Scapanus orarius. By Gregory D. Hartman and Terry L. Yates

Scapanus orarius (True, 1896)

Coast Mole

Scapanus orarius True, 1896:52. Type locality Shoalwater Bay (=Willapa Bay), Pacific County, Washington.

CONTEXT AND CONTENT. Order Insectivora, Family Talpidae, Subfamily Talpinae. Two subspecies of *S. orarius* are currently recognized (Yates, 1978):

S. o. orarius (True, 1896:52), see above.
S. o. schefferi (Jackson, 1915:63). Type locality Walla Walla, Walla Walla County, Washington (*yakimensis* Dalquest and Scheffer a synonym).

DIAGNOSIS. Total length less than 200 mm; tail less than one-fourth of total length. Greatest length of skull less than 40 mm; rostrum relatively narrow and long; sublacrimal-maxillary ridge not much developed; unicuspid teeth uncrowded and evenly spaced; mandible relatively weak.

GENERAL CHARACTERS. *Scapanus orarius* displays a variety of fossorial adaptations including a robust, depressed body, conoidal and depressed head, small eyes and auditory meatus concealed in the fur, and pelage that is easily moved in any direction. The velvet-like dark grey pelage lacks a distinct underfur, and hairs are of nearly equal length. The manus is highly modified for digging (Fig. 1); a sesamoid bone, the os falciforme, effectively widens the palmar surface of the manus. The os falciforme of *S. orarius* extends to the proximal end of the terminal phalange, and does not taper distally. Toes of the manus and pes are not webbed. As in all talpids, there is a humero-clavicular articulation that facilitates the lateral-thrust type of digging displayed by the animals.

The snout has its apical portion naked to the level of the anterior portion of the nasals; nostrils are directed superior, are crescentic, and have their concavities turned in laterally. The tail is fleshy, scantily haired, and tapers distally; there is a slight proximal constriction. There are eight mammae: two latero-pectoral, one latero-abdominal, and one inguinal on each side.

The skull of *S. orarius* (Fig. 2) is conoidal, flattened, and has a relatively broad braincase. Zygomata and audital bullae are complete; the latter are depressed. The frontal sinuses are somewhat swollen, and the mastoids are moderately heavy, although not particularly prominent. Anterior nares open forward with the anterior ends of the premaxillae extending beyond the edges of the nasals, forming a notch anterior to the nasals. There is a large, and roughly rectangular, interparietal present; it is slightly convex anteriorly, slightly concave posteriorly, and has a small posterior median projection.

The first upper incisor is long and broad (smaller than in *S. latimanus*), has a convex anterior surface, and is flat posteriorly. The second and third upper incisors, canine, and first three premolars are similar in form, simple and conical, although the third premolar may often possess a small postero-basal cusp. The upper molars are dilambdodont. In both the upper and lower molars, the first and second are subequal; the third is much smaller. Lower molars are M-shaped in transverse section; the first and second molars have a postero-internal basal accessory cusp, and the second and third molars each possess an antero-internal basal accessory cusp. The dental formula is i 3/3 c 1/1 p 4/4 m 3/3, total 44.

Males of *Scapanus orarius* average larger in size than females. The largest individuals are found in the easternmost portion of the range, and there is little clinal variation from north to south (Jackson, 1915; Yates, 1978).

Yates (1978) reported the following means and ranges (in parentheses) for measurements (in mm) of 35 adult male and 19 adult female *S. o. orarius* from northern California (measurements for males precede those for females): total length, 159.4 (136 to 190), 153.1 (133 to 168); tail length, 37.1 (30 to 45), 35.0 (21 to 46); length of hindfoot, 20.6 (16 to 24), 20.1 (15 to 22); greatest length of skull, 33.7 (32.5 to 35.1), 33.2 (32.1 to 34.2); basilar length, 28.2 (27.2 to 29.5), 27.9 (27.0 to 28.9); mastoid breadth, 16.1 (15.5 to 16.8), 15.9 (15.4 to 16.5); interorbital breadth, 7.8 (7.5 to 8.2), 7.8 (7.4 to 8.1); length of maxillary toothrow, 10.4 (9.8 to 10.9), 10.2 (9.5 to 10.6); length of palate, 14.2 (13.8 to 15.0), 14.0 (13.4 to 15.5); breadth across M2-M2, 8.5 (8.0 to 9.0), 8.4 (8.0 to 8.7); breadth across canines, 3.9 (3.6 to 4.2), 3.8 (3.5 to 4.0); depth of skull, 9.7 (9.2 to 10.5), 9.5 (8.8 to 10.1); breadth of mesopterygoid fossa, 4.0 (3.3 to 4.4), 3.9 (3.4 to 4.2).

