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Nesting Behavior and Movements of Western Pond Turtles, *Clemmys marmorata*

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*cinereus*, and is quite similar to other specimens of *S. preblei* in summer pelage.

To our knowledge, this record of *S. preblei* provides the first for Colorado and the southernmost of the species. The arid habitat of the Black Canyon's rim is quite different from habitats of neighboring *S. cinereus cinereus* or the distant grasslands shrew *Sorex cinereus haydeni* (= *S. haydeni*). The record seems an interesting and significant extension of the known range to the Black Canyon, Gunnison River region, from barren Tooele Co., Utah.

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### NESTING BEHAVIOR AND MOVEMENTS OF WESTERN POND TURTLES, *CLEMMYS MARMORATA*

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The western pond turtle, *Clemmys marmorata*, is distributed from Washington south to Baja California Norte (Stebbins, 1985). Many populations have been reduced or extirpated, especially where aquatic habitats have been modified or eliminated (Brattstrom, 1988; D. C. Holland, pers. obser.). The United States Fish and Wildlife Service is considering listing the western pond turtle as threatened or endangered (United States Department of the Interior, 1989), principally because of the loss of habitat. Our objectives were to characterize movements and nesting habits of western pond turtles. This information is needed to design conservation and management programs.

The reproductive biology of *C. marmorata* is not well known. Storer (1930) reports several anecdotal accounts of pond turtle nesting and concludes that sand banks along the courses of large rivers, or hillsides in foothill regions, are used for oviposition. He also concludes that nesting occurs up to 400 m from, and 60 to 90 m above, stream beds. Holland (1985) indicates that, along the central Californian coast, mating occurs in April and May, and eggs are laid from June through August. Holland (1985) additionally suggests that hatchlings overwinter in nests and emerge in

March or April. Incubation in captivity takes 73 to 80 days (Feldman, 1982). Feldman (1982) also makes a case for hatchlings overwintering in nests, based on his observations of captives.

Our study site was located in the Arroyo Laguna-Oak Knoll Creek drainage, 3 km northwest of San Simeon Point in northern San Luis Obispo Co., California, and was typical of many streams in the area. The arroyo was about 6.2 km long and drained part of a ridge of low hills between the Pacific Ocean and the Santa Lucia Mountains. Water from winter rains flowed in the arroyo from about December to April. By August, only pools of water up to about 200 m apart remained. The stream channel was 6 to 12 m wide, and the channel banks were a maximum of 9 m high. The stream bed was composed mostly of cobbles with scattered mud and sand bars. A mosaic of coastal steppe, coastal sagebrush, and oakwoods (Barbour and Major, 1988) covered the hills surrounding the arroyo. These hills rose nearly 60 m above the stream bed. Closed-canopy woodlands 4 to 10 m high, separated by patches of coastal sagebrush and steppe, characterized the riparian corridor (Figs. 1 and 2; Barrett, 1966).

Arroyo Laguna-Oak Knoll Creek supports a population of 150 to 180 *C. marmorata* (D. C.



FIG. 1—Arroyo Laguna-Oak Knoll Creek drainage, illustrating the distinct riparian corridor surrounded by coastal steppe. Sites A and B, marked by a black star, correspond to turtle 1 overnight sites A and B on Fig. 2.

Holland, pers. obser.). In early May 1989, we captured, x-rayed (Gibbons and Greene, 1979), radio-tagged, and marked four turtles. Our mark was a large number (1 to 4) on the carapace made with white fingernail polish. The turtles were captured 170, 285, 215, and 890 m, respectively, upstream from the mouth of the arroyo, and their

respective carapace lengths were 161.4, 154.5, 143.6, and 165.9 mm. We released the turtles 200 m upstream from the mouth of the arroyo on 19 May 1989. We recaptured, x-rayed, and released turtles 1 to 4 at their second capture sites 1,025, 100, 150, and 1,900 m, respectively, upstream from the mouth of the arroyo on 15 June 1989.

