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Abstract: The freshwater turtle community of Back Bay National Wildlife Refuge and False Cape State Park is comprised of seven species: *Clemmys guttata, Chrysemys picta, Chelydra serpentina, Kinosternon subrubrum, Pseudemys rubriventris, Terrapene carolina,* and *Trachemys scripta*. Resource partitioning in this community is accomplished by habitat selection and dietary differences. Three species exhibit strong female biased sexual size dimorphism and one species strong male biased sexual size dimorphism; three species do not exhibit strong size dimorphism. Nesting occurs from about late-May through June and probably longer. Clutch size ranges from a low of three in the smallest species (*Kinosternon subrubrum*) to a high of 55 in the largest species (*Chelydra serpentina*). Trapping success varied seasonally and annually. Freshwater turtles play important ecological roles in wetland ecosystems and every effort should be made to insure the continued viability of all populations.

Introduction

Turtles are conspicuous animals in most wetlands in southeastern North America. In Virginia there are from one to nine species syntopic in the same habitat (Mitchell and Pague, unpublished). Species richness varies depending on the type of wetland and its geographic location. Because of their abundance and positions in food webs, freshwater turtles play essential, although largely unstudied, roles in energy transfer in wetland ecosystems, despite the fact that their standing crop biomass is orders of magnitude less than that of plants (Congdon and Gibbons, 1990).

As many as nine species of freshwater turtles occur in southeastern Virginia. One of these, the chicken turtle (*Deirochelys reticularia*), is found only at the northern end of Virginia Beach and is a state endangered species (Mitchell and Buhlmann, in press). The remaining eight are found throughout much of the area in various syntopic combinations. Our objectives in this paper are to summarize information on various aspects of the ecology of the freshwater turtles in the vicinity of Back Bay, Virginia. We describe community composition, sexual size dimorphism, reproductive attributes of selected species, and effectiveness of trapping techniques.

Materials and Methods

We conducted a census of the freshwater turtle populations periodically in 1980-1983 and in 1986 and 1989. Traps were set in ditches lining waterfowl impoundments in Back Bay National Wildlife Refuge and in the ditches and shallow water marshes in False Cape State Park. Both of these areas are on the Currituck Spit, a coastal barrier ecosystem. Most turtles were caught in funnel traps made of 1 inch mesh chickenwire (Iverson, 1979), although 2.5 foot diameter hoop traps made of 1 inch netting without leads and fyke nets with leads (often called fish traps) were used on several occasions. Funnel traps and hoop traps were baited with sardines; holes were punched in the cans so consumption of the bait would not occur and alter natural growth rates. Fyke nets were unbaited. All traps were set with the top portion at or above the surface of the water so that turtles could reach air. Traps were checked at least once daily during each trapping period. Some of the captures were made by hand and with a dipnet. Nesting females were often found on dirt roads during the day and night.

All turtles were processed within 24 h of capture and most were returned to the exact location of capture. All measurements (to the nearest 0.1 mm) of carapace length (CL) and plastron length (PL) were made by one of us (JCM) with dial calipers to reduce investigator-induced error. We used Pesola scales to determine body mass to the nearest gram. Additional notes were taken on injuries, abnormalities, and ectoparasites.

Each turtle was assigned a unique number by filing notches in the carapacial margin. The coding system used the first four carapacial marginals on both sides of the cervical scute anteriorly and midline posteriorly. Numbers 1, 2, 4, and 7 were assigned in sequence (midline outward) as ones on the anterior left, tens on the anterior right, hundreds on the posterior left, and thousands on the posterior right. Up to 9999 individuals of each species can be uniquely marked with this coding system.

Males and females of each species were considered mature when they exceeded minimal sizes known for other populations (Mitchell, 1988; Mitchell and Pague, unpublished) or if the smallest known adult exhibited secondary sex characteristics (males) or contained oviductal eggs. Possession of elongated foreclaws upon maturation in male emydid turtles (*Chrysemys, Pseudemys, Trachemys*) provided additional information on whether sexual maturity had been achieved.

Reproductive data were derived from females in two ways. Some of the females found nesting were sacrificed for other studies. Others were examined for eggs during the nesting season by palping the inguinal area.

Results

Community structure - Seven species were trapped and/or collected during the the study (Table 1). Of these, six were were found within the first year of field work (1980). The seventh, *Clemmys guttata,* was not discovered until 21 May 1983.

