

Cryptotis parva. By John O. Whitaker, Jr.

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Cryptotis parva (Say, 1823) Least Shrew

- Sorex parvus* Say, 1823:163. Type locality west bank of Missouri River, approximately 2 mi. E Ft. Calhoun, formerly Engineer Catonment, Washington Co. Nebraska.
- Sorex cinereus* Bachman, 1837:373. Type locality Goose Creek about 22 miles from Charleston, South Carolina.
- Brachysorex harlani* Duvernoy, 1842:40. Type locality New Harmony, Posey Co., Indiana.
- Blarina berlandieri* Baird, 1858:5. Type locality Matamoros, Tamaulipas, Mexico.
- Blarina exilipes* Baird, 1858:51. Type locality Washington, Mississippi.
- Blarina eximius* Baird, 1858:52. Type locality DeKalb County, Illinois, and St. Louis, Missouri.
- Sorex micrurus* Tomes, 1861:279. Type locality Coban, Alta Verapaz, Guatemala.
- Blarina floridana* Merriam, 1895:19. Type locality Chester Shoal, 11 mi N Cape Canaveral, Brevard Co., Florida.
- Blarina orophila* J. A. Allen, 1895:340. Type locality Volcán Irazú (= Irazú Range), Cartago, Costa Rica (see Goodwin, 1944:2).
- Blarina soricina* Merriam, 1895:22. Tlalpan, 10 mi. S Mexico, Distrito Federal, Mexico.
- Blarina tropicalis* Merriam, 1895:22. A renaming of *micrurus* Tomes, preoccupied.
- Blarina pergracilis* Elliot, 1903:149. Type locality Ocotlán, Jalisco, Mexico.
- Blarina olivaceus* J. A. Allen, 1908:669. Type locality San Rafael del Norte, Jinotega, Nicaragua.
- Cryptotis celatus* Goodwin, 1956:58. Type locality Las Cuevas, Santiago Lachiguiri, District of Tehuantepec, Oaxaca, Mexico.

CONTEXT AND CONTENT. Order Insectivora, Superfamily Soricoidae, Family Soricidae, Subfamily Soricinae. As presently understood, the genus contains about 13 living species. Eight species inhabit Middle America (Choate, 1970), and one of these, *Cryptotis parva*, has a wide range north of Mexico. Most of the species inhabit woodlands, but *Cryptotis parva* is frequently found in open fields. Choate (1970) revised the Middle American taxa and currently is working on the remainder of the genus. Currently nine subspecies are recognized, as listed below.

- C. p. parva* (Say, 1823:163), see above (*cinereus* Bachman, *exilipes* Baird, and *eximius* Baird are synonyms).
- C. p. harlani* (Duvernoy, 1842:40), see above.
- C. p. berlandieri* (Baird, 1858:53), see above (*pergracilis* Elliot a synonym).
- C. p. floridana* (Merriam, 1895:19), see above.
- C. p. orophila* (J. A. Allen, 1895:340), see above (*olivaceus* J. A. Allen a synonym).
- C. p. soricina* (Merriam, 1895:22), see above.
- C. p. tropicalis* (Merriam, 1895:21), see above (*micrurus* Tomes a synonym).
- C. p. pueblensis* Jackson, 1933:79. Type locality Huauchinango, Puebla, Mexico (*celatus* Goodwin a synonym).
- C. p. elasson* Bole and Moulthrop, 1942:97. Type locality Bettsville, Seneca Co., Ohio.

DIAGNOSIS. The genus *Cryptotis* includes small, short-tailed, brownish shrews with four unicuspid teeth on each side of the upper jaw (figures 1 and 2) and a total of 30 teeth. These are the only North American shrews with four unicuspid teeth. *Cryptotis parva*, ranging from 67 to 103 mm total length, 12 to 22 tail, and 9 to 13 hind foot, is small as compared to most other species in the genus. It may be distinguished from other Central American species by its relatively short tail (less than 45% of length of head and body), its lack of bulbous dentition such as occurs in *C. nigrescens*, its small front feet, its condylo-

basal length of 15.3 to 18.4 mm, and other characters given by Choate (1970).

GENERAL CHARACTERS. This small brownish colored shrew has a short tail, inconspicuous ears, minute black eyes, and a long pointed snout. The fur is fine, dense, short and almost velvety. The skull is small but broader and higher than in *Sorex*. The rostrum is short and the zygomatic arches are incomplete. Like most other North American shrews, the teeth have chestnut-colored cusps. There are four unicuspid teeth, but the fourth is tiny and hidden in lateral view (see figure 1).

Some average values for total, tail, hind foot, and condylobasal lengths of *C. parva* from various parts of its range follow: Costa Rica and Panama 84.7, —, 11.6, 16.3 (Choate, 1970); Oaxaca 89.3, —, 12.0, 17.1 (Choate, 1970); Rio Grande area of Texas and Mexico 80.3, —, 11.8, 15.7 (Choate, 1970); Texas 78.2, 17.3, 10.7, —, (Davis, 1941); Maryland 76.3, 15.2, 10, 15.2 (Paradiso, 1969); Indiana 74.3, 15.6, 10.0, —, for males and 77.2, 16.5, 10.5, —, for females (Mumford, 1969) and 77.1, 16.3, 11.2, —, (Lindsay, 1960); North Carolina 75, 16.4, 10.6, — (Hamilton, 1943); North Carolina and Tennessee 74.3, 18.4, 10, — for males and 74.0, 18.0, 10.0, — for females (Komarek and Komarek, 1938); and New Jersey 84.4, 20.4, 11.6, — (Connor, 1953).

DISTRIBUTION. The present distribution is shown in Figure 3 (from Hall and Kelson, 1959; modified using Choate, 1970; Jarrell, 1965; Packard and Judd, 1968; Packard and Garner, 1964). Fossil records indicate (see later) that related species previously occurred much farther west than living species of *Cryptotis*.

