MICROHABITAT USE, HOME RANGE, AND MOVEMENTS OF THE ALLIGATOR SNAPPING TURTLE, *MACROCHELYS TEMMINCKII,* IN OKLAHOMA

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ABSTRACT—Little is known about the ecology of the alligator snapping turtle, *Macrochelys temminckii,* particularly demography and behavior. To learn more about the species in Oklahoma, we conducted a telemetry project on 2 small streams at Sequoyah National Wildlife Refuge, an 8,417.5-ha refuge located in east-central Oklahoma. Between June 1999 and August 2000, we fitted 19 *M. temminckii* with ultrasonic telemetry tags and studied turtle movements and microhabitat use. Turtles were checked 2 to 3 times weekly in summer and sporadically in winter. Several microhabitat variables were measured at each turtle location and a random location to help quantify microhabitat use vs. availability. We recorded 147 turtle locations. Turtles were always associated with submerged cover with a high percentage of overhead canopy cover. Turtles used deeper depths in late summer (but not deeper depths than random locations) and deeper depths in mid-winter (and deeper depths than random locations) than in early summer. They used shallower depths than random locations in early summer. This seasonal shift in depth use might be thermoregulatory, although evidence for this is indirect. The mean linear home range for all turtles was 777.8 m. Females had larger home ranges than males, and juveniles had larger home ranges than adults, although the latter was not statistically significant. *Macrochelys temminckii* used submerged structures as a core site, and stayed at each core site for an average of 12.3 d.

RESUMEN—No se sabe mucho de la ecología de la tortuga *Macrochelys temminckii,* especialmente de su demografía y comportamiento. Para conocer más a la especie en Oklahoma iniciamos un proyecto de telemetría en dos riachuelos chicos en el Refugio Nacional de Fauna Silvestre de Sequoyah, un refugio de 8,417.5 ha en el centro-este de Oklahoma. Entre junio de 1999 y agosto del 2000, armamos a 19 individuos de la tortuga con equipos de telemetría ultrasónica y estudiamos sus patrones de desplazamiento y uso de microhábitat. Se revisaron las tortugas 2 a 3 veces cada semana en el verano y esporádicamente en el invierno. Se registraron varios parámetros de microhábitat en cada ubicación de tortuga y una ubicación al azar para ayudar a cuantificar el uso vs. la disponibilidad de microhábitat. Se registraron 147 ubicaciones de tortugas. Las tortugas siempre estuvieron asociadas con cubierta sumergida con un alto porcentaje de dosel arriba. Las tortugas usaron agua más profunda en el verano tardío (pero no más profunda que las ubicaciones al azar) y agua más profunda a mediados del invierno (y más profunda que las ubicaciones al azar) que en el verano temprano. Usaron agua menos profunda que ubicaciones al azar en el verano temprano. Este cambio estacional en el uso de profundidad puede ser termorregulatorio, pero la evidencia no es directa. El promedio de rango de hogar lineal para todas las tortugas fue de 777.8 m. Las hembras tuvieron rangos de hogar más grandes que los machos, y los juveniles tuvieron rangos de hogar más grandes que los adultos, pero el último no fue estadísticamente significativo. *Macrochelys temminckii* usó estructuras sumergidas como un sitio principal y se quedó en cada sitio principal por un promedio de 12.3 días.

One of the earliest records of movement of *Macrochelys temminckii* was a 23-kg individual captured in the Washita River in Bryan County, Oklahoma, in 1915 (Wickham, 1922). The turtle was released in the Blue River, Bryan County, Oklahoma, in 1918, then recaptured 27 to 30 km upstream from the release site in 1921. More thorough studies of *M. temminckii* movement have been conducted in Kansas, Louisiana, and Missouri (Sloan and Taylor, 1987; Shipman et al., 1991, 1995; Harrel et al., 1996; Shipman and Neeley, 1998). Those studies showed that *M. temminckii* moved extensively throughout its aquatic environment, although individuals chose specific microhabitat sites as resting or core sites. The core sites had more structural cover and denser overhead canopy than other available habitats. *Macrochelys temminckii* is typically thought to be relatively sedentary (Ernst et al., 1994). Shipman et al. (1991) observed that individuals remained inactive for up to 8 d at a time.

While conducting a mark-recapture study of *M. temminckii* at Sequoyah National Wildlife Refuge (Sequoyah NWR), Sequoyah County, Oklahoma (Fig. 1), we outfitted individuals with telemetry tags. The primary goal was to quantify microhabitat use and possible core site selection. Movement data also were collected to determine movement patterns and home range use by *M. temminckii.* Previous studies had been conducted in more open, lentic environments (Sloan and Taylor, 1987) and a larger river (Shipman and Neeley, 1998).