Resource partitioning in Back Bay is accomplished in two ways, habitat preference and diet. Four species are basking turtles, two are bottom-walkers (Berry and Shine, 1980), and one is terrestrial (Table 1). Two of these turtles are carnivorous, three are omnivorous, and two are herbivorous, at least as adults (Table 1). Juveniles of *Pseudemys rubriventris* and *Trachemys scripta* are carnivorous, but as adults consume almost entirely plant material (Ernst and Barbour, 1972; Parmenter, 1980). Of the aquatic turtles, three are known to use Back Bay in their movement patterns (*Chelydra serpentina, Pseudemys rubrventris,* and *Trachemys scripta*). We presume the remaining species at least occasionally enter the bay but we have no reports or observations to confirm this assumption. Several slider turtles (*Trachemys scripta*) were found to harbor one or more barnacles (Mitchell and Pague, unpublished), indicating that either these ectoparasites lived in the bay durign times of high salinity or these turtles spent a substantial amount of time in the Atlantic Ocean.

Sexual size dimorphism - Adult males averaged smaller than adult females in three species (carapace length in mm): *Chrysemys picta* males - 134.1, n = 47, females - 137.5, n = 31; *Pseudemys rubriventris males* - 222.1, n = 10, females - 272.6, n = 9; *Trachemys scripta* males - 158.4, n = 20, females - 248.2, n = 21 (Mitchell and Pague, 1990). The largest male *Chelydra serpentina* measured was 396 mm CL and the largest female was 281 mm CL. Sexual size dimorphism was not apparent in *Kinosternon subrubrum* (male average 92.0, n = 62; female average 93.1, n = 25). Two species were represented by a single sex. Four adult female *Terrapene carolina* averaged 136.2 mm CL and the single male spotted turtle, *Clemmys guttata,* was 108.9 mm CL.

Sexual dimorphism in turtles is often more pronounced in body mass. For example, in three species the females had substantially greater maximum body mass than males (*Chrysemys picta* males 430 g, females 545 g; *Pseudemys rubriventris* males 2120 g, females 3530 g; *Trachemys scripta* males 1350 g, females 3200 g). The largest male *Chelydra serpentina* weighed 14.3 kg and the largest females 5.3 kg. The largest male *Kinosternon subrubrum* in Back Bay (206 g) was only slightly heavier than the largest female (196 g). The largest female *Terrapene carolina* weighed 591 g and the single male *Clemmys guttata* weighed 148 g.

Reproduction - With the exception of *Trachemys scripta,* we observed few nesting female turtles. Observed nesting occurred between late May and late June for *T. scripta* and *Pseudemys rubriventris.* A clutch of four *Kinosternon subrubrum* eggs was found in a sand bank.

One *Chrysemys picta* contained four oviductal eggs averaging 29.6 × 15.9 mm in size. One *Chelydra serpentina* contained 55 oviductal eggs (average diameter = 27.7 mm, average wet mass = 12.6 g). Three *Kinosternon subrubrum* contained an average of 3.0 (2-4) oviductal eggs (26.5 × 15.6 mm, 4.5 g). A single *Pseudemys rubriventris* contained 29 oviductal eggs (29.8 × 19.7 mm, 6.8 g). Clutch size in four *Terrapene carolina* averaged 3.5 (2-5) eggs (38.9 × 22.3 mm, 12.0 g). Mitchell and Pague (1990) reported an average clutch size of 9.7 (6-14) eggs for 21 *Trachemys scripta* from Back Bay. These averaged 34.2 × 23.1 mm in size and 10.8 g wet mass.

Trapping success - Trapping success varied among sessions on a seasonal and annual basis (Table 2). *Chrysemys picta, Kinosternon subrubrum, and Trachemys scripta* were caught more often than any other species during all but the 1989 trapping period.

Trapping success data were kept for each trap type during the 1989 trapping session (Table 2), allowing the following observations. *Chelydra serpentina, Pseudemys rubriventris,* and *Trachemys scripta* were captured more often in fyke nets with leads than in chicken wire traps. The opposite result

was obtained for *Chrysemys picta* and *Kinosternon subrubrum*.

Discussion

Barrier islands and coastal spits of southeastern North America harbor variously diverse freshwater turtle communities. Gibbons and Coker (1978) listed from one to five species of freshwater turtles on nine Atlantic coast barrier islands. Six islands had three, or fewer, one had four, and two had five species. Braswell (1988) found four species in the ponds of Nags Head Woods, Bodie Island, North Carolina. Few of the Virginia barrier islands harbor freshwater turtles. Assateague Island has five species, Smith Island has three species, Hog Island had populations of two species, and Fisherman Island contains one species (Conant et al., 1990). In contrast, nine species occur on mainland southeastern Virginia. Thus, the freshwater turtle community of the Currituck Spit more closely resembles the mainland fauna than other barrier ecosystems. The only conspicuously absent freshwater turtle is *Sternotherus odoratus* (stinkpot), a species that cannot tolerate even low levels of salinity (Dunson, 1986). We presume the varying salinity in Back Bay has prevented the stinkpot from colonizing Currituck Spit, although it has had little apparent affect on the other species in the vicinity.