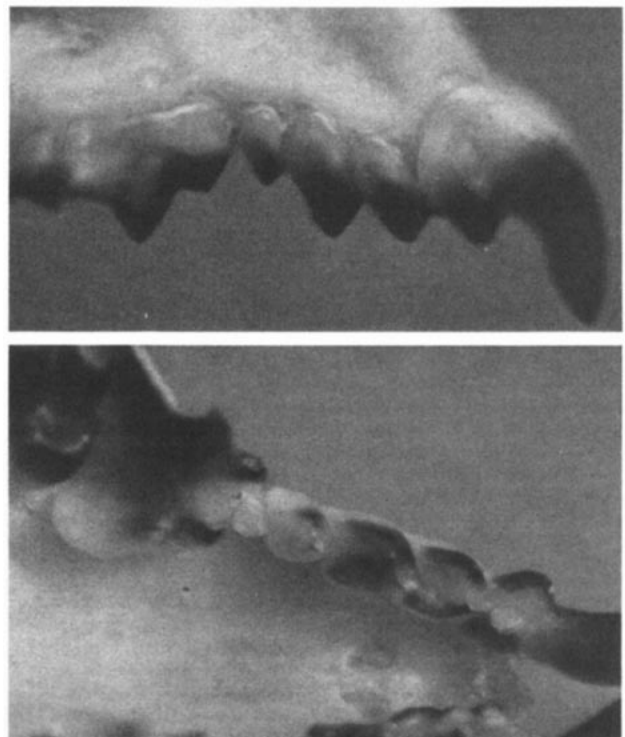


FIGURE 1. Lateral view (above) of anterior region of skull of *Cryptotis parva* showing large bicuspid incisor and first three unicuspid teeth (the fourth is hidden), and ventral view (below) showing all four unicuspid teeth. Photos by the author.

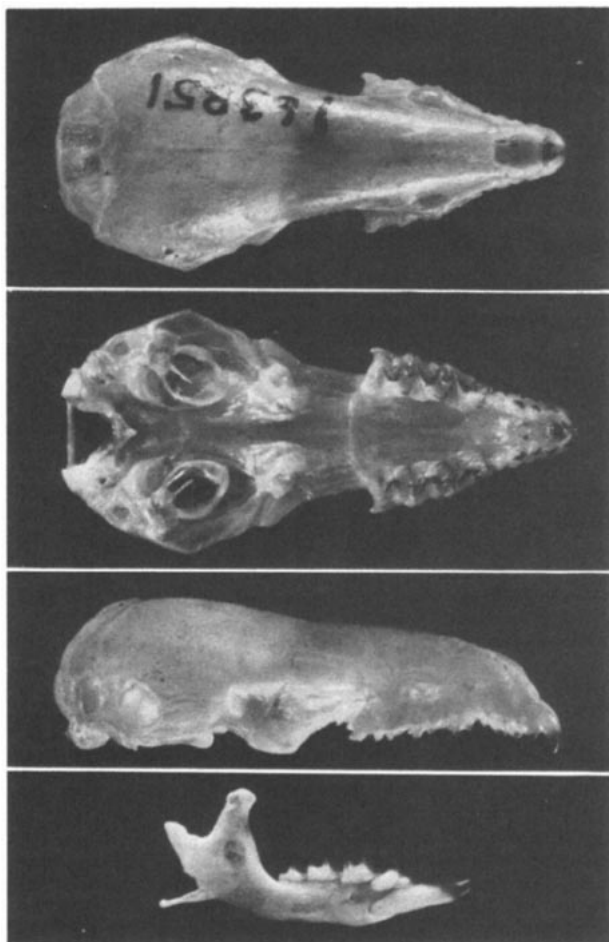


FIGURE 2. Dorsal, ventral, and lateral views of skull, and mandible of *Cryptotis parva* (AMNH 163851, a male from Gulf Hammock, Levy Co., Florida). Photographed by Arthur Singer, Department of Photography, American Museum of Natural History.

FOSSIL RECORD. Three extinct species of *Cryptotis* have been described. One is *C. adamsi* (Hibbard, 1953), from the late Pliocene of Meade County, Kansas, Rexroad formation, Rexroad fauna. This species also was reported from the mid-Pliocene Christmas Valley local fauna of Lack County, Oregon (Repenning, 1967), but Choate (1970) questioned this record. The others are *Cryptotis meadensis* Hibbard, 1953, same data; and *C. kansansensis* Hibbard, 1958, from the early Pleistocene of Kingman County, Kansas. *C. adamsi* has five unicuspid, which indicates close relationship with and probable origin from *Blarina* (Choate, 1970).

A closely related fossil genus, *Paracryptotis*, contains two species, *P. rex* Hibbard, 1950, from the late Pliocene of Meade County, Kansas, Rexroad formation, Rexroad fauna; and *P. gidleyi* (Gazin, 1933) from the late Pliocene, Hagerman Lake beds, near Hagerman, Idaho. *P. rex* was also recorded from the mid-Pliocene Rome fauna of Oregon (Repenning, 1967); *P. gidleyi* is known only from the type locality.

Cryptotis parva has been reported from Pleistocene deposits of Robinson Cave, Overton Co., Tennessee (Guilday *et al.*, 1969), from Crankshaft Cave, Jefferson Co., Missouri (Parmalee *et al.*, 1969), and from Nichol's Hammock, 0.7 mi N Princeton, Dade Co., Florida (Hirschfeld, 1968). All these localities are within the present range of *C. parva*.

FORM. The homologies of the "unicuspids" of shrews are quite uncertain. Choate (1970) reviewed the literature and elected to retain the descriptive term unicuspid for the small teeth behind the large incisor. The tooth formula for Recent *Cryptotis* is thus (Choate, 1970): $i\ 1/1, u\ 4/1, p\ 1/1, m\ 3/3$, total 30. The milk teeth are shed in *Cryptotis* prior to birth. Choate found no evidence of secondary sexual differences.