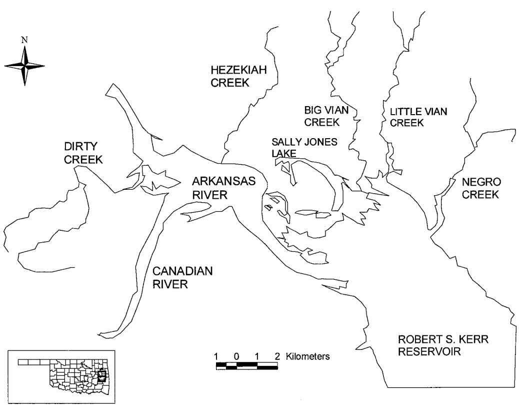

FIG. 1—Study area for tracking project of *Macrochelys temminckii* at Sequoyah National Wildlife Refuge, Oklahoma, from June 1999 to August 2000.

The site at Sequoyah NWR consisted of 2 small creeks that drain into the Arkansas River. The only other published study conducted in this type of smaller, lotic habitat was conducted by Shipman (1995) in Kansas. The sample size for the Kansas study was only one individual, a 24.7-kg female. The study at Sequoyah NWR provides more complete data on the species and also provides a comparison to populations in a variety of habitats.

METHODS—Turtles were captured using commercial hoop nets that were 2.1 m long and constructed of four 1.05-m hoops covered with 2.5-cm square mesh. Nets were set upstream from submerged structures, such as fallen trees. Nets were baited with fresh fish suspended by a piece of twine on the hoop farthest from the opening of the net. Baitfish were procured with gill nets or incidental capture in the turtle nets. Turtle nets were set late in the afternoon or evening and checked the following morning.

Tags were ultrasonic sensors that were 65 mm long and had a mass of 8 g. We attached tags to the rear margin of the carapace by drilling 0.63-cm holes in the carapace and looping heavy-gauge monofilament fishing line and plastic cable ties through the holes and transmitters. We tracked turtles using a Sonotronics USR-5W digital receiver and a directional hydrophone (Sonotronics, Tucson, Arizona). Turtle locations were pinpointed using triangulation.

We divided the study area into 2 sub-areas, Big Vian Creek and Little Vian Creek. Big Vian Creek was navigable from the mouth to 4 km upstream; Little Vian Creek was navigable from the mouth to 2 km upstream. The mouths of the 2 streams were separated by 0.5-km straight distance.

At each turtle location, we measured depth of the stream, canopy cover, and cover type. Canopy cover was estimated with a concave forestry densiometer (Lemmon, 1957). We compared microhabitat variables at sites used by the turtles against microhabitat characteristics at random points. To locate random points, we laid a grid over the study area; the grid was composed of a numbered flag placed every 50 m from the mouth of each stream to the point at which the stream became unnavigable. We chose random points along the stream by using x-y coordinates along the grid. The x-coordinate corresponded to points at or between numbered flags, while the y-coordinate represented distance from the bank. Random coordinates were selected from a random number table. We recorded the same set of microhabitat data at a random point paired with each turtle point the same day. We used paired *t*-tests to compare microhabitat data collected at each turtle location to those collected at random locations, and 2-sample *t*-tests to analyze seasonal differences in microhabitat use.

We located turtles 2 to 3 times weekly from June through the first part of August in 1999 and 2000. We also located them sporadically in September and November 1999 and February 2000. A linear home range was determined by measuring the distance between the 2 farthest points along the stream at which a turtle was located. We analyzed movement patterns only for the period of time between June and August when regular location checks were made. We included in the analysis only movements between core sites, or from a core site to a baited net. We defined a core site as a submerged structure that a turtle used for ≥3 d during inactive periods.

For turtles located from May through September, we collected measurements of habitat variables at their exact location and also at random locations on the same day. However, during November and February, we located turtles (n = 22) and measured habitat variables at their locations, but not at random points. Thus, we collected suitable data for pairwise data analysis for May through September, but not November and February. To include those latter months in pairwise analyses of depths, we tested the idea that if random depths varied little from month to month from May through September, then we would be justified to draw from those months random depths to match with the depths actually used by the turtles during November and February. We found no significant difference of random depths collected from May through September (ANOVA: $F_{4,94}$ = 0.48, P = 0.749). This does not imply that maximum depth of the streams did not change over the months, only that depths of random sites did not differ, probably because random sites included many shallower depths, which do not differ in relation to maximum depth. Thus, we drew depths of random points (n = 22) from May to September to match with actual depths used by turtles during the small samples in November and February.