Measurements of the type (adult male) for *S. o. schefferi* (Jackson, 1915) are: total length, 170; length of tail vertebrae, 35; length of hindfoot, 23; greatest length of skull, 34.7; palatilar length, 14.6; mastoid breadth, 16.7; interorbital breadth, 8.4; length of maxillary toothrow, 11.2; length of mandibular molar–premolar row, 10.9. External and cranial measurements of three adult male *S. o. schefferi* (including type) and cranial measurements of two adult females reported by Jackson (1915) from the type locality (males precede females; ranges in parentheses) are: total length, 168.7 (165 to 171); length of tail vertebrae, 34.7 (34 to 35); length of hindfoot, 23.0 (23.0); greatest length of skull, 34.4 (34.2 to 34.7), 32.9 (32.8 to 32.9); palatilar length, 14.4 (14.2 to 14.6), 13.7 (13.6 to 13.8); mastoid breadth, 16.4 (16.2 to 16.7), 15.9 (15.8 to 15.9); interorbital breadth, 8.3 (8.2 to 8.4), 8.2 (8.2); length of maxillary toothrow, 11.1 (11.0 to 11.2), 10.6 (10.6); length of mandibular molar–premolar row, 10.8 (10.8 to 10.9), 10.4 (10.3 to 10.5).

Compared with *S. o. orarius* to the west, *S. o. schefferi* is larger in size and lighter in color. Cranially, *orarius* differs from *schefferi* in shorter skull and less inflated maxillary region. *S. o. orarius* approaches *S. o. schefferi* in size only in the area of Puget Sound, Washington. Intergradation between *orarius* and *schefferi* appears to occur through Steven's Pass, Chelan Co., Washington (Yates, 1978).

Dalquest and Scheffer (1944) described a third subspecies, *S. o. yakimensis*, from central Washington based on six specimens which they considered to differ from *S. o. schefferi* in darker color, narrower skull, and longer pterygoids and interpterygoid fossae. Yates (1978) examined a series of *yakimensis* from Kittitas and

Fig. 1. Anterior lateral view of *Scapanus orarius*. Photo by Clyde M. Senger.
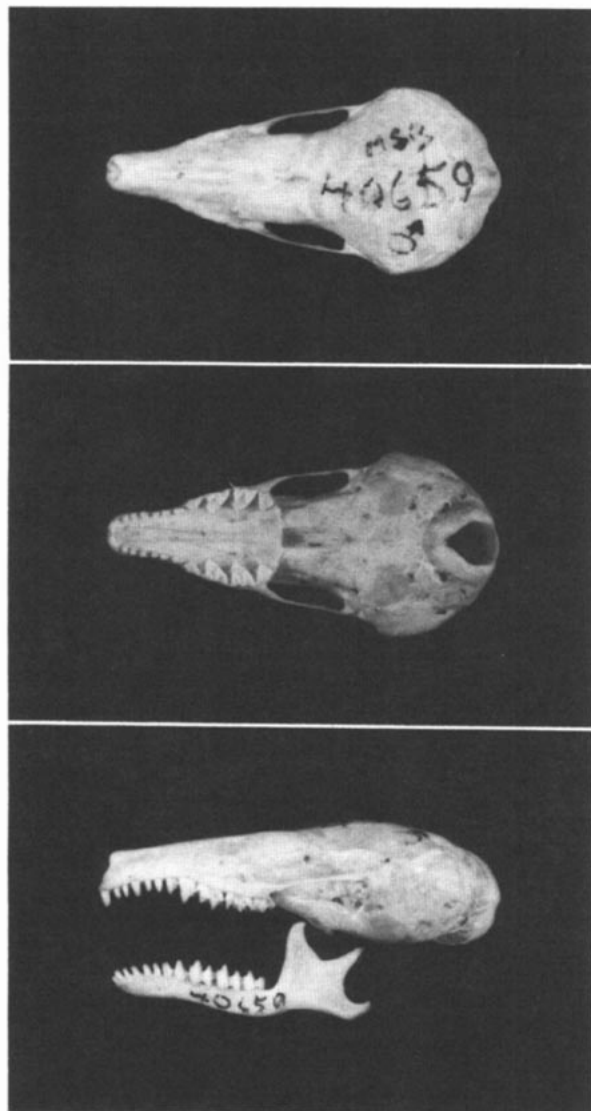
FIG. 2. Dorsal, ventral, and lateral views of cranium and lateral view of lower jaw of juvenile *Scapanus orarius orarius* (MSB 40659). Greatest length of skull is 32.3 mm.