The male reproductive tract and penis of *Cryptotis parva*

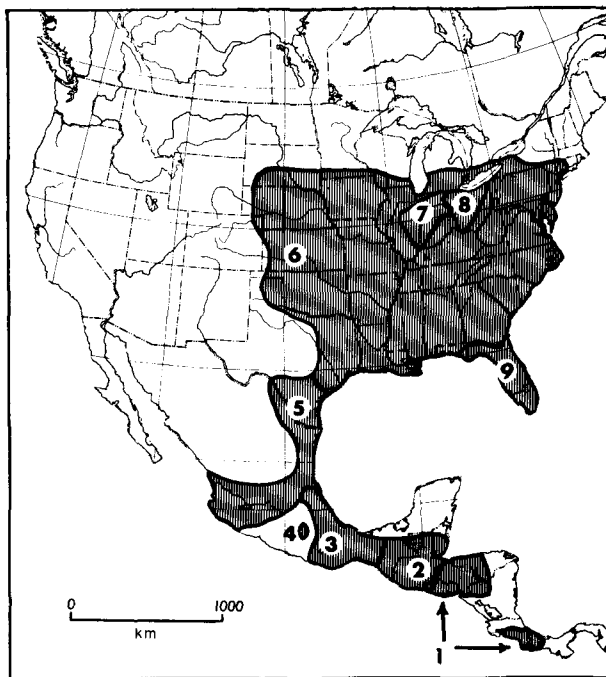


FIGURE 3. Geographic distribution of *Cryptotis parva* and its subspecies, as follows: 1, *C. p. orophila*; 2, *C. p. tropicalis*; 3, *C. p. pueblensis*; 4, *C. p. soricina*; 5, *C. p. berlandiera*; 6, *C. p. parva*; 7, *C. p. harlani*; 8, *C. p. elasson*; 9, *C. p. floridana*.

were figured by Martin (1967). The glans penis of *Cryptotis* "is rather bulbous, short and heavily sulcated," compared to *Blarina*. The prostate glands are round, flattened structures surrounding the anterior portion of the urinary vesicle, whereas the bulbo-urethral glands are attached to the penile crura. The testes are posterior and dorsal to the penis, and in breeding males occupy "pouchlike extensions of the caudal end of the abdominal cavity" at the base of the tail.

Dryden and Conaway (1970) found "anal tonsils," two pairs of lateral lymphoid masses (but none ventrally) in 10 adult *Cryptotis* examined. These masses "were associated with lateral folds of the anal canal, but some masses were not deeply indented by folds. When the fold did extend into the lymphoid area, the anal epithelium was unmodified." The tonsils vary structurally between groups of insectivores, and some lack them entirely.

Hamilton (1944) discussed molting in a captive individual; it commenced on 17 September, starting on the face and progressing rapidly over the head and shoulders. The summer pelage was being replaced by the winter pelage, which is darker because it lacks the sepia-tipped hairs. Concurrently, pea-sized areas on the rump and mid-belly began shedding. These areas remained well defined for several days, then the lines of demarcation were "lost in the general renewal of fur." Hamilton further reported that he took individuals in southern Georgia and Florida that were molting, but that there was little seasonal color change, at least in south Florida. *Cryptotis* apparently molts irrespective of season although molt is more common in late spring and late autumn (Hamilton, 1944; Pfeiffer and Gass, 1963a). Choate (1970) stated that the molt from juvenal or adult summer pelage to adult winter pelage begins on the rump or venter, and that it usually progresses more rapidly below than above, often forming a saddle across the back. The molt progresses anteriorly, the head being the last area to molt. Molt from juvenal to summer pelage may start on the head and progress posteriorly, or in reverse. Spring molting usually begins anteriorly and progresses posteriorly. Old adults however, may molt at any time of year and may cease molt abruptly, forming patterns including old and new hair.

Elder (1960) reported a white specimen with pink eyes taken on 24 January 1953 in Missouri, and Choate (1970) reported an individual from Texas (U.S. National Museum 347435) that "lacks pigment in the hairs except in the basal gray region, which appears normal." Other morphological abnormalities found by Choate in three specimens were the

absence of one unicuspid, the absence of a pair of upper unicuspid, and "enormously robust parastyles on both second upper molars, causing those teeth to be markedly distorted."

FUNCTION. Sealander (1964) obtained blood values for two adult females from Arkansas: one, a pregnant female weighing 4.3 g, yielded hemoglobin concentration 1.27 mg/10 mm³ of blood, corpuscles made up 43.9% of blood volume, mean concentration of hemoglobin in the corpuscles was 29.0%; in another female, nonpregnant and weighing 2.6 g, corresponding values were 1.90, 57.4, and 33.1. In the second individual the oxygen capacity of the blood was 26% by volume. The erythrocyte diameter in the two averaged 6.3 μm (5.8 to 6.4).

Digestion is rapid. Pieces of chiton and hair traversed the entire digestive tract in periods of 95 to 114 minutes (Hamilton, 1944). The consistency of fecal material changed within 2 hours of a change in diet (Davis and Joeris, 1945).

Other shrews have high metabolic rates and the smallest species appear to be near the theoretically lowest limit of mammalian size (Redmond and Layne, 1958). Data from seven shrews of both sexes, weighing from 4.1 to 5.0 g, were compared with the same data from white mice, white rats, and rabbits, and decreased metabolic rates (as measured by volume of oxygen consumed per unit of dry weight of tissue per hour) were obtained with increased size of the animal. However, the rate for liver was lower for *Cryptotis* than for the mouse or rat, and higher than for the rabbit. The rate for the kidney, was much higher in the shrew than in the other species. For lung the rate was approximately equal for shrew, rabbit, and rat, but slightly higher for mouse; for diaphragm it was about equal for shrew and mouse, but lower in rat. Because of its small size, one would expect the values for the shrew to be above those for the other species in each case. The authors stated that the striking difference "would seem to indicate that the high respiratory rates exhibited by shrews must be due to 'extrinsic' factors such as nervous stimulation, hormone levels, or concentrations of metabolites in blood or tissue fluids rather than to generally higher 'inherent' rates of tissue metabolism." The authors suggested two alternative explanations, both admittedly speculative: 1) the observed low rates for the tissues may reflect the relatively primitive status of insectivores among mammals, with the high rate being maintained through evolutionary development of controlling mechanisms to compensate for heat loss or other physiological factors; 2) the low rates in the three tissues could themselves be an energy conserving measure, through lowered metabolic rates during inactive periods. This is supported by observations that shrews sleep soundly (Christian, 1950) and awake slowly and sluggishly, with trembling or convulsive movements suggestive of an animal waking from hibernation (Layne and Redmond, 1959). Determinations of respiratory rates of sleeping shrews would be desirable. Moore (1943) timed the breathing of a *Cryptotis* at rest at about 70 breaths per minute.

