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Ecology of the Eastern Spiny Softshell, *Apalone spinifera spinifera*, in the Lamoille River, Vermont

Terry E. Graham[1,2] and Andrew A. Graham[2]

[1]*Department of Biology, Worcester State College, Worcester, Massachusetts 01602 USA;*
[2]*Wetlands and Wildlife Associates, 209 Pommagussett Road, Rutland, Massachusetts 01543 USA*

Abstract. – Thirty-seven eastern spiny softshells, *Apalone spinifera spinifera*, were captured near the mouth of the Lamoille River, Chittenden Co., Vermont. Males ranged in carapace length (CL) from 111.2–174.1 mm, and in weight from 105–495 g; females ranged from 218.3–365.3 mm, and from 810–3750 g. A population size of 60 adults (95% confidence interval: 35–115) was estimated for the study area and the sex ratio was not significantly different from 1:1 (18 males:17 females). Movements were extensive in spring and late summer. Telemetered turtles left their wintering grounds about 3 km upriver from Lake Champlain in late April to descend to the lake for feeding and reproduction. They nested from 14 June to 12 July 1990 on sandy beaches mostly in the vicinity of the river's mouth at Lake Champlain. Clutch size ranged from 10–21 ($\bar{x}$ = 16.0 ± 0.92). Forty-eight hatchlings ranged in CL from 32.8–43.7 mm ($\bar{x}$ = 38.8 ± 0.41), and in weight from 4.53–9.17 g ($\bar{x}$ = 6.71 ± 0.224). After the nesting period adults moved into the river and by early September had traveled upstream to settle near their wintering grounds. In October they moved to their hibernaculum on a narrow segment of the river bottom.

Key Words. – Reptilia; Testudines; Trionychidae; *Apalone spinifera spinifera*; turtle; ecology; life history; reproduction; telemetry; movements; hibernation; Vermont; USA

In spite of the fact that *Apalone spinifera* is the most widespread species of the genus in North America (Webb, 1962, 1973), knowledge of its ecology is incomplete. The disjunct northeastern population in Lake Champlain, Vermont, first reported by Thompson (1842), has been largely overlooked. The difficulty of capturing these scarce animals in sufficient numbers for study in Vermont has undoubtedly contributed to the paucity of information about them. For Vermont, where the spiny softshell is presently listed as a threatened species, old literature records of softshell distribution were summarized by Graham (1989a), preliminary analysis of status and ecology was presented by Graham (1989b), and notes on burying behavior and pattern dimorphism were reported by Graham and Graham (1991) and Graham (1991).

The research reported here was conducted from 1989–91 to determine spiny softshell abundance, local distribution, population structure, movements, nesting habits, and reproductive potential in the lower Lamoille River, Milton and Colchester, Chittenden Co., Vermont. The results of this study will be useful to nongame wildlife biologists involved with the management and recovery of *A. s. spinifera* in Vermont and elsewhere.

MATERIALS AND METHODS

Reconnaissance for spiny softshells on the Lamoille River, Chittenden County, Vermont, commenced in April 1989. The area at the river mouth and upstream from Lake Champlain for roughly 3 km was surveyed and trapped through August 1990. Standard commercial grade nylon turtle traps (Nylon Net Co.) baited with canned sardines packed in soybean oil were used, along with four modified New Hampshire fyke nets (Sterling Net and Twine Co.), each equipped with two 1.5 m throats, 25 cm throat mouths, six aluminum frames, a 61 m lead, and two 7.6 m wings (lead and wings 1.2 m deep). Scuba gear was employed on several occasions to make underwater observations of turtles and habitat.