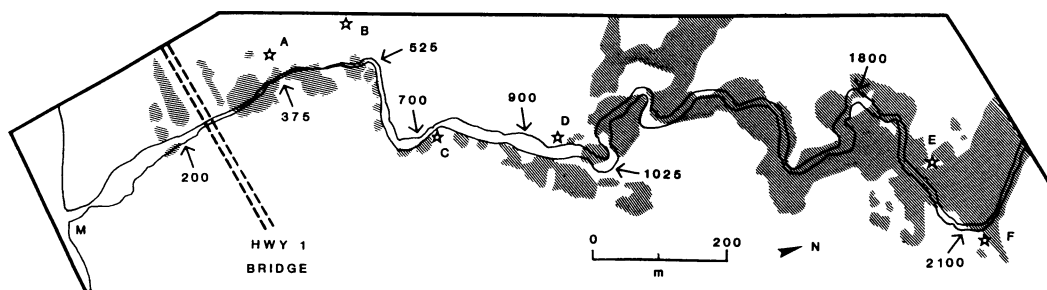


FIG. 2—Arroyo Laguna-Oak Knoll Creek, illustrating path of stream bed (parallel solid lines) and extent of closed-canopy riparian woodland (shaded). Distances from mouth of arroyo (M) are in meters (arrows). Stars show turtle overnight sites outside the stream bed: A = turtle 1, 26 May 1989; B = turtle 1, 2 June 1989; C = turtle 1, 5 June 1989; D = turtle 1, 10 June 1989; E = turtle 4, 16 and 18 June 1989; F = turtle 4, 21 June 1989.

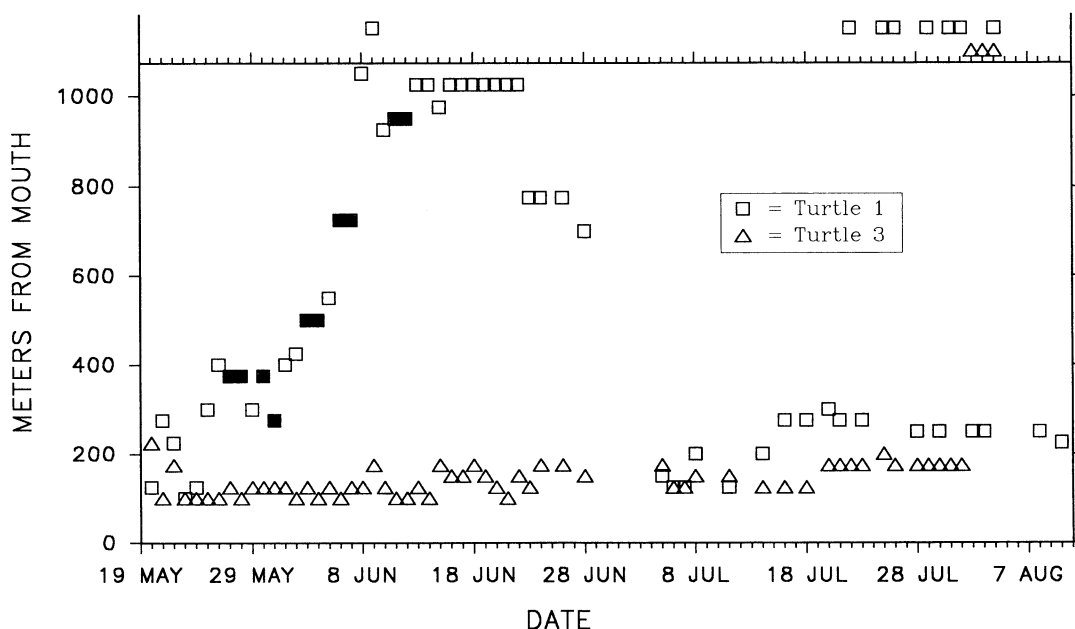


FIG. 3—Movements of radio-tagged turtles 1 and 3 in Arroyo Laguna-Oak Knoll Creek from 19 May through 9 August 1989. Filled-in symbols show sites outside the stream bed, and the symbols outside and across the top of the graph indicate we searched but did not find the turtles. There is no symbol on dates when we did not radio-track.