The mean of 32 rectal temperatures, taken between the hours of 0900 and 2400 from four adult shrews, two females and two males weighing 5.1 to 6.4 g, over an 8-day period was 35.0 ± 0.3° C, with a range of 31.9 to 39.1° C (Layne and Redmond, 1959). Temperatures of individual shrews were relatively constant from day to day. One which was docile and easily captured averaged 33.6° C, while the other three, which were highly excitable and struggled to avoid capture, averaged 35.6, 35.4, and 35.5. The mean of 16 measurements taken between 1600 and 2400 was 35.5° C, while the mean of 16 taken between 0900 and 1230 was 34.6°. This difference was associated with slightly more activity in the evening than during the morning. Layne and Redmond (1959) recorded skin temperatures for sleeping shrews on four occasions. They held a rapidly equilibrating thermometer firmly against the shrew's abdomen in such a way that the bulb was practically surrounded by tissue. Ambient temperatures averaged about 26.0° C. The recorded temperatures were 34.5, 34.8, 35.4, and 35.5° C. From these measurements the authors conclude that "the possibility that a pronounced depression of temperature occurs during sleep . . . does seem unlikely." Three oral temperatures were obtained on recently born *Cryptotis* weighing 0.33 and 0.37 g the day of, and the day following, their births. The readings were 31.4, 31.7, and 31.9° C, or about 3 degrees below the mean body temperatures of adults. The temperature data support Pearson's (1948) contention that shrews do not have significantly higher body temperatures than mice, even though they have much higher metabolic rates. Layne and Redmond (*op. cit.*) suggested that shrews may have greater metabolic lability than do other nonhibernating small mammals.

The fact that near normal temperatures are maintained by shrews while asleep may be indicative of "internal heat-regulating mechanisms to control heat lost to a point at which a substantial reduction of metabolism is possible. Behavioral phenomena such as communal nesting and huddling may also play a role in this connection."

Barrett (1969) used a metabolic cage to measure food intake and fecal and urine production in an adult female. There was approximately 2660 cc of space in the cage, and water supply was unrestricted. The shrew showed no change in weight throughout the study period of 7 weeks; it averaged 3.6 ± 0.2 g. The shrew was fed only baby mice. Caloric values per gram of dry weight were: shrew feces 3.35 kcal; urine 1.88 kcal; baby mice 6.20 kcal (or 1.24 kcal/g of live weight). The mice were 20.26% of their total weight when dry, 6.61% of dry weight was fat; one value of 9.01 kcal/g of fat was obtained. The mean ingestion was 4.57 ± 1.62 st. dev. kcal/day, or 3.83 ± 1.31 g wet weight of food per day. Hence, the shrew consumed an average amount of food per day of slightly more than its own body weight. Springer (1937) had found a 5.0-g shrew to ingest 5.5 g wet weight of food per day, and Hamilton (1944) found a 4.7-g shrew to use 3.6 g per day; ingestion coefficients of these two were thus 1.1 and 0.8, respectively. Barrett found the energy lost as feces was 0.47 kcal/day and as urine 0.11 kcal/day. Respiration was estimated from these values to be 4.17 kcal/day or 1.16 kcal/g/day. The assimilation efficiency [(ingested energy minus fecal energy) • 100/ingested energy] was 90.1.

Pfeiffer and Gass (1963b) found that oxygen consumption in a 6.36-g adult male nearly doubled from a basal rate of 7.0 cc/g/hr to 13.2 cc/g/hr during vigorous activity.

ONTOGENY AND REPRODUCTION. Hamilton (1944) described a newborn young. Its weight was 0.32 g, total length 22 mm, tail 3 mm, and hind foot 2.5 mm. Vibrissae were present, but small. Claws were small but distinct. Even when stained with alizarin no developing teeth could be seen in either jaw. The skull was 7.4 mm long and the dentary was 4 mm long. The forelimbs were better developed than the hind limbs. Conaway (1958) gave the following details concerning development: there was little change in appearance during the first 2 days, but by day 3 the dorsum began to darken and crawling movements occurred; on day 4 pigmentation was seen in the nose and chin, and the dorsum had become dark by day 5; hair was visible on day 6 and had become prominent on the side glands by day 7; by day 14 the eyes had opened, the young were fully haired and appeared as adults except for the small size and the silvery immature pelage. The weight increase through 30 days was figured. The birthweight was about 0.3 g (two individuals) and on days 1 to 5, respectively, weights were about 0.5 (two), 0.6 (three), 0.7 to 0.9 (three), 0.9 to 1.6 (four), and 1.0 to 1.8 (six). Corresponding values on days 10, 15, 20, and 25 were 2.3 to 2.7 (three), 3.1 (one), 3.7 (one), and 3.7 to 4.6 (five). By about 30 days the weight had leveled off presumably at the adult level. Hamilton (1943) stated that weaning did not occur until nearly day 21, and Conaway (1958) found that nursing continued until day 21 or 22. Young *Cryptotis* followed close behind the mother until day 20 to 23, but without attaching to her (Gould, 1969). Gould also stated that the ears opened on days 10 or 11.

Relatively little is known about reproduction in this species. Hamilton (1944) stated that breeding probably is from March to November in the northern parts of its range, but that in Florida breeding may extend throughout the year. Choate (1970) indicated that breeding may occur throughout the year in Middle America, at least at certain elevations and altitudes, but stated that "the peak of reproduction occurs between the vernal equinox and autumnal equinox." He found young in every month but March and May. Published records and personal observations of embryo counts range from two to seven, with a mean of 4.9, and the numbers of young in 16 litters vary from three to seven, with a mean of 4.5 (Brimley, 1923; Broadbooks, 1952; Choate, 1970; Conaway, 1958; Connor, 1953; Davis and Joeris, 1945; Hamilton, 1934, 1944; Kilham, 1954; Pournelle, 1950; and Welter and Sollberger, 1959). In addition, I examined one female shrew taken in Indiana on 27 June 1965, which appeared to have three placentae but no embryos in each uterine horn, indicating recent partus. Histological examination by R. A. Smith confirmed this interpretation. In addition, in Indiana, no embryos or placental scars were found in 56 females taken between October 18 and March 14. Numbers each month were 10, 24, six, 11, one, and four. Gottschang (1965) found one nursing female in Ohio on 4 November, and a male in breeding condition was taken

on 20 March, but none of 37 others examined from November 1962 through March 1963 showed evidence of breeding. Layne (1958a) took one female on October 30 that had enlarged mammary glands, indicating a recent litter, but she was no longer lactating. Davis and Joeris (1945) observed no evidence of reproduction in individuals taken from November to February in Texas.