Initially, softshells were captured in fyke nets and most subsequent captures were in baited traps or by hand (Graham and Graham, 1991). Within 24 hours of capture, measurements (to 0.1 mm) of the carapace, plastron, and tail were taken with vernier calipers. Each animal was carefully weighed with a spring balance (Pesola 2.5 kg or 10 kg capacity ± 0.3%). Turtles were individually marked (1 cm deep v-notches) with a razor knife following a system modified after Fitch and Plummer (1975) and released at their original point of capture. Although the notches began to fill in within a few weeks, marks were subsequently readable for the remainder of the study. Population estimates based on mark-recapture data were obtained using the Jolly-Seber method (Jolly, 1965; Seber, 1965). The calculation procedure was summarized by Caughley (1977), and its use with open populations has been recommended by Lindeman (1990), as opposed to the Schnabel method (Graham, 1979) which is only appropriate for closed populations. The assumption of closure was probably violated for our population for two reasons. First, the data were collected over several months, and second, river turtles usually have open populations (e.g., Plummer, 1977a) subject to flux because of migration. The 95% confidence interval for the Jolly-Seber estimate was derived by the method outlined by Caughley (1977).

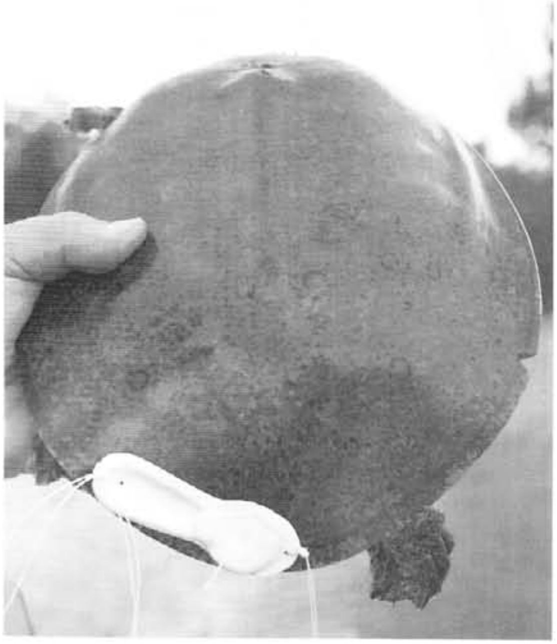

Figure 1. Adult female softshell, *Apalone s. spinifera*, with radiotransmitter sewn to rear carapacial margin prior to trimming of excess line and gluing of knots.

Four of the softshells (2 males, 2 females) obtained at the beginning of the study were fitted with 49 MHz transmitters for radiotracking (Fig. 1). The radios (battery life ca. 1 yr) were tied just above the trailing edge of each animal's carapace with 18 lb braided nylon fishing line threaded through the shell with a large carpet needle. The knots were trimmed and coated with epoxy cement to prevent slippage. A portable receiver (model LA-12) was used with a 30 inch M-Yagi square loop antenna (AVM Instrument Co.) to obtain radio fixes.

All turtle locations were determined from "verified fixes" rather than by triangulation because it was always possible to maneuver our boat over stationary animals and then carefully place marker buoys to identify their positions. These markers enabled us to determine the direction and distance each animal travelled in the interval (usually one day) to the next tracking trial. A hand-held sighting compass (Suunto model KB 14/360R) was used to obtain bearings from buoy to buoy. Interbuoy distances were measured either with a very accurate (to 0.1 m) hip chain (Topometric Products, Ltd.) or a hand-held range finder (Optimeter 620). To facilitate determination of long distance movements, we used a fiberglass tape (Leitz-drag type) to tag reference trees along the river at 100 m intervals.

During June and July 1990, we searched for female softshells and their nests on sandbars along the river and on beaches near the river mouth. One gravid female, hand-captured as she attempted to escape from her nesting site into the lake, was radiographed to determine the presence and number of oviductal eggs. Softshell nests were identified from tracks and other disturbance in the sand. Nests were excavated and eggs were counted and in a few cases measured before reburial. Fourteen nests were caged with vinyl-coated wire mesh to exclude predators and provide information on hatching and emergence and the ability of eggs to overwinter successfully. Two to four eggs were initially removed from each nest and taken to the laboratory for incubation at 28.5°C.

Forty-one young that hatched in the lab or emerged within caged natural nests were measured, marked, and released from 25 August to 10 October 1990 in shallow water near their original nests.