Cedar Creek Bioelectronics Laboratory (Bethel, Minnesota) constructed the 164 MHz radio transmitters. Each unit, along with a coiled 0.25-wave antenna and battery, was encased in epoxy and attached to the turtles with 5-min epoxy near the midline of the third vertebral shield. We used dental acrylic to contour the 10-g, rectangular units (4 cm long, 1.5 cm wide, 1 cm deep) to the carapace. The batteries were predicted to last about 60 days, with a transmitter pulse rate of about 60/min and a signal duration of about 14 milliseconds.

We located the turtles hourly between 0800 and 2000 h from 20 to 25 May 1989, every 2 to 3 h between about 0800 and 2000 h from 26 May through 7 June, once or twice a day in the morning or late afternoon from 9 to 21 June, and every other day from 21 June until 28 August. By the end of August, all transmitters were dead, and we could no longer locate the turtles. Rarely were we unable to find the turtles during radio-searches (Figs. 3 and 4). We plotted locations of turtles to the nearest 25 m segment of stream course on a map we drew from aerial photographs taken in June 1989.

Turtles 1 and 4 left the stream bed and con-

structed nests after moving upstream about 1 and 2 km between 19 May and 9 August. We never found turtles 2 and 3 outside the stream bed, and they moved <500 m up the stream channel during our study (Figs. 3 and 4). We used extreme locations on consecutive days to described daily movements for each turtle from 20 May to 21 June 1989. The medians and means ( $\pm 1$  SD) of these daily movements for turtles 1 to 4 were 37.5 and 60.5 m (73.5), 25.0 and 54.6 m (74.6), 25.0 and 28.0 m (27.8), and 25.0 and 87.1 m (156.1), respectively.

All six locations where we found turtle 1 out of the stream bed were in open, grassy areas with a southern exposure (Figs. 1–3). On two of these excursions, we saw her excavate nests. In both cases, she dug holes after moistening the soil with the contents of her bladder. She deposited no eggs in the holes and left them open. When we recaptured and x-rayed her on 15 June 1991, she had deposited her six eggs. Turtle 1 started all of her trips out the stream bed between 1700 and 2000 h. On four excursions, we were certain she was not disturbed by our radio-tracking activity (26 May; 2, 5, and 10 June). On these days, she traveled nearly perpendicularly away from the