Conaway's (1958) observations of copulation on seven occasions were similar to Pearson's (1944) for *Blarina*. Copulation occurred on 2 days in two instances, and on 1 day in the remainder. Gestation, counting from the last mating, lasted 21 to 23 days for each of five litters produced in captivity. Birth was never observed, but occurred in late afternoon. Postpartum estrus occurred in one female of three that were caged with males after partus. In one female, partus (five young) occurred on 3 March, copulation occurred on 3 March, and a litter of four was produced on 24 March. One litter was in a cage with six adults including both sexes and all young died of starvation in 5 days. Conaway concluded that disturbance caused by the excess adults prevented the young from nursing. The nest and young of another litter produced in a cage with four adults were intentionally scattered. All four adults immediately ran about carrying young from place to place in the cage. Sometimes two adults picked up the same individual, then tugging occurred until finally possession was gained by one of the adults. Finally all young were moved to the site of the old nest, and the adults reassembled the nest. The litter survived. Cooper (1960) also reported that after a female *Cryptotis parva* had been separated from her young, she "picked one after another up in her mouth and carried them frantically around the box for as long as 20 to 25 seconds each." Before long she had gathered them together, under a section of limb.

ECOLOGY. In general, *Cryptotis parva* inhabits grassy, weedy, and brushy fields, at least in the northern parts of its range (Hamilton, 1934; Lindsay, 1960; Gottschang, 1965; Howell, 1954; Davis and Joeris, 1945; Choate, 1970; Layne, 1958a; Mumford, 1969; Paradiso, 1969; Komarek and Komarek, 1938). Lyon (1925), however, took one individual in oak-maple woods near a clearing in Porter County, Indiana. Mumford (1969) stated that woods are evidently unsuitable. He reported that one was found dead at the bottom of a ravine in deciduous woods in Indiana, but that a predator could have dropped it there. I have taken approximately 150 *Cryptotis* from Indiana, all from field areas, none from woods. Perhaps in the south *Cryptotis* is more apt to use woodland habitats, for Smith (1938) found a nest in a cabbage palm forest with an understory of waxmyrtle (*Myrica cerifera*), and Layne (1968) took ten, one in pine-oak woodland, six in level pine-lands, one in wetlands, and two in oldfields. Davis and Joeris (1945) took one from woodland in Texas. Choate (1970) reported them as sometimes occurring in "scrubby live oak, pine-oak, dense humid tropical forests, and in cloud forests" of Mexico and Central America. Komarek and Komarek (1938) took some from *Synaptomys* runways in an open grassy patch at the forest margin in the Smoky Mountains. Some authors have mentioned that the species uses runways of other small mammals (such as *Microtus*, *Sigmodon*, or *Oryzomys*) or makes tiny runways of its own (Lindsay, 1960; Gottschang, 1965; Davis and Joeris, 1945; Layne, 1958a; Hamilton, 1944). Many authors mentioned the dryness of fields where *Cryptotis* are taken, but Connor (1953) took five adults and a nest of four young in a brackish tidal meadow in New Jersey under the side of a shack that had fallen over. Choate (1970) stated that *Cryptotis*, primarily a grassland animal, may also occur in mesquite, yucca, agave, or grass covered llanos. However, in Middle America it is most often taken in numbers in "restricted damp or mesic areas, such as at the borders of streams or lakes, within otherwise relatively arid habitats." He reported them from many elevations, varying from 10 m along the Rio Grande and on the coastal plain, to 2950 m on the Sierra de Coalcoman in Michoacan. In the United States, 905 m is the highest elevation at which the species has been reported (Komarek and Komarek, 1938). Peterson (1936) reported one individual from a basement and one from a garage in New York.

Davis and Joeris (1945) felt that soil type was not important in determining whether *Cryptotis* was present or absent. They felt that the presence of dense herbaceous ground cover, especially of grasses (particularly *Andropogon*, *Cynodon* and *Sorghum halepense*), was important. Paradiso (1969) and Hamilton (1944) reported *C. parva* from the coastal marshes of Maryland and Virginia, respectively, and Paradiso reported that on the coastal island of Assateague it is found in all

habitats except the beach dunes and is one of the two most common small mammals (with *Microtus pennsylvanicus*).