FIG. 3. Geographic distribution of subspecies of *Scapanus orarius*: 1, *S. o. orarius*; 2, *S. o. schefferi*.

Yakima counties, Washington, and found few consistent differences between it and samples of *schefferi*, thus giving little justification to recognition of *yakimensis* as a distinct subspecies.

DISTRIBUTION. *Scapanus orarius* occurs from southwestern British Columbia south through the western portions of Washington and Oregon to coastal northwest California. It also is known to occur in parts of eastern Washington and Oregon and from one area of extreme west-central Idaho (Fig. 3).

FOSSIL RECORD. The earliest known fossils of the genus *Scapanus* are from the middle Pliocene (Hemphillian) of western North America (Hutchison, 1968). Based upon osteological evidence, Hutchison (1968) suggested that all species of *Scapanus* probably arose from the middle Miocene (Barstovian) species *Scapanoscapter simplicidens*. Hutchison also suggested that *S. orarius* may have diverged from *S. townsendii* during the late Pliocene (Blancan) or early Pleistocene.

FORM AND FUNCTION. The velvet-like texture of the pelage of *S. orarius* is in part related to a series of transverse vermiculations on each hair that are both structural and chromatic. Individual hairs consist of normally pigmented cylindrical sections approximately 1.0 to 2.0 mm long, alternating with finer flat (and unpigmented) sections 0.2 to 0.5 mm in length; the flat sections act as hinges upon which the hair bends, and allow the hair to be
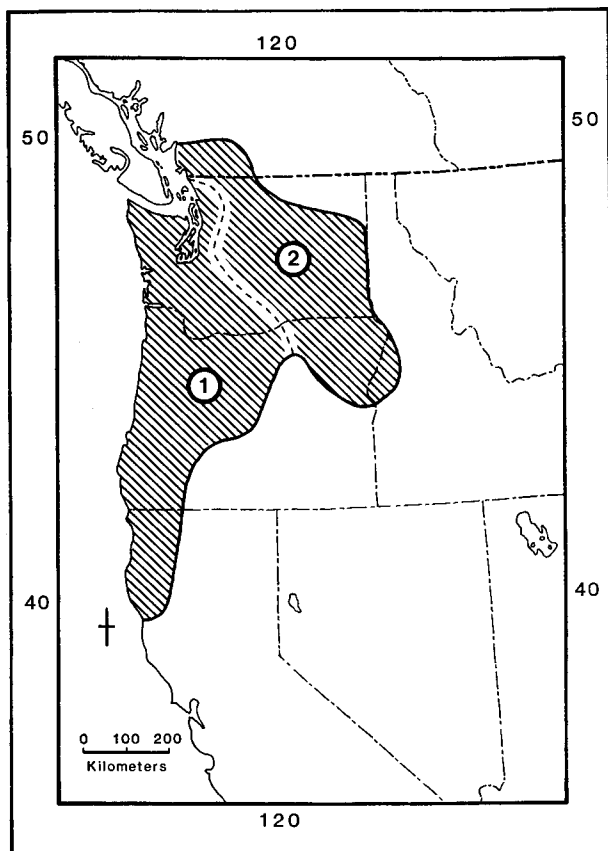
easily moved forward or backward. The vermiculations are more noticeable on the fur of the back, less so on the belly, and usually are more pronounced in worn pelage than in fresh (Jackson, 1915). Color abnormalities resulting from sudoriferous dermal gland secretions (Eadie, 1954) appear to be more common in *S. orarius* than any other species of *Scapanus* (Jackson, 1915).