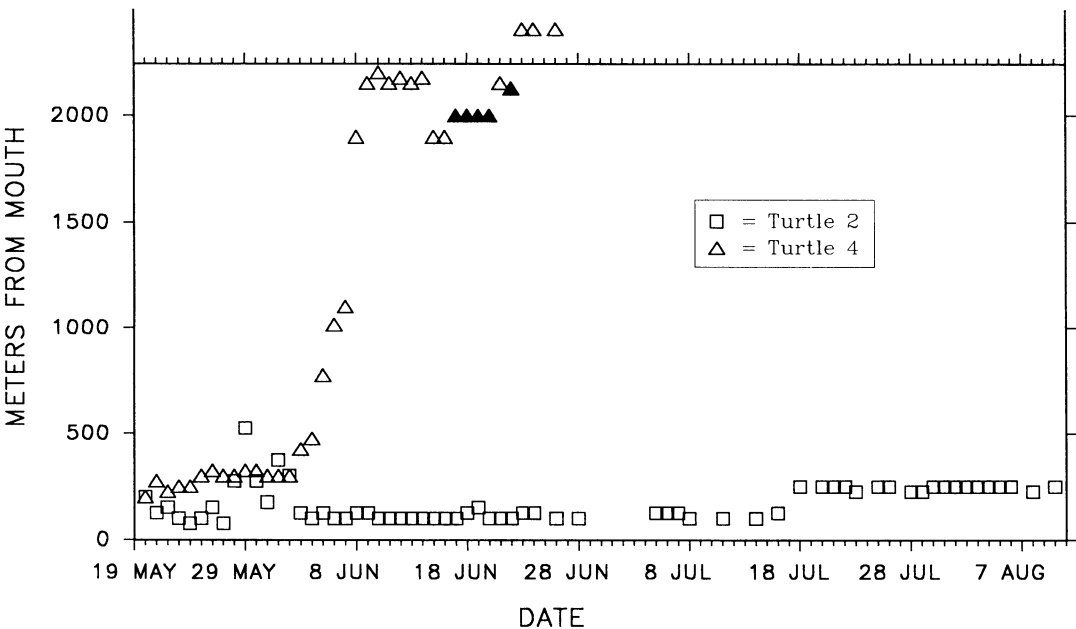


FIG. 4—Movements of radio-tagged turtles 2 and 4 in Arroyo Laguna-Oak Knoll Creek from 19 May through 9 August 1989. Filled-in symbols show sites outside the stream bed, and the symbols outside and across the top of the graph indicate we searched but did not find the turtles. There is no symbol on dates when we did not radio-track.

edge of the arroyo 41.4, 59.7, 14.3, and 21.3 m, respectively. These sites were 3.4, 11.6, 3.8, and 8.1 m above the stream bed. In all four cases, within about an hour of dawn the next morning, we found her either on, or within about 45 cm of, the same site as the evening before. In the morning, she remained motionless in the sun until between 0815 and 0900 h when she walked back to the arroyo along the route by which she had left. We checked her nest sites periodically until 15 June but found no evidence that she revisited them.

Turtle 2 (with four eggs) traveled upstream to a sharp bend in the stream and then returned down stream (Figs. 2 and 4). We searched 30 m into the grassland on both sides of the bend but found no evidence of nesting. Turtle 3 (with three eggs) was comparatively sedentary, and we never tracked her out of the arroyo (Fig. 3).

Turtle 4 was still gravid with seven eggs when we recaptured and x-rayed her on 15 June 1991. On 16, 18, and 21 June, she made overnight excursions out of the stream bed (Figs. 2 and 4). These sites had open, southern exposures, and were 15.2, 19.5, and 15.2 m from the arroyo edge, and 5.4, 5.4, and 11.3 m above the stream bed.

Only after the 18 June trip did we discover an open, empty nest hole. Transmitter failure on 22 June prevented us from tracking her further.

The three nest holes we observed were flask or pear shaped. Each was surrounded by a turtle-shaped bare area that was trampled and scraped clean of vegetation. The holes ranged from 6.5 to 8 cm deep, 6.5 to 7 cm across the widest part, and 3.5 to 4 cm across the opening. We do not know how long it took the females to make a nest, but we suspect it took at least several hours to dig in the hard dry soil.

Unfortunately, little research has been done on the movements of *C. marmorata* to compare with our work. Bury (1972) reported that a radio-tagged male pond turtle in a northern California stream travelled 700 m in 4 days. Bury (1972) also opportunistically recaptured marked turtles. The maximum movement of a recaptured turtle within one summer was 1,550 m. These movement data are similar in extent to our results for turtles 1 and 4 (Figs. 3 and 4). Our data, however, may have been influenced by homing behavior because we mistakenly did not release the turtles at their capture sites (see methods). On the other hand, the 30 m difference between the capture



and release sites of turtle 1 is small compared to her 1-km upstream movement (Fig. 3).

Why do some female pond turtles spend an entire night far from water and shelter and risk predation while digging a nest in dry, hard soil? There are at least three likely hypotheses, which are not mutually exclusive. First, southern exposure outside the riparian corridor may provide necessary heat for a short, successful incubation, while cooler, shaded habitats within the riparian corridor may not be warm enough. In addition, if *Clemmys* has environmental sex determination, as in some other turtles (Janzen and Paukstis, 1991), then upland nesting sites may be an important life-history and population-dynamics factor. Second, females that oviposit within the flood plains of arroyos may experience low reproductive success. Because of the Mediterranean climate of central and southern California, arroyos are prone to sudden flooding only during the winter. These floods often scour the stream beds of vegetation as well as sand and mud bars (Major, 1988). Scouring would probably wash eggs to sea. Third, nest predation may be less frequent in uplands. Upland sites may be outside the habitat normally frequented by raccoons (*Procyon lotor*), a known and significant turtle-nest predator (Christiansen and Gallaway, 1984; Holland, 1985; Temple, 1987). Also, mud and sand bars are often only a few meters long and widely spaced in central coast arroyos. In this situation, a gravid female might increase her reproductive success by selecting a nesting site distant from others. Widely spaced nests may discourage development of efficient search images by predators, such as raccoons, striped skunks (*Mephitis mephitis*), and coyotes (*Canis latrans*).