There is a surprising amount of information concerning predation on this species, especially by owls, considering the relatively small number of individuals usually taken by mouse-trapping. This indicates that *Cryptotis* is often rather common but is less susceptible to trapping than are many other species of small mammals. Latham (1950) found 138 *Cryptotis parva* among items in 834 long-eared owl pellets from Pennsylvania, 108 among an unspecified number of barn owl pellets from Delaware and Pennsylvania, and one among prey items in 22 stomachs of housecats from Pennsylvania. Among the prey of barn owls in Ohio, Stupka (1931) and Phillips (1951) respectively, found 126 *Cryptotis* (among 8151 skulls) and 12 *Cryptotis* (or 1.41%). Davis (1938, 1940) found 171 (41% of the prey items, from an unknown number of pellets) and 102 of 152 prey in 25 barn owl pellets from Texas, only nine pellets lacked *Cryptotis* and one contained 20. Kirkpatrick and Conaway (1947) found 47 *Cryptotis* skulls in 145 barn owl pellets from Tippecanoe County, Indiana. Linsdale (1928) reported two *Cryptotis* were caught, but that the lower jaws of 99 individuals were found in short-eared owl pellets from one Missouri locality. Pearson and Pearson (1947) found 3 *Cryptotis* among 1152 mammals taken by Pennsylvania barn owls. Stickle and Stickle (1948) found *Cryptotis* remains in 3 of 118 pellets and Dalquest (1968) found a few *Cryptotis* in barn owl pellets from Texas. Linzey and Linzey (1971) reported a *Cryptotis* in the stomach of a screech owl from The Great Smoky Mountains. Mumford and Handley (1956) found the remains of 11 in owl pellets, and Wolfe and Rogers (1969) found 6 *Cryptotis* among 42 small mammals in owl pellets from Alabama. As of 1961 (Jackson, 1961), there were only three specimens of *Cryptotis* from Wisconsin, all from predators, two from the great horned owl (Nelson, 1934) and one from a red fox (Hanson, 1944). Cope (1949) found 27 *Cryptotis* in the digestive tract of one rough-legged hawk from Indiana; Crabb (1941) found *Cryptotis* remains in 11 of 330 spring scats of the spotted skunk, *Spilogale putorius*, from Iowa, but none in 75, 254, or 185 scats of this species collected in winter, summer, and autumn. McMurry (1945) found three least shrews in the stomach of a feral house cat from Oklahoma, the only remains of *C. parva* in 223 stomachs of this predator examined. Kilgore (1969) reported one *Cryptotis* among 488 scats and seven stomachs of swift foxes, *Vulpes velox*, from Oklahoma. Welter and Solleberger (1939) found a *Cryptotis* in the stomach of a hognose snake, *Heterodon platyrhinos*. Snyder (1929) found three young to have been regurgitated by a milksnake, *Lampropeltis dolia* *triangulum*. He concluded they had been recently swallowed, because one survived. Hunt (1951) found a young *Cryptotis* in the stomach of *Lampropeltis calligaster*, and Hamilton (1934) reported a dog digging one from an underground nest in New York. Cooper (1960) reported that a coastal plain milksnake, *Lampropeltis dolia* *temporalis*, would not eat a *Cryptotis*, although it would eat young mice the same size.

Layne (1968) looked for the nematode, *Capillaria hepatica*, in 10 *Cryptotis* from Florida but found none, and Solomon and Warner (1969) found a *Cryptotis parva* from Virginia negative for *Trichinella spiralis*. The following species of mites have been reported from *C. parva*; *Orycterovenus soricis* (Rupes and Whitaker, 1968; Whitaker and Wilson, 1968; Whitaker and Mumford, 1972); *Dermacarus hypudaei* (Whitaker and Mumford, 1972); *Androlaelaps fahrenheitsi* (Strandtmann, 1949; Whitaker and Wilson, 1968; Whitaker and Mumford, 1972); *Eulaelaps stabularis* (Jameson, 1947); *Haemogamasus harperi* (Keegan, 1951); *H. liponyssoides* (Whitaker and Wilson, 1968; Whitaker and Mumford, 1972); *Hirstionyssus talpae* (Drummond, 1957; Herrin, 1970; Jameson, 1947; Whitaker and Mumford, 1972); *Myonyssus jamesoni* (Whitaker and Wilson, 1968; Whitaker and Mumford, 1972); *Blarinobia cryptotis* (McDaniel, 1967; Whitaker and Mumford, 1972), and *Protomyobia claparedei* (Ewing, 1938; McDaniel, 1967; Whitaker and Wilson, 1968; Whitaker and Mumford, 1972). Whitaker and Corthum (1967) and Whitaker and Mumford (1972) reported four species of fleas from the least shrew, *Corrodopsylla hamiltoni*, *Ctenophthalmus pseudagyrtis*, *Promyopsylla scotti*, and *Epitedia wenmanni*, with only the first two being of regular occurrence. Traub (1944) and Jameson (1947) reported *Corrodopsylla hamiltoni* from *Cryptotis* from New York and Kansas. Wilson (1961) reported *Ctenophthalmus pseudagyrtis* on *C. parva* from Indiana. Layne (1958b) reported *Corrodopsylla curvata* on *Cryptotis parva* from Illinois, and Hamilton reported *Doratopsylla blariniae* on this species from New York. The chigger, *Neotrombicula sylvilagi* (Brennan

and Wharnton) was found on *Cryptotis parva* from Kansas by Kardos (1954). Loomis (1956) reported the following species of chiggers from *C. parva*; *Eutrombicula alfreddugesi*, *E. lipovskyana*, *Neotrombicula sylvilagi*, *Euschongastia jonesi*, and *Pseudoschongastia jarneri*.

The most regularly occurring parasites seem to be: *Orycterovenus soricis* (actually a hypopial or transport form), *Androlaelaps fahrenheitsi*, *Protomyobia claparedei*, *Hirstionyssus talpae*, *Blarinobia cryptotis*, *Ctenophthalmus pseudagyrtis*, and *Corrodopsylla hamiltoni*.

Verts and Barr (1960) found six individuals of this shrew from Illinois negative for rabies.

Hamilton (1944) examined the stomach contents of 12 least shrews and reported fragments of insects, earthworms, centipedes, molluscs, and a small amount of vegetation. Included among the insects were Scarabaeidae, Carabidae, and beetle larvae. He reported that on Chincoteague Island, Virginia, *Cryptotis* was apparently eating snails, *Melampus lineatus* Say. Evermann and Butler (1894) reported that the species was referred to by an Indiana native as the "bee mole" because of its habit of entering bee hives and feeding on the brood. Mohr (1935) examining the stomach of one *Cryptotis* from Illinois found it had eaten 50% chinch bugs (five individuals) and 50% spider (one individual). Hatt (1938) found that when a medium sized *Rana pipiens* was put in with a captive shrew, the shrew attacked the knees of the frog, immobilized it by finally severing the patellar tendons, and then ate it. Hatt also saw attempts at this behavior when three *Cryptotis* in a window well were chasing a frog. A baby housemouse, *Mus musculus*, was not touched. The shrew would also bite the joints of the largest legs of grasshoppers and crickets before eating them. Welter and Sollberger (1959) reported that *Cryptotis* ate crickets in captivity by giving several bites to the head; six were killed this way and used later. Chamberlain (1929) stated that when a captive shrew was offered a large grub, the shrew pounced on it, bit its head in several places, then commenced feeding at the head.

