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OVERWINTERING SITES AND THERMAL RELATIONS OF HIBERNATING BOG TURTLES, *CLEMMYS MUHLENBERGII*.—

Hibernation is a typical behavioral feature of north temperate turtles (Penney, 1987). Gregory (1982) and Hutchison (1979) provide reviews of the subject, but detailed observations of hibernating turtles under natural conditions are available for only a few species (*Terrapene carolina*—Carpenter, 1957; Gatten, 1987; *Malaclemys terrapin*—Yearicks et al., 1981; *Chelydra serpentina*—Ultsch and Lee, 1983). Here we describe the hibernacula and thermal relations of overwintering bog turtles (*Clemmys muhlenbergii*) in Pennsylvania and New Jersey.

Methods.—Forty-four hibernating *C. muhlenbergii* were captured at Piedmont sites in Lancaster Co., Pennsylvania, and Sussex Co., New Jersey, and a Coastal Plain site in Monmouth Co., New Jersey. Studies were conducted from 1965–85 in Pennsylvania and 1977–80 in New Jersey. Turtles were located by hand probing known burrows, stepping on turtles in the mud, or by probing the soft bottom of waterways, muskrat (*Ondatra zibethicus*) burrows, or tussocks of *Carex* with a wooden pole. Detailed descriptions of the study sites and populations are given elsewhere (Ernst, 1976, 1977; Zappalorti, 1976). Cloacal, air, water, and substrate temperatures (the latter three taken as near as possible to the point of capture) were recorded at time of capture with a Yellow Springs thermistor thermometer or Schultheis quick reading thermometer. Substrate temperatures of buried turtles were taken at the depth at which they were found. Turtles were then sexed using characters given by Ernst and Barbour (1972), marked for future identification by cutting notches in the marginal scutes (Ernst et al., 1974), and released at the capture site. Data were combined for the two New Jersey sites because of a high degree of habitat similarity. Statistical tests are considered to be significant if $P < 0.05$.

Results.—*Hibernacula.*—Muskrat burrows were abundant at the Pennsylvania site, and hibernating *Clemmys muhlenbergii* found within them were partially to totally buried in the main tunnel 1.0–1.8 m from the entrance in 3.0–7.5 cm of water and mud (Table 1). Six other turtles were found buried 20–25 cm into the mud bottom of marsh rivulets under 5–15 cm of water. A single individual was found dormant among the roots of a large clump of *Carex*. The turtle was located above the water line and about 16 cm from the outer periphery of the tussock. *Carex* clumps were abundant at the Pennsylvania site, but despite their common use as nesting sites and summer retreats, no other hibernating turtles were located within them. A male and female were found overwintering together in a muskrat burrow during two consecutive winters. Most *Clemmys muhlenbergii* were dormant from late Sept. until the middle of April (Ernst, 1977). Hibernating juveniles were not located in Pennsylvania.

TABLE 1. OBSERVED HIBERNACULA USED BY BOG TURTLES, *Clemmys muhlenbergii* DURING THIS INVESTIGATION. Percentages for hibernacula use within states are given in parentheses.

Sites	Pennsylvania	New Jersey	Total
Soft bottom of waterway	6 (32)	13 (52)	19 (43)
Muskrat burrow	12 (63)	0 —	12 (27)
Carex clump	1 (5)	1 (4)	2 (5)
Submerged at base of cedar stump	0 —	5 (20)	5 (11)
Meadow vole burrows	0 —	6 (24)	6 (14)
Total	19 (100)	25 (100)	44 (100)

All hibernacula in New Jersey were situated in subterranean rivulets or seepage areas where water flowed continuously from underground springs (Table 1). It was occasionally necessary to chop through 3–13 cm of ice to relocate hibernating turtles. Four adults were found in burrows leading to soft-bottomed waterways that appeared to have been excavated by the turtles themselves, as evidenced by claw marks and the shape of the burrow. Other burrows (in *Sphagnum* moss) appeared to have been enlarged tunnels originally created by meadow voles (*Microtus pennsylvanicus*). Dormant turtles in all burrows were found under 5–55 cm of water and mud. During the active season (mid-April–end of Sept.), 45 individuals were observed using the runways and burrows of other small terrestrial mammals including meadow voles, eastern chipmunks (*Tamias striatus*), white-footed mice (*Peromyscus leucopus*), and meadow jumping mice (*Zapus hudsonius*). Four adult tur-

TABLE 2. HIBERNATION DATA FOR A FEMALE *Clemmys muhlenbergii* IN NEW JERSEY. All temperatures in degrees C.