Stroganov (1945) described the auditory ossicles of "*Scapanus* sp.," "*Scalopus* sp.," and other Recent talpids. The malleus of *Scapanus* differs from that of *Scalopus* by smaller size and by its manubrium. In *Scapanus*, the manubrium and proximal part of the neck extend in a stright line, whereas in *Scalopus* these elements form an obtuse angle. The processus longus is thinner and shorter, and the processus brevis much longer than in *Scalopus*. Stapes of *Scapanus* are about one-half as wide as in *Scalopus*. Ear bones of *Scapanus* and *Scalopus* are conformably more massive than those of Old World fossorial species.

The baculum of *S. orarius* is located in the extreme distal portion of the glans. There is considerable overlap in the size of bacula of *S. orarius* and *S. townsendii* (Maser and Brown, 1972). Bacula of *S. orarius* ($n = 5$) had an average length of 0.48 mm (range 0.32 to 0.58) and an average width of 0.22 mm (range 0.16 to 0.34), whereas those of *S. townsendii* ($n = 6$) had an average length of 0.42 mm (range 0.36 to 0.59) and an average width of 0.27 mm (range 0.18 to 0.42). Bacula of both species were relatively transparent and there was little uniformity in size or shape between individuals of the same species. Maser and Brown (1972) figured the penis of *S. orarius*, but gave no description.

Ziegler (1971) examined dental homologies of Recent talpids, and noted distinct differences in the degree of functional development of the milk dentition. The "more-or-less" fossorial moles (*Condylura, Parascalops, Scalopus, Scapanus,* and *Talpa*) possess milk teeth that are rudimentary and resorbed before eruption, or are so small that, when erupted, they probably cannot serve the normal function of the adult dentition. Shrew moles (*Uropsilus, Urotrichus, Dymecodon,* and *Neurotrichus*) have milk teeth that are well formed, similar to, and only slightly smaller than their corresponding permanent teeth. Ziegler (1971) suggested that well-developed milk

teeth represent a relatively unspecialized (that is, non-fossorial), primitive condition.

ONTOGENY AND REPRODUCTION. Vernal molt appears to begin in March and all animals are in full summer pelage by the middle of May. Autumnal molt is known to begin as early as 17 August, although most moles appear to undergo the change to winter pelage during October. The sequence of molt is less definite than that observed in the eastern mole, *Scalopus aquaticus*. New pelage of coast moles appears most frequently on the head and throat first, then extends onto the nape of the neck and the back with the abdomen being the last area to molt. Molt is occasionally like that of *Scalopus*, with the underside molting first followed consecutively by the sides and back. Unlike some other moles, differences in color, texture, and length of hair between old and new pelages are usually slight (Jackson, 1915).

In British Columbia, mating occurs from January to early March. Testes begin to enlarge in early January and show a gradual increase in size until early March (maximum size 15 by 10 mm), followed by a gradual decrease in size during late March and April; testes are regressed by May (Glendenning, 1959).

Females produce one litter per year and become reproductively active at approximately 9 to 10 months of age. Dalquest (1948) stated that four young, born from late March to early April, constitute an average litter. Glendenning (1959) reported that yearling females have two embryos, 2-year-olds three, and "fully mature" females four. Mating has not been observed and the gestation period is unknown. One nest examined by Glendenning (1959) contained two young that were almost naked, weighed 13 and 15 g, were 5.5 cm long, and had well-formed feet and tails; another nest contained four young, each weighing 40 g. Glendenning (1959) also reported the capture of three young in the same tunnel system during the middle of April. The young each weighed 32 g at capture and, in Glendenning's opinion, probably were not weaned. Nests consisted of a concavity approximately 15 cm below the surface of the soil and measuring approximately 20 cm across. Nests were lined with coarse grass. There were three entrances to one nest from which tunnels radiated in all directions.