Throughout this paper means are presented with standard errors in both text and tables. Student's t-tests were used to test for significance of observed intersexual size differences. A sexual dimorphism index (SDI) was calculated for carapace length (CL) using the method of Lovich and Gibbons (1992), where

$$\mathrm{SDI} = \frac{\text{mean CL of larger sex}}{\text{mean CL of smaller sex}} - 1$$

(when females are larger). All specimens with CL > 110 mm were used to evaluate size dimorphism. At the time of examination the two smallest individuals (CL = 60 and 80 mm) were not assigned to sex, although it was subsequently discovered that carapacial pattern dimorphism can be used to reliably sex juveniles > 52 mm CL (Graham, 1991).

RESULTS

Morphometrics. — Data for 37 softshells taken in this study (Table 1) showed that carapace length (CL) of males ranged from 111.2–174.1 mm ($\bar{x} = 152.6 \pm 4.05$, $n = 18$), and females ranged from 218.3–365.3 mm ($\bar{x} = 322.8 \pm 11.01$, $n = 17$). Sexual size dimorphism of adult carapace length was considerable. The smallest female was 1.96 times longer than the smallest male, while the largest female was 2.10 times longer than the longest male. Mean female CL was significantly greater than mean male CL (t = 14.884, d.f. = 33, $p < 0.0001$). The calculated sexual dimorphism index was 1.12.

Male plastron length (PL) ranged from 78.6–122.3 mm ($\bar{x} = 106.9 \pm 2.94$, $n = 18$) and female PL ranged from 184.5–299.1 mm ($\bar{x} = 219.0 \pm 7.50$, $n = 17$). Body weight of males ranged from 105–495 gm ($\bar{x} = 321.1 \pm 25.20$, $n = 17$), and of females from 810–3750 gm ($\bar{x} = 2555.7 \pm 341.84$, $n = 11$). Inspection of the PRTL and PM-CM data (Table 1) reveals that in all cases the male cloaca opens posterior to the rear carapacial margin (PRTL > PM-CM), while in females it opens anterior to it (PRTL < PM-CM).

Population Size. — Chi square analysis indicates that the sex ratio (18M:17F) is not significantly different from 1:1 ($\chi^2 = 0.0$, d.f. = 1, $p = 0.99$). Since only males were recaptured during our study, we calculated a Jolly-Seber estimate just for adult males and then doubled it to estimate the entire adult population. From this the adult population estimate was 60 with a 95% confidence interval of 5–115. Since 35 adults were actually captured in our study, the

Table 1. Comparative morphometric data for male and female eastern spiny softshells *(Apalone spinifera spinifera)* captured near the mouth of the Lamoille River, Vermont, in 1989 and 1990. All measurements are given to the closest 0.1 mm; weights to the closest g. CL = carapace length, CW = carapace width at widest point, PL = plastron length, PRTL = preanal tail length, PM-CM = distance from rear plastral margin to rear carapacial margin, WT = weight.

	CL	CW	PL	PRTL	PM-CM	WT
MALES						
n	18	18	18	18	14	18
mean	152.6	124.7	114.3	59.6	55.4	321.1
S.E.	4.048	3.547	4.816	2.223	1.472	25.191
range	111.2–174.1	98.9–149.9	78.6–150.7	34.9–67.3	39.3–62.2	105–495
FEMALES						
n	17	17	17	17	17	11
mean	322.8	255.6	223.3	105.4	114.9	2555.9
S.E.	11.001	8.203	8.373	4.778	4.365	341.896
range	218.3–365.3	184.5–299.1	145.9–273.8	64.2–125.7	77.8–133.3	810–3750

confidence interval ranged from 35-115. This estimate is for the lower portion of the Lamoille River extending from the public access (boat launch) to Lake Champlain and does not include the area in the south fork of the river adjacent to the island at the river's mouth because we never saw or trapped softshells there. Softshell population density estimated for the roughly two-month period when the animals were resident in the 1100 m segment of the river (north fork) was 6.6 adults/ha. Population size structure plotted for all 37 softshells (Fig. 2) shows that carapace length varied more widely in adult females than in adult males, and that size, and therefore age structure, may be skewed towards adults.