Although we did not gather data on whether hatchlings overwinter in nests, this phenomenon is probably closely associated with the evolution of nest-site selection. Gibbons and Nelson (1978) proposed several reasons for the evolution of overwintering in aquatic turtles, but they favored the hypothesis that it was a strategy to avoid unpredictable, adverse environmental conditions for the hatchlings. In central and southern California, overwintering in nests outside the stream channel may allow hatchlings to avoid the scouring action of winter runoff, as previously discussed for eggs.

Because our pond turtles moved several hundred meters up and down the arroyos (Figs. 3 and 4) as well as considerable distances overland prior to oviposition, they may require a long,

relatively wide "corridor" of habitat. Our data, and nesting accounts in Storer (1930), suggest this habitat corridor may extend at least up to 0.5 km on each side of water courses. Protection of these upland areas is clearly critical during the 70- to 80-day incubation period (Feldman, 1982) in summer, but it also may be equally important to protect the upland areas year-round because of the likelihood that the hatchlings overwinter in nests (Feldman, 1982; Holland, 1985).

As the human population continues to grow in California, riparian corridors and the water itself in many of the arroyos will come under increasing demand for urban and agricultural uses. Without some protection of the arroyos and associated upland areas, the long-term survival of pond turtle populations in central and southern California cannot be assured.

We thank the Hearst Corporation for permission to conduct fieldwork on Rancho Piedra Blanca. The United States Fish and Wildlife Service provided the radio-tracking equipment. J. Eliason, B. Hatfield, and S. Wright assisted with radio-tracking. We appreciate the assistance of J. Truax in radiographing the turtles and D. Hilger for providing dental supplies. The research was conducted under permit from the California Department of Fish and Game. Thoughtful comments on early drafts of this manuscript were provided by B. Bury, K. Dodd, R. Hays, J. Staton, and two anonymous reviewers.

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## DIETS OF MOUNTAIN LIONS IN SOUTHWESTERN ARIZONA

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The primary diet of mountain lions (*Felis concolor*) is comprised of ungulates (Young and Goldman, 1946; Robinette et al., 1959; Hornocker, 1970; Shaw, 1977; Leopold and Krausman, 1986). However, diets of mountain lions in the Lower Sonoran Desert where ungulate densities are low (<1 deer/km<sup>2</sup>; P. R. Krausman, pers. obser.) have not been described. The Harquahala Mountains in southwestern Arizona contain high densities of mountain lions (Shaw, pers. obser.). While conducting ungulate studies adjacent to the Harquahala Mountains and monitoring the movements of three mountain lions, we collected scats to determine the diets of lions inhabiting the Lower Sonoran Desert.

Five mountain ranges and surrounding areas were searched for scats from mountain lions: Harcuvar and Harquahala mountains, La Paz Co., 70 km west of Wickenburg, Arizona; and Vulture, Big Horn, and Belmont mountains, Maricopa Co., Arizona, approximately 80 km west of Phoenix, Arizona. Elevations ranged from

426 m on the desert floor to 1,732 m in the Harquahala Mountains. The topography ranged from desert flats to rugged cliffs. Mean yearly precipitation was approximately 20 cm (Sellers and Hill, 1974), occurring in winter and late summer. Summer temperatures often exceeded 45°C. Ranching, mining, agriculture, and hunting were common uses of this area.

When a scat was located, it was placed in a labeled paper bag and stored in a freezer. Scats were air-dried for 1 to 2 weeks prior to analysis. We calculated frequency of occurrence of food items and estimated the volume of food items in each scat with a volumetric cylinder. A reference collection of hair-scale impressions of food items was made following Williamson (1951). Scale photographs of hair (Adorjan and Kolensky, 1969; Moore et al., 1974) were used to confirm species identification of food items. Individual scats were broken apart and sorted into separate piles based on hair type (Krausman and Ables, 1981). Hair mounts were made using representatives from