RESULTS—Between June 1999 and August 2000, we outfitted 19 *M. temminckii* (8 males, 4 females, 7 subadults) with ultrasonic tags. We obtained ≥2 mo of data on 16 turtles. We recorded 147 turtle locations and used 109 locations for microhabitat analysis.

Turtles selected sites with higher canopy cover than random sites (t = 4.665, df = 108, P < 0.001). Turtles were always associated with some sort of structure, including overhanging trees and shrubs, dead submerged trees, and beaver dens. The only possible exceptions were when individuals were in water too deep for us to discern any submerged cover. There was no difference between depths used by turtles and random depths when all locations were pooled (t = −0.500, df = 108, P = 0.618), although seasonal differences in depth use were observed. Depths were deeper in the hottest months (July and August; t = −4.27, df = 75, P < 0.001) and the coldest months (November and February; t = −4.94, df = 33, P < 0.001) compared to spring and early summer months (May and June). There was no difference in depth use between July and August and November and February (t = −0.313, df = 59, P = 0.755), although winter depths were slightly deeper than late summer depths.

Turtles used shallower depths than occurred at random points in May and June (t = −2.168, df = 59, P = 0.034) and deeper depths than at random points in November and February (t = 3.230, df = 21, P = 0.004). There were no differences between random depths and depths used by turtles in July and August (t = 1.231, df = 49, P = 0.224).

The mean linear home range for all turtles was 777.8 m. Females had significantly larger linear home ranges than males (Table 1; t = 2.32, df = 8, P = 0.048), and juveniles had larger linear home ranges than adults (Table 1), but not significantly so (t = 1.40, df = 14, P = 0.18), due probably to limited sample sizes and considerable individual variation. The average distance moved between core sites was 431.2 m for juveniles and 219.3 m for adults (Table 1), but this was not a significant difference (t = 1.73, df = 14, P = 0.097), again due probably to limited sample sizes and considerable individual variation. Turtles made nearly twice as many movements in June as in July. During summer, when regular location points were taken (June through August), turtles remained at core sites for 12.3 d ± 9.7 d (range,

TABLE 1—Mean home range size (±1 *SD*) and mean distance moved between core sizes (±1 *SD*) by male, female, and juvenile *Macrochelys temmincki.*

Sex	n	Mean home range size (m)	Mean distance moved between core sites (m)
Male	7	481.4 ± 227.7	168.2 ± 137.1
Female	3	878.3 ± 298.4	249.2 ± 218.6
Juvenile	6	1,073.3 ± 1,015.4	431.2 ± 542.2

3 to 38 d) before moving to new core sites. All turtles remained at a single core site throughout winter (November and February).

On 3 occasions at Sequoyah NWR, nocturnal checks were made on several turtles at 2-h intervals. An 11.8-kg male was observed making an inter-core site movement between 2000 and 2200 h. The individual was moving when he was located and moved another 200 m upstream within a 2-h period before settling under a fallen tree. No other movements were recorded during the nocturnal observations.

Three turtles moved between creeks based on mark-recapture data. A 5.4-kg juvenile and a 9.5-kg male moved from Big Vian Creek to Little Vian Creek. The original captures and recaptures occurred 1 y apart. An 11.8-kg female was recaptured in Hezekiah Creek 2 mo after its first capture in Big Vian Creek (Fig. 1). Hezekiah Creek also is a tributary of the Arkansas River and is located 16 km upstream from Big Vian Creek (Fig. 1).

Macrochelys temminckii was visibly observed on only a single occasion. An individual estimated at 5 kg was observed surfacing to breathe in about 3 m of water. The incident occurred at 1945 h on 12 July 2000. The water was fairly clear and visibility was approximately 2 m in depth.

DISCUSSION—During the course of the study, individual *M. temminckii* moved widely, but chose specific microhabitat sites as core sites. Females moved somewhat longer distances and occupied significantly larger home ranges than males. There were slight differences in movement patterns between adults and juveniles; juveniles typically had larger home ranges and made longer movements, although there was considerable variation between individuals regardless of sex or age (Table 1).