Growth. — Three males, measured initially in 1989 and recaptured in 1990, were remeasured to obtain carapacial growth data. One animal grew from 111.2 to 122.0 mm (9.7%), another grew from 148.6 to 151.8 mm (2.2%), and a third increased from 139.4 to 141.2 mm (1.3%).

Nesting, Eggs, and Hatchlings. — Evidence of softshell nesting activity was first recorded in 1990. Four nesting areas were identified from tracks, raided nests, and intact nests. We saw females on shore at three of these sites. Three of the sites had fine sand substrate, the fourth site (beach to the south along the lake shore) contained coarse sand intermixed with gravel. All nesting areas were initially open, but an island face sandbar site subsequently became shaded by water willow (*Salix* spp.). Selected nest sites ranged approximately 1–5 m from the water. They were quite close to the water on the coarse sand/gravel beach, where five nests were 2.0–3.7 m ($\bar{x} = 3.1 \pm 0.29$) from the nearest water, and on the narrow sandbar at the island face, where some were as close as 1 m to water. On the broad, more gently sloping fine sand beach (height 20+ m) at the upstream sandbar, nests were as much as 15 m from the water, and all were > 10 m from it.

Nesting beaches were raked twice daily (early morning and late afternoon) to obtain a fresh uncluttered record of onshore activity. Tracks observed, together with sightings of turtles on land, indicated that daily nesting occurred from 1030–1630 hrs. The duration of the nesting period was about four weeks (June 15 to July 12). One animal drowned in a flooded baited trap after a thunder shower on August 29. She was later dissected (MCZ-R-178147) and found to contain 28 enlarged yolked follicles. Although not measured, these follicles appeared to be of similar size, i.e., were not separable into size classes. While no direct evidence of double-clutching was noted, these 28 enlarged follicles suggested that two clutches might have been laid the following year, in that the largest clutch size we found was 21, and mean clutch size was about 16.

Fourteen softshell nests were located and caged as follows: five on a small sandbar at the lake-face of the island at the river's mouth, one on the south point of the same island, five on a lake beach about 1 km to the south, and three on a sandbar upstream about 2.5 km above the Rt. 2 bridge. Those on the upstream sandbar were later washed out when the river flooded after a heavy rainfall. The single nest on the south point of the island was inundated after the lake rose about 1 m in August; it contained 10 dead eggs when excavated on 19 August.

Four additional caged nests, which were left to overwinter when emergence had not occurred by late October, failed to yield viable young the following spring. Clutch size for those nests was not recorded, and it is unknown whether or not they were inundated (D. Barnes, *pers. comm.*).

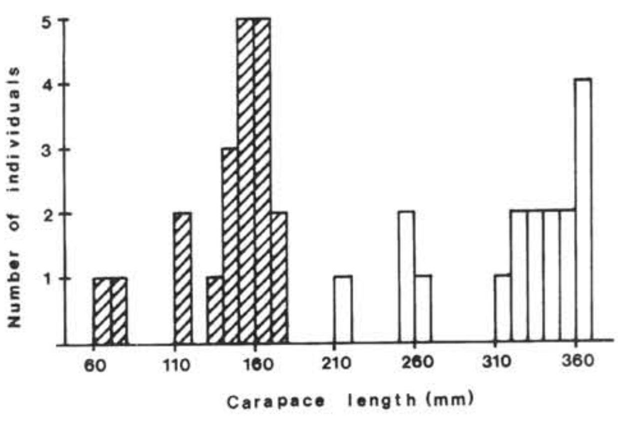

Figure 2. Population size structure (length-frequency distribution) of 37 *Apalone s. spinifera* from the Lamoille River, Vermont. The shaded portions indicate the numbers of juveniles and males, while the unshaded portions represent the numbers of females. Carapace length is plotted in 10 mm intervals.

