builds 3 types of nests (Hooven et al. 1975; Jewett 1931; Johnston and Rudd 1957). The natal nest is a domed cup of dead vegetation (leaves and grass) and moss, lined with mammalian hair or fine grasses. Other materials such as paper and feathers may be incorporated. The dome is lost as the young grow. Outside dimensions vary, 6–24 cm across and 4–6 cm high. Cup dimension are 3–4 cm across and 2–3 cm deep. The resting nest is an open cup, 2–8 cm across and very shallow. The cold-weather nest is a round or oval domed structure, smaller than the natal nest.

Nests are constructed by grasping material in the mouth and arranging it below and to the side of the animal with rapid movements; the animals occasionally dig into the material and push it behind or to the side such that a dome may be formed (Eisenberg 1964). Nests are under woody debris or other cover.

When foraging or exploring, *S. vagrans* occasionally stands on its hind legs, twitching its snout in the air (Eisenberg 1964). When climbing twigs, the tail may be used in a semiprehensile fashion, wrapping it partially around the twigs for balance (Maser 1966).

Captive *S. vagrans* prey on earthworms by rapidly biting the worm several times, then retreating momentarily and repeating the biting attack. When the worm is subdued, the vagrant shrew begins feeding by biting and pulling off pieces from one end of the worm (Maser 1966). Excess food may be cached (Eisenberg 1964).

Vagrant shrews employ a crude form of echolocation, using low-intensity, high-frequency pulses to supplement olfactory or auditory clues and kinesthetic memory. Demonstrated limitations in their ability to discriminate objects suggest that echolocation is probably used to explore their surroundings rather than to locate prey (Buchler 1976).

Self-maintenance behaviors include scratching with hind feet and wiping the snout with the front paws. Licking is limited to the anal and genital area (Eisenberg 1964).

**GENETICS.** *Sorex vagrans* has  $2n = 54$  chromosomes, with some variation in autosomes among subspecies. FN varies from 58 to 64. Autosomes of *S. v. vagrans* are composed of 2 pairs of small metacentrics, 1 pair of dotlike metacentrics, 2 pairs of submetacentrics, and a graded series of 21 acrocentric pairs (Brown 1974).

**CONSERVATION STATUS.** In California, *S. v. haliocoetes* is classified as a "Species of Special Concern."

**REMARKS.** *Sorex vagrans* is also known as the wandering shrew. The genus name is from the Latin *sorex*, the genitive case of *soricis*, which means shrew; the specific epithet is from the Latin *vago*, which means to wander (van Zyll de Jong 1983).

Findley (1955) considered *S. vagrans* and *S. obscurus* (= *monticolus*) to be subspecies of *vagrans*. As a result, publications prior to Hennings and Hoffmann (1977) presented data on both *S. vagrans* and *S. monticolus* as though from *S. vagrans* only. The Central American relict *S. v. orizabae* is very similar to *S. oreopolus* (Junge and Hoffmann 1981).

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