Date of recapture	Time of recapture	Cloacal temp.	Substrate temp.	Air temp.	Buried depth of turtle (cm)
5 Nov. 1977	1255 h	12.0	12.0	14.2	45
15 Oct. 1978	1531 h	11.2	12.0	8.0	5
20 Oct. 1978	1500 h	11.8	9.2	16.6	10
29 Oct. 1978	1518 h	9.0	8.8	17.0	45
5 Nov. 1978	1450 h	7.8	8.4	9.0	48
29 Dec. 1978	1648 h	1.5	0.8	−5.0	50
28 Jan. 1979	1150 h	1.4	2.0	−3.0	55
6 Oct. 1979	1300 h	15.1	19.5	14.5	10
13 Oct. 1979	1320 h	10.8	10.1	15.2	18
21 Oct. 1979	1245 h	12.3	11.8	21.1	30
24 Nov. 1979	1520 h	9.6	8.8	16.2	50
13 Jan. 1980	1415 h	2.0	1.6	0.0	55
13 Feb. 1980	1500 h	1.8	2.0	−5.0	53
18 March 1980	1330 h	2.8	2.8	8.0	48
25 April 1980	1450 h	19.2	16.3	17.0	Surface

tles were observed burrowing into *Sphagnum* moss clumps along soft-bottomed waterways that later served as their hibernacula. One adult male was found buried in mud and water between the roots of two *Carex* tussocks at the Coastal Plain site. An individual female turtle was captured 14 times over four successive winters while hibernating (Table 2). She was always found under moving water submerged in mud, lying next to the roots of an alder bush (*Alnus*). The actual depth at which she burrowed into the soft bottom was inversely related to substrate temperature (Spearman's rho = −0.86, P = 0.002). Subsequent recaptures (n = 8) during the spring and summer were never farther than 55 m from the hibernaculum. Other turtles occasionally returned to the same hibernation site two or more years in a row (n = 12). Although most hibernacula contained only one turtle, groups of 2–5 individuals were observed on four separate occasions. The five turtles found at the base of a cedar stump, on the same day (Table 1), were all less than 7 yr old (one hatchling, two yearlings, one 4 yr old, and one 6 yr old). This hibernaculum was located in a known nesting area approx. 40 m from the area where all the mature adults hibernated during the 4 yr of observation.

Thermal relations.—Cloacal temperatures of hibernating *C. muhlenbergii* were highly correlated with environmental temperatures, as expected for an ectotherm. Coefficients of determination (r^2) were: 0.52 for air temperature, 0.84 for water temperature, and 0.96 for substrate temperature. The slopes of regression equations for cloacal temperature vs water and substrate temperatures were not significantly less than one indicating thermal conformity. Cloacal temperatures for 43 dormant turtles (not including data in Table 2) ranged from 2.6–16.0 C with a mean of 8.6. There was no significant difference between male and female cloacal temperatures ($t = 0.36$, 40 df, $P > 0.10$).

Discussion.—Previous information regarding the behavior of hibernating *C. muhlenbergii* is scant. Holub and Bloomer (1977) reported that larger specimens selected deeper areas in the bogland for hibernation, whereas hatchlings and juveniles overwintered in the immediate vicinity of nest sites. Hibernating congregations of 3–141 specimens were reported by Bloomer (1978). Other references to hibernation in this species, which generally suggest a dormant period of about 6 mo, are reviewed by Bury (1979).