Table 2. Egg and hatchling parameters for spiny softshell clutches. CW = carapace width, CL = carapace length, and PL = plastron length (measurements in mm and weights in g).

	n	Mean	Range	SE
Clutch size	14	16.2	13–21	0.833
Egg weight	74	9.38	6.32–12.81	0.246
Egg diameter	73	25.5	22.3–28.8	0.239
Hatchling weight	48	6.71	4.53–9.17	0.224
Hatchling CW	47	35.1	31.0–39.6	0.367
Hatchling CL	48	38.8	32.8–43.7	0.412
Hatchling PL	48	27.7	23.3–31.0	0.300

Softshell egg and hatchling parameters are presented in Table 2. A total of 41 softshell hatchlings, some from eggs incubated at 28.5°C in the lab and the rest from natural nests, were released near their original nest sites in the fall of 1990. Following incubation of eggs in the laboratory, it was possible to identify a few individual hatchlings with the egg they came from. Measurements of those eggs and hatchlings are given in Table 3 and are separated into two groups: 1) normal sized eggs and hatchlings (n = 12) from three separate nests, and 2) under-sized eggs and hatchlings (n = 11) from a single clutch. To offset the observed variation in egg shape (some eggs were perfectly round, while others were slightly elongate) egg diameter was determined as the average of the least and greatest diameters (Table 2). All softshell eggs were similar in appearance to those of snapping turtles, but their shells were considerably more brittle. Hatchlings from normal eggs were significantly heavier and longer in carapace than those from under-sized eggs (t-test, $p < .001$).

Basking Habits. — Basking softshells emerged just above the water's surface on large fallen cottonwoods (*Populus deltoides*) from which the bark had dropped to provide a very smooth basking surface. Softshells often basked alongside map turtles, *Graptemys geographica*, but unlike the map turtles, which were usually farther up the basking sites and were exposed well out of the water, *Apalone* seemed to prefer to remain close to the water and were often spotted with their legs and plastron submerged. We never observed *Apalone* basking on beaches or sandbars in our study; partially submerged dead tree trunks were always the preferred sunning substrate. Despite the fact that they were repeatedly frightened off these logs by passing boats, they usually returned to bask within 10–15 min.

Table 3. Comparison of spiny softshell egg and hatchling parameters for 12 normal and 11 under sized eggs. Measurements in mm and weights in g.

	n	Mean	Range	SE
Normal	12			
Egg weight		10.81	9.94–12.63	0.232
Egg diameter		26.8	25.8–28.1	0.197
Hatchling weight		7.45	6.55–8.71	0.289
Hatchling CL		39.6	37.2–43.7	0.533
Under-sized	11			
Egg weight		6.70	6.47–7.05	0.067
Egg diameter		22.7	22.3–23.8	0.123
Hatchling weight		4.82	4.53–5.23	0.074
Hatchling CL		35.2	32.8–37.0	0.394

Movements. — The movements of radio-tracked softshells are presented in Fig. 3. One of the four animals fitted with transmitters (M7) was only tracked for a short period because of equipment failure. The other three animals (M3, F4, F5) were tracked from release in July 1989 until 14 April 1990. A total of 41 (M3 = 17, F4 = 12, F5 = 12) radio fixes were made on these three animals in 1989, and the plotted location points are given in Fig. 3. Although all of the tracked softshells were originally captured on the island face in the lake, they did not remain there after release, but moved instead into the north fork of the river; only one of them (M3) returned to the lake briefly. For the first 5–6 weeks of the radio-tracking effort all animals moved about within the vicinity of the north fork mouth. Movement upriver was first noted during late August when M3 was found near the public boat access on the 24th. Not long after (August 31) the two females also moved upstream near the access. One of them (F4) moved back downriver to the upstream tip of the island, but had returned to the access area by October 9 and was located between M3 and F5 on the south side of the river.