Springer (1937) kept two captive *Cryptotis* from Florida. Each consumed between 3.5 and 8.1 g of food per 24-hour period (average of 5.5 g). In captivity they ate many kinds of invertebrates and also frogs and lizards. They drank frequently. *Blatta orientalis*, *Spirobalus* sp., and snails (*Planorbis* sp. and *Euglandina* sp.) were refused. The shrews would make a preliminary bite, then a series of scattered bites over the body of the prey, then would start feeding when movement became feeble. Lizards were seized by the tail until it came off; it was then eaten. Presumably the lizard could then escape. Moore (1943) observed *Cryptotis* kill grasshoppers by biting them in the head after creeping up to them, but in contrast, shrews would run up to crickets "like a football player after a fumbled ball" and bite them also in the head. They attacked a preying mantis in the same way, but otherwise attacked by running in and nipping at prey. Small and softer individuals of grasshoppers as well as crickets and softer arthropods were eaten in their entirety, whereas only the insides of larger grasshoppers were eaten. Shrews preferred crickets over grasshoppers and ate grasshoppers only after the crickets were gone. When excess insects were provided, they were taken into the burrow and stored there. Insects were carried in the jaws, or, in the case of larger individuals, the shrew would enter the burrow and afterwards pull in the prey. Hamilton (1934) recorded that a captive *Cryptotis*, which averaged 4.7 g in weight, consumed about 3.6 g of food per day. Stomachs of three shrews of this species from New York examined by him contained fragments of earthworms, adult beetles, and centipedes along with much finely chewed insect material. Layne (1958a) found earthworms, insects, and unidentified arthropods in three stomachs from shrews of this species from Illinois.

Whitaker and Mumford (1972) examined the stomachs of 109 least shrews from Indiana. The top five foods, listed in percentages of volume (percent frequencies in parentheses) were lepidopterous larvae 17.9 (29.4), earthworms 11.2 (15.6), spider 6.8 (11.0), internal organs of crickets and grasshoppers 6.6 (7.3), and coleopterous larvae 4.7 (7.3). Other foods found were unidentified insect (5.8% volume), Aphididae (3.8), Chilopoda (3.6), mast (3.5), snails and slugs (3.3), Gryllidae (3.2), unidentified Coleoptera (3.0), internal organs of coleopterous larvae (2.8), dipterous larvae (2.4), unidentified Hymenoptera (2.2), Miridae (2.2), sowbug (1.9), unidentified Hymenoptera (1.8), Carabidae (1.7), unidentified Diptera (1.6), Scarabaeidae (1.2), unidentified seeds (1.2), Acrididae (1.1), Cicadellidae (1.0), *Endogone* (0.9), Membracidae (0.9), Formicidae (0.8), unidentified fungal spores (0.8), vegetation (0.5), *Setaria* seeds (0.4), Cantharidae (0.4), Vespidae (0.3),

scarabaeid larvae (0.2), muscoid fly (0.1), mites (0.1), and Enchytraeidae (trace). It appeared that under field conditions (as also seen in the laboratory by Moore, 1943) least shrews must often open the abdomens of larger crickets and grasshoppers and eat out the internal organs.

Practically nothing exists in the literature concerning populations or population dynamics of *C. parva*, presumably because the species is so difficult to trap in numbers using conventional techniques. Davis (1938, 1940) reported heavy concentrations on the basis of large numbers in barn owl pellets in Texas, as noted above. Kirkpatrick and Conaway (1947) took 22 shrews of this species in 92 trap-nights in Tippecanoe County, Indiana, along with 47 skulls in 145 barn owl pellets. These figures also suggest a high local population. Howell (1954) used a circular study area to determine populations of several species. He stated that the home range for *Cryptotis* was difficult to determine, but estimated it for one female at 0.57 acre (2800 m²), and for one male at 0.41 acre (1700 m²). He trapped individuals indicating a density of at least 1.73 per hectare, but estimated that about 4.95 per hectare actually were present. One indication of longevity is available. Pfeiffer and Gass (1963a) stated that one captive individual they kept from a nestling died at 21 months apparently of "old age."

BEHAVIOR. Several authors report this species to be somewhat colonial or at least social, inasmuch as they exhibit the unlikely characteristic for shrews of being able to exist together in numbers in the same nest. Jackson (1961) reported about 25 shrews of this species found in a single leaf nest under a log in April in Virginia. Connor (1953) found two females huddled together in plant remains under a horizontal section of wall in a brackish tidal meadow in New Jersey (an adult and four young were found in the same spot 2 weeks later), and he and Springer (1937) reported that captives huddled together in the laboratory. Hamilton (1934) reported five in a nest of rootlets and grass under a heavy rock slab, all huddled in a ball, and another instance of three in a nest of dry grass about 100 mm below the surface of the ground. Davis and Joeris (1945) found a nest in December in Texas occupied by 12 individuals, and also reported that captive individuals ate and slept together. McCarley (1959) found a *Cryptotis* nest under a log on a hillside in an open field with sparse vegetation on 7 January 1958, in Nacogdoches, Texas. The log was in contact with the ground throughout its length and the nest, in a 50 mm depression, was of leaves and grass. It measured about 100 by 150 mm, with no extensive runways leading from it, but adjacent to the nest was a pile of fecal droppings about 100 by 150 mm in diameter and 12 mm high, indicating that the nest probably had been in use for some time. The nest contained at least 31 individuals, and the next day contained six. McCarley hypothesized that this behavior functioned as a heat conservation measure. Smith (1938) found a nest with two individuals under a prostrate cabbage palm (*Sabal palmetto*) in a forest of cabbage palms with an understory of wax myrtle and scrubby live oaks. A tunnel ran the length of the log, a lateral tunnel led to the nest and another ran to the main tunnel about 0.6 m from the nest. The nest was loosely constructed of panic grass (*Panicum mutabile*) and was about 125 mm in diameter. The leaves were loosely piled in a globular mass that also included shed snake skin. Runways opened to the surface and became paths, or lead to shallow runways under humus. Snyder (1929) found two individuals in a nest of leaves and dried grass under driftwood on an open sandy beach. The nest had entrances at top and bottom, and a short tunnel led to the bottom entrance. Lindsay (1960) found two shrews in a nest under a board. The nest was in a depression, was about 100 mm in diameter and 70 mm deep, was of dry grasses, and had entrances at the top and bottom. A short tunnel in the soil led to the bottom entrance. Broadbooks (1952) found a nest containing three young and both parents in Texas under a large piece of sheet metal. The nest was a loose pile of willow leaves, 180 mm in diameter and 50 mm high in a shallow depression. Two runways connected with the nest, one from the bottom and one from the side. There was a toilet area about 75 mm in diameter at the edge of the nest.