ECOLOGY AND BEHAVIOR. *Scapanus orarius* is primarily fossorial, but occasionally is active on the surface, especially juveniles during dispersal in summer months (Dalquest, 1948; Giger, 1965; Howell, 1922; Maser et al., 1981). Coast moles are not restricted to any one vegetational zone or successional stage. Habitats include the following: agricultural land, coastal sand dunes, grassy meadows, sagebrush (*Artemisia*)–grass, alder (*Alnus*) and dogwood (*Cornus*) deciduous forest, yellow-pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), redwood (*Sequoia sempervirens*), and spruce (*Picea*) and hemlock (*Tsuga*) woodlands (Caswell, 1953; Dalquest, 1948; Glendenning, 1959; Ingles, 1965; Maser et al., 1981; Yates, 1978). Maser et al. (1981) noted that along the coast of Oregon, *S. orarius* avoids beach, coastal lake, and tideland river habitats.

Glendenning (1959) reported a positive correlation between population density of coast moles and rough estimates of earthworm populations. Schaefer and Sadleir (1981) used the number of mounds pushed up by moles as an index of habitat suitability and found that moles occurred more frequently in areas with large earthworm populations, relatively high soil-water content, and low soil-bulk density. In general, *S. orarius* occurs in lighter, better-drained soils than those inhabited by *S. townsendii* and is found along streams and in forest habitats that the latter species avoids (Dalquest, 1948; Glendenning, 1959; Maser et al., 1981; Schaefer and Sadleir, 1981; Yates, 1978). Although *S. orarius* and *S. townsendii* generally are found in different microhabitats where they occur in sympatry, syntopy is fairly common (Dalquest, 1948; Maser et al., 1981).

Glendenning (1959) determined the age of 940 coast moles by use of body mass and skin texture, but did not state his methods. Forty-five percent of the moles were adults over 1 year old, and 6% were over 3 years of age. Schaefer (1978) placed coast moles from British Columbia into four age classes based upon the following toothwear criteria: age 0 to 1 year, no noticeable wear; 1 to 2 years, noticeable wear on first and second molars with some wear on the second and third premolars; 2 to 3 years, extensive wear on the fourth premolar and first and second molars, second and third premolars worn to level of gingivae; 3 to 4 years, canines and second and third incisors worn to level of gingivae. Yates (1978)

placed *S. orarius* collected throughout the range of the species into three age classes as follows: juveniles, external roots of upper molars and often the fourth premolars exposed through maxillary bones, deciduous premolars often still present, teeth showing no evidence of wear; subadults, external roots of last two upper molars frequently exposed through maxillary bones, little or no evidence of wear on upper molars or premolars; adults, external roots of upper molars and premolars not exposed through maxillary bones, upper molars and premolars showing some evidence of wear (ranging from rounded to flat crowns), saggital crest often present.

Dalquest (1948) stated that *S. orarius* in Washington live deeper in the ground and form surface ridges less often than *S. townsendii*. However, according to Maser et al. (1981) coast moles in western Oregon usually are found in burrows that are more shallow than those of Townsend's mole and, in eastern Oregon (where *S. townsendii* does not occur), the coast mole constructs surface ridges more frequently than Townsend's mole. Glendenning (1959) reported that tunnels of *S. orarius* in British Columbia are constructed at three different levels: surface tunnels, made just below the surface of the soil, often used only once while foraging, dispersing, or searching for a mate; regular hunting tunnels at depths ranging from 7 to 90 cm; and, more rarely, deep tunnels constructed at depths of 1 to 2 m during dry periods. Mice and voles regularly use the tunnel systems of coast moles (Couch, 1924; Glendenning, 1959). During autumn and winter when soil moisture is higher, tunnel systems are extended, resulting in the appearance of numerous molehills smaller than those of *S. townsendii*; they average approximately 30 cm in diameter and 15 cm in height. Glendenning (1959) reported that from October to March, a single coast mole may construct between 200 and 400 hills. Formation of molehills is the same as in *Scalopus* (Hisaw, 1923), with the voiding tunnel consisting of a loose column of soil.