Attempts to locate the softshells during a scuba dive on 19 November 1989 were unsuccessful. They may have been buried in the sandy bottom because they were not seen in the area where their presence was determined before and after the dive by telemetry. A very large snapping turtle was found resting on the bottom and 10–20 adult map turtles were captured. All of these were sluggish but mobile; most were taken at depths of 1–3 m as they crawled down the steep clay slope along the shore. The depth was 6–7 m at the bottom of the slope and the substrate there was deep soft sand. Water temperature at the base of this depression was 6.3°C and the dissolved oxygen concentration (Winkler titration) was 10.1 mg/l. The dimensions of this deep oval flat (long axis oriented parallel with river flow) were estimated at 30 x 60 m. The river was 75 m wide at this point and the depression was located close to the south bank, not at midstream. This wintering flat was the deepest spot on the lower section of the river (below Rt. 2 bridge down to the lake; bathymetry by J. Bonin, *pers. comm.*) and current on the bottom was almost undetectable. Subsequent fall and winter scuba dives at this same location in 1991 and 1992 also failed to demonstrate softshells, but did result in the discovery of a large aggregation (> 100) of wintering common map turtles, *Graptemys geographica*, which instead of burying in the bottom remained fully exposed (Graham and Graham, 1992). An attempt to locate buried softshells using sonic tags and a hand-held underwater detector in November 1993 was unsuccessful. However, that dive and another in 1995 demonstrated that six other softshells use the same area for hibernation.

During two visits to the study area on 1 and 14 April 1990 bottom temperature of the turtle wintering site was 3°C at 7.3 m. All three animals were located (by telemetry) exactly where they had been found in late November of the