This study indicates that the overwintering behavior of *C. muhlenbergii* is similar to that of the syntopic spotted turtle, *C. guttata* (Ernst, 1976, 1982), and wood turtle, *C. insculpta* (Ernst, 1986). Important differences include a longer period of dormancy in *C. guttata* (Lovich, 1988), and that *C. insculpta* at the Pennsylvania site has not been found to use muskrat burrows for hibernation (Ernst, 1986). Differences in the use of various types of hibernacula between New

Jersey and Pennsylvania populations of *C. muhlenbergii* (Table 1) may be due to differences in microtopography or the relative abundance of burrowing mammals at each site. Meadow voles were not common at the Pennsylvania site during the period of study, and muskrats, although present at the New Jersey sites, were not found in habitat preferred by *C. muhlenbergii.*

The thermal relationships reported in this paper demonstrate that hibernating *C. muhlenbergii* are thermal conformers, a situation also reported for hibernating *C. insculpta* (Ernst, 1986) and *Chrysemys picta* (Peterson, 1987). In spite of this, hibernating *Clemmys muhlenbergii* may be able to behaviorally regulate body temperatures to some degree by selecting favorable hibernacula or moving vertically within the substrate in response to various environmental temperatures. Such behavior was observed by Carpenter (1957) for *Terrapene carolina triunquis,* and Peterson (1987) for *Chrysemys picta.* In fact, Sturbaum (1982) concluded that while turtles possess physiological mechanisms for altering heat exchange rates, their primary means of control is behavioral.

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OXYBELIS BOULENGERI PROCTER, A VALID SPECIES OF VINE SNAKE FROM SOUTH AMERICA.—Procter (1923) described *Oxybelis boulengeri* from a single specimen collected "in Trinidad, River Mamore, Bolivia." She considered *O. boulengeri* closely allied with *O. argenteus* and tabulated these differences (condition in *O. argenteus* vs condition in *O. boulengeri*): Eye moderate, 7 times in total head-length, vs large, 5½ times in head-length. Frontal 3 times as long as broad, vs 4 times as long as broad. Anal entire, vs divided. Throat with regular punctuations, vs immaculate. Coloration upper surface light brown; ventrals cream, with 2 wide green lateral and a slender median streak, vs upper surface olive ventrals dark bright green with pale median streak.

Amaral (1930a) examined the holotype and considered the immaculate throat and divided anal plate as variations anticipated for *O. argenteus.* Amaral (1930b) listed *O. boulengeri* Procter as a junior synonym of *O. argenteus* (Daudin) but provided no justifications for the action. For the next 44 yr, *O. boulengeri* was ignored or listed within synonymies of *O. argenteus.*

In Keiser (1974), I remarked: "*Oxybelis boulengeri* Procter (1923), although synonymized by Amaral (1930a), may be a rare but valid species which is closely allied with *Oxybelis argenteus.*" My recognition was tentative pending examination of the holotype and a review of museum specimens of *O. argenteus.* Despite these comments, *O. boulengeri* has subsequently been recognized in the literature only as a junior synonym of *O. argenteus.*

I have examined the holotype (BMNH 1946.1.9.86) and seven specimens (AMNH 56138, KU 204928, 207786, 207787 and 207788 from Peru; CAS 49355 and MNRJ 649 from Brazil) which appear to be of the same species. Six of the seven specimens and the holotype are from localities within the Rio Madeira drainage. This watershed includes southeastern Peru, northern Bolivia, and much of western Brazil. MNRJ 649 is from "Paraná de Fonte Boa, Alto Rio Amazonas, Estado do Amazonas," and, assuming the validity of the data, is not from the Rio Madeira drainage. Localities are shown in Figure 1. Data from these eight specimens compared to a series of 244 *O. argenteus* show that *O. boulengeri* possesses unique features and shared features present only in low frequencies in *O. argenteus.*

Fig. 1. Distribution map of localities of eight specimens of *Oxybelis boulengeri* in South America. Circled star is type locality.

Methods.—Spencer and Wild M5 stereomicroscopes were used for examinations requiring magnification. Measurements were made with a Fowler electronic digital caliper and, where critical, checked with a Wild MMS 225 Digital Length Measuring Set attached to the Wild M5 microscope. Eye diameter is the diameter of the orbit as measured from the preocular notch to the postocular notch. Other measurements and scale count methods are defined in Keiser (1974). Institutional abbreviations are as listed in Leviton et al., 1985.

Diagnostic characters.—Procter (1923) twice noted the relatively large eyes of *O. boulengeri.* An