Gottschang (1965) reported runways about the "diameter of a lead pencil." Paradiso (1969) stated that *Cryptotis* will use the burrows of other mammals but may also make its own, which are difficult to identify because of similarity to those of certain insects. *Cryptotis* digs by rooting about with its snout, and using the forefeet and sometimes the hind feet for dirt removal (Chamberlain, 1929); Davis and Joeris (1945) stated that the front feet are used for digging, and recorded

two shrews cooperating in building a burrow. One did most of the digging, the other removed dirt and packed the tunnel walls with most of it, although a little was scattered near the entrance. In about 2 hours of continuous work the two formed a burrow 0.6 m long and with four openings. These captive shrews burrowed through the surface soil in the manner of moles, pushing up a tiny ridge of soil as they went. Moore (1943) measured the burrow produced by a captive as 13 mm high and 18 mm wide.

A female *Cryptotis* (Conaway, 1958) was aggressive in that she attempted to bite whenever her young were handled. She carried them back to the nest if placed outside until after they were 18 days old, when they were first permitted to leave the nest. A litter born to a captive female was killed by the female (Broadbooks, 1952).

Davis and Joeris (1945) found *Cryptotis* to be cleanly, "washing and combing" its fur with the front feet. Special parts of the cage were used for defecation, and the nest was kept clean. Moore (1943) stated that feces and urine were extruded at the same time, taking but an instant, but accompanied by a contortion, seemingly a peristalsis of the whole body.

Hamilton (1934, 1944) and Davis and Joeris (1945) stated that *Cryptotis* is active at all hours, but more active at night. Broadbooks (1952) found a captive female to scurry about rapidly, often holding her nose in the air, sniffing and quivering her vibrissae. Hamilton (1944) and Jackson (1961) stated that individual *Cryptotis* will sleep for a considerable period when well fed, with "head, feet, and tail curled under its belly." Broadbooks found the species to be a good swimmer. In water its body was so high that it nearly seemed to be running on the surface.

Hamilton (1944) did not think sight and smell were of great importance to this species, nor that hearing was acute, unless for supersonic sounds. Moore (1943) felt that *Cryptotis* depended little on sight, more on hearing, yet mostly on smell. Springer (1937) found the species to produce odor detectable to 3 m, only at times. Cooper (1960) also stated that a female "exuded a characteristic musky smell." Springer (1937) found the species to make "flicker-like" calls, which were not excessively high and thin, and could be heard to about 0.5 m, and Moore (1943) reported that individuals often emitted tiny "bird-like chirpings."

Gould (1969) studied sound production and communication in *Cryptotis*. Baby *Cryptotis* emitted clicks when removed from their mothers at 9 days of age and "twittered" when a dispersed group was put back into the nest with the mother. Gould described several calls in adult *Cryptotis* including low intensity "clicks," "puts," and "twitters," but the clicks were the prominent calls. These calls often are used when shrews are alone and exploring unfamiliar surroundings. Sometimes forward and upward body extensions are associated with the calls. The "put" rate is similar to the "sniffing" rate, hence Gould suggested that this call is simply an acoustical result of intense sniffing. Single chirps are sometimes given during excretion. Twittering had developed by 10 days of age, and possibly earlier. The clicks apparently are identical to those of infant shrews and are produced by males during courtship as well as during exploration. When the response of the female has begun to shift from aggressive to slightly receptive, the male may sit close to her with his snout alongside hers and their vibrissae in contact. One male in this situation emitted 13 clicks in five seconds. Clicks are also emitted when the forefeet are used to wash the mouth, when investigation of a small object is occurring, or when the snout is extended over the edge of an object. Females emit single and repeated clicks of medium intensity when receptive, and a medium intensity ultrasonic train of pulses (50 to 420 ms, mean of 12 pulses 162 ms) was produced by shrews of either sex during intense exploration. Gould felt it was probably used for echolocation. High intensity sounds consisted of buzzes and usually were produced during close encounters between two individuals, especially by unreceptive females encountering males.

No fights were observed during the many encounters studied by Gould between two shrews of this species. Springer (1937) likewise found no fighting, even when two shrews were feeding from the same piece of food. They occupied the same nest in apparent harmony.

For information on nests of *Cryptotis* containing two or more adults see above. Many of those nests were in relatively sparsely vegetated situations under some flat object such as rocks, boards, or sheet metal. In two cases there was a fecal pile near the nest. Reports of other nests are as follows: nest

of dried grass under a flat rock in Kentucky (Welter and Solberger, 1939); nest and runway system in dense Bermuda grass, under a piece of tin about 0.6 m square—the nest about 13 mm deeper than the burrows and 75 mm in diameter, and its sides and bottom lined with grass (Hunt, 1951); nest under a plank in a cow pasture in dry earth and sparse vegetation, in a damp depression, and containing pieces of grass and leaves. Another nest 50 mm in diameter and of the same material was under a fence post in a closely cropped field (Kilham, 1954). A nest of shredded grass, smaller than a baseball, flattened above (Hamilton, 1944), and thought to be that of *Cryptotis* was under a marsh elder (*Iva frutescens*). A nest under a log in Texas was of shredded corn husks (Jackson, 1961). Another nest was in a leaf filled hollow under a board on an earthen bank (Cooper, 1960).

Davis and Joeris (1945) found three burrows occupied by *Cryptotis*. One appeared to be essentially a crack in clay soil, but extended about 200 mm below the surface and ended in a nest; one, slightly less than 25 mm in diameter and 250 mm long, was in sandy loam and apparently was dug by the shrew. It reached 200 mm below the surface and terminated in a nest. The third was at least 1.5 m long, reached to 200 mm below the surface, and had a short side branch leading to a nest chamber. Davis (1944) dug a *Cryptotis* out of a sand bank.

GENETICS. No information was found on genetics of this species.

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- The principal editor for this account was S. ANDERSON.
- J. O. WHITAKER, JR., DEPARTMENT OF LIFE SCIENCES, INDIANA STATE UNIVERSITY, TERRE HAUTE 47809.