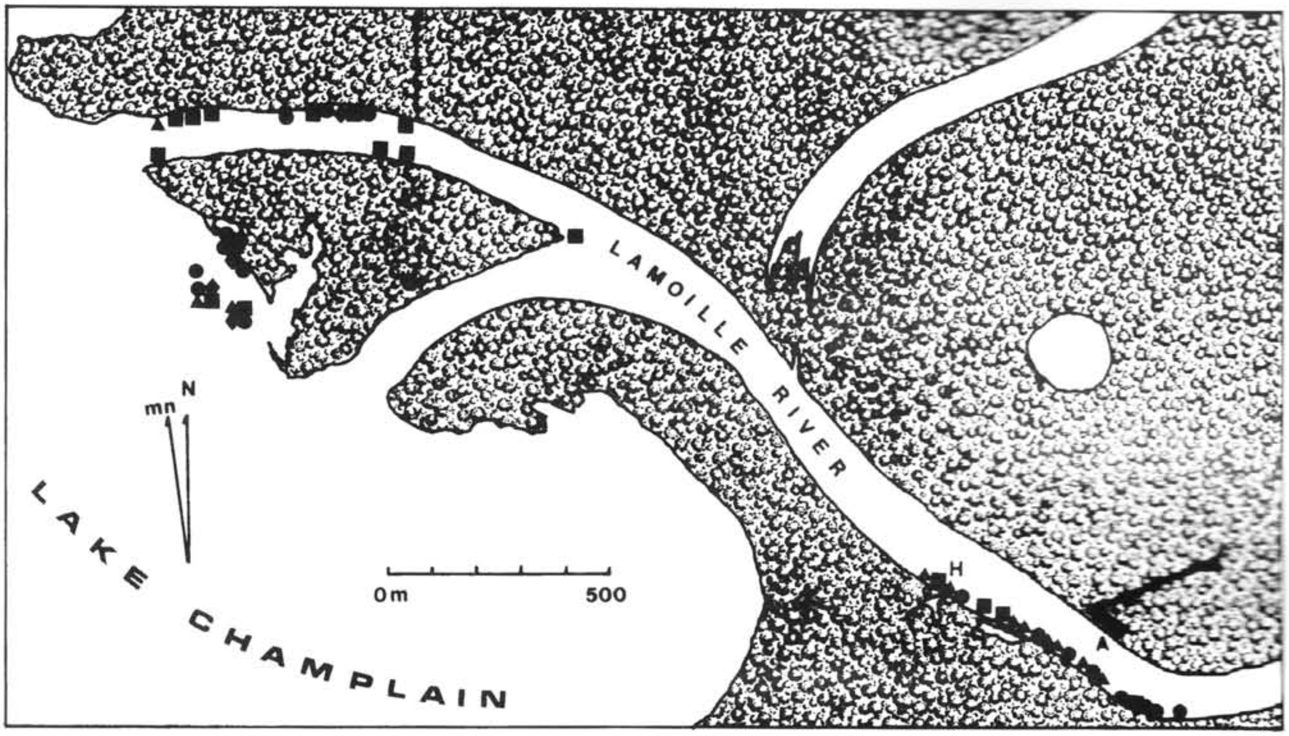

Figure 3. Plotted locations of four spiny softshells, 2 males and 2 females, determined by radiotelemetry from 27 July through 19 November 1989 in Lamoille River, Vermont. Symbol designations are: M3 (●), M7 (◆), F4 (■), F5 (▲). The most southern four-symbol cluster near the island face indicates the point of original capture (fyke net), while the cluster just northwest of it shows the initial point of release for all four radio-fitted animals. H = hibernation site. A = public boat access.

previous fall. On 14 May 1990 the bottom temperature was 12°C, and all three animals had left the wintering area. A subsequent downstream search of the river revealed that F4 was located in the north fork approximately 1/3 of the way to the lake from the upstream tip of the island. A very faint signal was received from F5 near the river's mouth but her exact position could not be determined, nor could M3 be located. Later in the year (5 July), F5 was located about 1 km to the north at the Sandbar Refuge adjacent to Rt. 2. Neither this site nor the other 1990 location data are included in Fig. 3.

DISCUSSION

Morphometrics and Growth. — The pronounced sexual dimorphism in length and weight was not unexpected in light of the studies of Dunson (1967). He found 16 Michigan males ranging from 194.5–506.0 g and 127–175 mm CL and four Michigan females ranging from 649.2–1950.5 g and 205–285 mm CL. Among ten animals from Arkansas and three from Minnesota, the largest male was 202 mm CL and 710.5 g, while the largest female was 432 mm CL and 6810 g (Dunson, 1967). Ernst and Barbour (1972) reported that male CL ranges from 127–216 mm, and female CL ranges from 165–457 mm.

The absolute growth data presented here, despite the small sample size, suggest that growth rate decreases as males get larger, a trend similar to that observed by Breckenridge (1955). He estimated that growth of a hatchling initially 38.1 mm in CL was about 47.8 mm during its first year, but that by the time it had reached 50.8 mm its annual growth rate had dropped to 42.2 mm. Plummer (1977b) found that hatchling *A. mutica* doubled their plastral length by the end of their first year, and that monthly plastral growth rate in males declined steadily once PL reached 80 mm. The fact that the sex ratio in this population was not found to differ significantly from 1:1 was expected based on the apparent lack of temperature-dependent sex determination (TSD) in *Apalone spinifera* and reports of adult sex ratios not differing significantly from 1:1 in Wisconsin, Alabama, and Mississippi (Vogt and Bull, 1982). A temperature-independent (= genetic) sex determination mechanism is more likely to maintain a sex ratio of 1:1 than is a temperature-dependent mechanism (Vogt and Bull, 1982).

Nesting, Eggs, and Hatchlings. — The high number of enlarged yolked follicles (28) found in the dissected specimen during August suggests the possibility of two smaller clutches the next year. Robinson and Murphy (1978) reported evidence for two clutches per season in Tennessee, based on the fact that large females contained up to twice as many enlarged follicles as they did oviductal eggs at one time. Ernst and Barbour (1972) suggested a clutch size of 4–32 eggs, that probably more than one clutch is laid annually, and that overwintering of hatchlings in the nest may occur in the northern parts of the range. The range in clutch size observed in our study (10–21) encompassed the observed size (17) of a clutch laid 28 June 1958 near Minneapolis on the Missisippi River (Breckenridge, 1960). Breckenridge recorded nesting onset at 1700 hrs, time to completion as 26 min. and nest distance to the water as 2.6 m. He indicated that he caged this nest to deter predators and that unhatched young did not survive the winter. He suggested that the failure of the eggs to hatch early enough for hatchling emergence before cold weather probably resulted from delayed development occasioned by the unseasonably cool June–August period in 1958. None of our four caged nests left to overwinter yielded viable hatchlings in the spring of 1991. While it is unknown whether these nests were inundated, overwinter nest survival so far north in this species is probably rare, if it occurs at all. However, Minton (1972) did document overwintering in Indiana.