Schaefer and Sadleir (1979) found carbon dioxide concentrations in tunnels of *S. orarius* averaged more than 10 times that of the atmosphere; oxygen concentrations were concomitantly reduced. Carbon dioxide concentrations were approximately twice as great in the soil air as in the tunnels, suggesting that molehills may be important to the aeration of tunnel systems. In low lying areas, moles may drown when tunnels flood. Adult coast moles swim readily, and surviving adults quickly reinhabit areas that were flooded (Glendenning, 1959).

Coast moles are solitary except during the breeding season when males enlarge their home ranges by constructing long runways marked by large, widely separated mounds. These tunnels serve to communicate with the tunnel systems of neighboring females (Glendenning, 1959). Although moles generally do not enter the active tunnel systems of other individuals, they sometimes enter and use abandoned tunnel systems (Schaefer, 1978). Similar behavior was reported for *Parascalops* (Wright, 1945) and *Scalopus* (Hartman and Gottschang, 1983). Moles probably are opportunists with regard to habitat selection (Hartman and Gottschang, 1983), not surprising when the amount of energy that must be expended to construct and maintain a tunnel system is considered.

Maser et al. (1981) stated that the coast mole is primarily nocturnal. Schaefer (1982) followed a coast mole of undetermined sex labeled with Iridium 192 during daylight hours for 50 h 48 min during the months of November, December, and January. The mole did not confine its activity to any specific time of the day and its activity was not synchronous with that of other moles in the same field. The mole was most active in the vicinity of the nest and visited the perimeter of its home range less frequently; it never traversed its entire home range during any one period of activity and always returned to its nest to sleep. Similar behavior was noted for *Scalopus* during winter (Harvey, 1976). Schaefer (1981) estimated the home ranges of 15 coast moles to average approximately 0.12 ha, somewhat smaller than that reported for female *Scalopus* (range 0.15 to 0.35 ha; Harvey, 1976).

As with most North American talpids, earthworms (Lumbricidae) compose the major component of the diet of *S. orarius*. Moore (1933) examined the stomach contents of eight coast moles from Oregon and reported the following food items and volume percentages: earthworms, 69.9; Diptera, 25.1; Lepidoptera, 1.6; Coleoptera, 0.9; Chilopoda, 0.6; Orthoptera, 0.3; Hymenoptera, 0.2; and vegetable material, 1.2. Glendenning (1959) reported the following stomach contents and approximate volume percentages from 108 moles trapped in British Columbia: earthworms, 93; slugs (Gastropoda), 2; larval insects, 2; adult insects (chiefly Hymenoptera), 1;

earthworm ova, 1; undetermined, 1. Whitaker et al. (1979) examined the stomach contents of 25 *S. orarius* from eastern Oregon. Food items reported by percent volumes (percent frequencies of occurrence in parentheses) were: earthworms, 56.2 (92.0); adult insects, 8.7; insect larvae, 7.4; centipedes (Chilopoda) and millipedes (Diplopoda), 6.7; shrew or mouse remains, 6.0 (8.0); insect pupae, 5.2; vegetation (primarily fungi, Endogonaceae, and seeds), 7.8. The most frequently occurring adult insects were Hymenoptera: Formicidae, 44.0% frequency; Coleoptera: Scarbaeidae, 16.0; *Chauliognathus*, 8.0; Chrysomelidae, 4.0. Larval insects occurred in the following frequencies: Coleoptera: unidentified, 20.0; Elateridae, 12.0; Carabidae, 8.0; Scarabaeidae, 8.0; Diptera: unidentified, 16.0; Tipulidae, 4.0; Lepidoptera, 12.0. The most frequently occurring pupae were those of Formicidae, 20.0; unidentified pupae were found in 16% of the stomachs. Dalquest (1948) reported that a coast mole ate portions of a vole (*Microtus oregoni*) killed in a snap trap. Glendenning (1959) reported that captive coast moles consumed nearly twice their body mass in earthworms daily; however, such experiments may not reflect actual food consumption of moles in the wild (Jensen, 1983).