Shipman and Neeley (1998) found that *M. temminckii* in the St. Francis River of Missouri had a mean linear home range of 1,793.6 m, which was considerably larger than what we found in our study. There were major differences between the study sites; the Missouri study occurred in a large river and the Oklahoma sites in our study were smaller streams. The major constraint on home-range size of *M. temminckii* in our study might have been availability of suitable habitat, such as appropriate water depths and submerged shelter.

Movement was primarily restricted to distances between core sites. Turtles occupied core sites for 3 d to several months. The types and duration of movements from a core site in this species are poorly known. Shipman et al. (1991) observed a 24.7-kg female in Kansas and recorded movements between 0200 and 0700 h lasting 1 to 3 h. One turtle was observed at Sequoyah NWR between 2000 and 2200 h moving between core sites and another surfacing to breathe at 1945 h.

Movements out of a local study area also might occur. Several tagged individuals were not located at the close of the study, suggesting possible dispersal. There were 3 cases of intercreek dispersal based on mark-recapture data at Sequoyah NWR (Riedle, 2001). One instance involved an individual moving 16 km in a 2-mo time period. *Macrochelys temminckii* is known to make long movements. The 24.7-kg female studied by Shipman et al. (1991) moved 7 km in 5 y. An Oklahoma specimen moved 27 to 30 km in 3 y (Wickham, 1922). Dispersal along rivers might be a common phenomenon for *M. temminckii*. Specimens reach the northern extent of the range of the species along the Mississippi River in Illinois and Iowa (Pritchard, 1989) and in Kansas along the Arkansas, Verdigris, and Neosho rivers (Shipman et al., 1995).

Two kilometers upstream from the mouth of Little Vian Creek, stream morphology changed from deeper-water runs with a mud-sand-detritus substrate to a gravel-bottom, riffle-pool habitat. Riffles were generally <25 cm deep, with some pools 2 to 3 m deep. This riffle-pool habitat is not generally thought to be ideal *M. temminckii* habitat (Ernst et al., 1994). During summer 1999, a 16.8-kg female with an ultrasonic tag occupied core sites near the transition between deeper runs and shallower riffles. After a high water event in late summer 1999, she was not located again until June 2000 near the same transition zone in the stream. It was possible the turtle moved upstream into some of the deeper pools during the high water event and then moved back downstream when water levels subsided.

Core sites used by *M. temminckii* were similar and consisted of some type of submerged structure with dense overhead canopy cover. Cover types were generally submerged logs, but turtles also used overhanging shrubs and beaver dens. *Macrochelys temminckii* might use beaver dens as diurnal refugia due to the cover they offer and air pockets they contain (Shipman, 1993). Beaver dens at Sequoyah NWR are composed of a tunnel leading under the bank into a partially submerged chamber. A 34.5-kg male was observed on several occasions occupying such a den. Based on the sporadic signal given by the ultrasonic telemetry tag, the turtle was resting at or near the surface of the water. Ultrasonic signals can be received only through a liquid medium, and the signal cut out in a pattern that suggested that the carapace was bobbing in and out of the water.

The variation in seasonal depth use by *M. temminckii* at Sequoyah NWR was intriguing. Little is known about thermoregulation in *M. temminckii*. The species does not bask, and only females leave the water (to lay eggs). Captive individuals refuse food at 18°C, become inactive at 10°C, and have a critical thermal maximum between 38.5 and 40.7°C (Allen and Neil, 1950; Hutchison et al., 1966; Grimpe, 1987). Based on seasonal depth use, we suggest that *M. temminckii* might thermoregulate by altering its depth in the water column. In the hottest and coldest months, turtles were found in deeper water. It is likely that during the hottest months turtles moved to deeper water to cool down (or avoid hyperthermia), whereas in the coldest months, they moved to deeper water to warm up (or avoid hypothermia). In the spring and early summer (May and June), turtles were found at shallower depths than randomly available, perhaps to raise their body temperatures to more optimal levels.

Macrochelys temminckii seems to prefer deeper water with associated structure and overhead canopy, and these might be factors that limit its distribution. It is a secretive species, and it is still not understood why it moves from one core site to another and what determines duration of the stays at each core site. *Macrochelys temminckii* occurred in high densities on Sequoyah NWR (33 individuals/km stretch of stream) (Riedle, 2001), and competition for food and space might be one factor that stimulates movement from one core site to another. Regardless, *M. temminckii* can disperse over considerable distances, and this might be a mechanism for colonization of new sites. From a conservation standpoint, river impoundments might be the major factor affecting dispersal between healthy and depleted populations in Oklahoma and elsewhere.

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