Nesting at a greater distance from water on the upstream sandbar may afford protection to nests from inundation during floods which accompany rainstorms. At nesting sites near the river's mouth, but actually along the lake shore, such flooding does not result from single stochastic events. Therefore, the need to nest at higher elevation (= a greater distance from the water) is not as great at lake shore sites. In support of this supposition, only 1 of 11 sites at the lake were flooded in 1990, while all three upstream sites were completely washed away. For smooth softshells in the Kansas River, Plummer (1976) found that the length of time that eggs experienced inundation was the most critical factor affecting their survival. Submersion for more than two days greatly decreased development and hatching success.

Movements. — Only Plummer and Shirer (1975) have studied movements in this genus. They found that riverine *A. mutica* had restricted linear home ranges which shifted frequently, larger female home ranges which included areas on both sides of the river, smaller male home ranges confined to one side, and long but brief forays outside their home ranges by both sexes. They concluded that the far-ranging movement patterns of individuals indicated an ill-defined population whose individuals lacked fidelity to a restricted area.

Our observation that all three turtles chose to move upriver at about the same time (late August) and their selection of the same well-defined short segment of the river for overwintering suggests that the bottom along the southern shoreline across from the public boat access in some way affords whatever unique features these animals seek in a wintering site. If the wintering habitat selected by these turtles is unique and therefore sought after, their use of it might facilitate mating in the spring, since all three individuals wintered so close together. The possibility exists that a large congregation of wintering *Apalone* uses this site, and determination of what special features it offers will require future evaluation by scuba divers. Although our telemetry sample size was very small, unpublished observations made subsequent to 1990 support our contention that most of the softshells in the area use the same hibernation site. We attached sonic tags to two adult males in late summer 1993 and two adult females in late summer 1995 and in November of those years discovered that all animals had moved to the same hibernation site used by the telemetered adults in late 1989 (T. Graham, unpubl. data). In addition, hand capture of two very large unburied females by scuba divers occurred at this hibernation site in November 1995.

Turtle locations plotted in Fig. 3 demonstrate that softshells show a very dynamic pattern of seasonal movements in spring and late summer. The male was somewhat more active than either of the females, and some of his wanderings were more extensive. Annual activity and movements of adult *A. s. spinifera* in the lower Lamoille River in 1989–90 can be summarized as follows: Adult softshells wintered in a deep (6–7 m) depression in the river bottom. They left the hibernation area in April, when water temperature approached 12°C, to travel downstream to the river mouth and eventually into the lake. They then moved along the shore for some distance, foraging for food and possibly mating. Following the nesting season (about 14 June to 12 July 1990) the turtles moved back into the north fork of the river where they remained until late August. At that time they moved upstream on both sides of the river to the vicinity of the boat access. By early October, or when the water temperature dropped below 12°C, they moved to their wintering site across from the boat access and probably remained buried there until water temperature approached 12°C the following April.

From our observations of basking softshells, it is evident that in Vermont they do not bask aerially as frequently or as extensively throughout the year as map turtles. However, aquatic basking on submerged vegetation and burrowing in warmer water near shore may afford them the warming required for the optimization of processes such as food digestion (Graham and Graham, 1991).

Management. — A recommended strategy for management of *A. s. spinifera* should include: (1) identification and protection of nesting habitats from development or other impacts, (2) avoidance of disturbance to the river channel via dredging or other activities because of its potential impact on the hibernation site and/or hibernating animals, (3) regulation of boat speed on the river and exclusion of jet skis to eliminate the erosional impact of vehicle wakes to the river bank and to reduce the likelihood of direct propeller damage to free-ranging turtles, (4) prevention of dam or weir installation near the river mouth, (5) education of fishermen to discourage abuse of hooked turtles.

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