Cowan (1942) and Giger (1965) found remains of coast moles in regurgitated pellets of barn owls (*Tyto alba*), particularly during summer and autumn months when juvenile moles disperse. Maser and Brodie (1966) reported predation on *S. orarius* by long-eared owls (*Asio otus*). According to Maser et al. (1981), the rubber boa (*Charina bottae*) is a predator of nestling coast moles. Cats and dogs frequently kill coast moles, but seldom eat them (Glendenning, 1959; Maser et al., 1981). Additionally, humans kill large numbers of coast moles each year.

Glendenning (1959) reported two coast moles with numerous cestodes present in the duodenum, but did not identify the species of the tapeworms. Durette-Desset and Vaucher (174) reported the nematode *Tricholinstowia maseri* from the intestine of *S. orarius*. Two ticks, *Ixodes pacificus* (Gregson, 1956) and *Ixodes angustus* (Yates et al., 1979), four species of fleas, *Epitedia scapani* (Glendenning, 1959), *Corypsylla ornata* (Glendenning, 1959; Yates et al., 1979), *Nearctopsylla jordani*, and *Catallagia decipiens* (Yates et al., 1979), and the following mites have been reported from *S. orarius*: *Haemogamasus liponyssoides* (Yates et al., 1979), *H. occidentalis* (Keegan, 1951; Spencer, 1941; Whitaker et al., 1979), *H. reidi*, *H. ambulans*, *Androlaelaps fahrenholzi*, *A. casalis*, *Hirstionyssus obsoletus*, *Pygmephorus horridus*, *Pygmephorus* sp. (Whitaker et al., 1979), and *H. blarinae* (Yates et al., 1979). Whitaker et al. (1979) also reported the occurrence of the nonparasitic mite *Euryparasitus* sp. (Cyrtolaelapidae) on *S. orarius*.

Scapanus orarius is economically neutral in most areas, but does some damage to lawns, gardens, and golf courses. Damage to crops generally is the result of either digging by the moles, which destroys root systems, or the presence of meadow mice (*Microtus* spp.) that regularly use the tunnel systems of the moles and eat roots, bulbs, and corms; however, the coast mole consumes large numbers of injurious insects (Glendenning, 1959).

Glendenning (1959) tested a variety of methods for controlling coast moles and reported that only two were effective: scissor-type kill traps, and use of napthalene flakes as a temporary repellant. Other techniques tested included choker-loop, pit, barrel, and harpoon traps, poison baits, explosives, caustic irritants, and poison gas. Ennik (1967) reported that the number of molehills produced by European moles (*Talpa europaea*) in pastures was reduced by application of ammonium nitrate limestone; however, Schaefer (1981) found that application of nitrogen fertilizer (70 kg N/ha and 140 kg N/ha, the same amounts used by Ennik) had no effect on *S. orarius* molehill densities in British Columbia.

GENETICS. The karyotype of *Scapanus orarius* has not been reported. Yates and Greenbaum (1982) reported that *S. orarius* is genically more similar to *S. townsendii* than to *S. latimanus*, although the level of differentiation among these three species does not appear to be great. Yates and Greenbaum (1982) also reported average heterozygosity ($\bar{H}$) to be 0.0 for *S. orarius*.

REMARKS. The generic name *Scapanus* is derived from the Greek *skapane*, meaning "digging tool," and the specific name *orarius* from the Latin meaning "belonging to the coast." *S. orarius* was not recognized as a distinct species of the genus *Scapanus* until True revised the North American talpids in 1896. Although the biology of all North American moles is poorly known, *Scapanus*

orarius probably is the least studied species, with the possible exception of the shrew-mole, *Neurotrichus gibbsii*.

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G. D. HARTMAN AND T. L. YATES, DEPARTMENT OF BIOLOGY AND MUSEUM OF SOUTHWESTERN BIOLOGY, UNIVERSITY OF NEW MEXICO, ALBUQUERQUE 87131.