Gibbons and Lovich (1990) demonstrated that sexual size dimorphism exhibits geographic variation and is closely tied to localized environmental conditions. For comparisons they suggested a standard sexual dimorphism index (SDI): the mean shell length of the sample containing the larger sex divided by the mean shell length of the sample with the smaller sex. When SDI is positive the female is the larger sex, when negative the male is larger.

Our data set allows us to compare SDI among four species in Back Bay and the SDI for each species with other populations listed in Gibbons and Lovich (1990). The *Chrysemys picta* population in Back Bay has a SDI of 1.03, *Pseudemys rubriventris* a SDI of 1.23, *Kinosternon subrubrum* a SDI of 1.01, and *Trachemys scripta* a SDI of 1.57. SDI for 12 populations of painted turtles ranges from 1.13 to 1.58 (Gibbons and Lovich, 1990). Thus, our Back Bay sample is the least sexually dimorphic population of those reported. SDI has been reported for only a Massachusetts population of red-bellied turtles (1.12: Graham, 1971; Gibbons and Lovich, 1990). Our results for this species in Back Bay suggest that populations at the southern end of the range exhibit more pronounced sexual size dimorphism than at the northern end of the range. Because the population biology of this species has been little studied, this conclusion must be regarded as tenuous. SDI for 10 populations of the eastern mud turtle, including the one in Back Bay, range from -1.07 to 1.18, with most close to 1.00 (Gibbons and Lovich, 1990).

Sexual size dimorphism is best known for *Trachemys scripta*. Known SDI values range from 1.09 to 1.61 (Gibbons and Lovich, 1990). The SDI for yellow-bellied sliders in Back Bay is substantially higher than SDI's reported for other barrier ecosystem populations (Caper's Island [1.35], Kiawah Island [1.28] in South Carolina, Gibbons and Lovich, 1990). This may be due to sampling bias. Our sample consisted largely of females found nesting and males caught in traps. We cannot determine without further study whether this result is a sampling artifact, or if sexual size dimorphism is truly pronounced at the northeastern edge of the range of this species.

With one exception, all of our information on reproduction in the freshwater turtles of Back Bay is anecdotal and the values reported above are within the ranges reported for other populations (Ernst and Barbour, 1972; Mitchell, 1985a, 1985b, 1988). Mitchell and Pague (1990) compared the reproductive ecology of *Trachemys scripta* between populations from Back Bay and Dismal Swamp. They found no significant differences in body size, clutch size, and egg size relationships between the Back Bay population and the Dismal Swamp population. In both populations females are as large as those populations from thermally enhanced aquatic systems, with no significant relationship of clutch size to body size, but egg length, width, and wet mass are significantly correlated with body size. Annual growth of juveniles 1-6 years old in Back Bay is 13.1 mm.

The ecological and energetic relationships of freshwater turtles in wetland ecosystems are undoubtedly greater than now realized. Turtles utilize both the aquatic and terrestrial habitats for different parts of their life histories. The diversity of foraging modes in freshwater turtles (carnivory, herbivory, and omnivory), coupled with their ubiquity and numbers, suggests that they play complex, but crucial roles in the maintanence of wetland energy dynamics. Eggs are laid on land and their energetic content has great consequence for terrestrial food webs and energy flow. Eggs in turtle nests are usually eaten by terrestrial predators, such as foxes and raccoons. Congdon and Gibbons (1990 and references therein) list nest predation rates of 41% to 95% and demonstrate that nest predation can be as high as 100% in some years. The average annual energy gained by predators from turtle eggs in a Michigan wetland was 2.3 kg/ha of marsh (Congdon and Gibbons, 1990). The redistribution of nutrients by turtles alone in wetland ecosystems makes these animals valuable participants.

The conservation of freshwater turtles in wetlands has taken a back seat to the conservation of plants, fish, and birds. Freshwater turtles in the Back Bay region have no legal protection and could be exploited at will. This has already been the case with snapping turtles. Prolonged harvesting of these animals is likely to be detrimental to them and the Back Bay ecosystem. How alteration of wetland habitats affect freshwater turtle populations is unknown and should be studied. Are freshwater impoundments that are created for waterfowl appropriate habitats for these animals? What affect does the wet and dry cycles of these impoundments have on the ecology and survival of freshwater turtles? How will the changing salinity of Back Bay affect their local distribution and population sizes? What are the actual dietary components of the freshwater turtles in the Back Bay region? What are the ecological relationships of these animals to fish and waterfowl? Answering these questions could greatly improve our understanding of the role of freshwater turtles in wetlands ecosystems.

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Table 1. Species diversity and community structure of freshwater turtles in Back Bay, Virginia. Abbreviations: BA = basking turtle, BW = bottom walker, C = carnivore, H = herbivore, O = omnivore, TR = terrestrial.

Clemmys guttata	Spotted Turtle	C, BA
Chrysemys picta picta	Eastern Painted Turtle	O, BA
Chelydra serpentina serpentina	Snapping Turtle	O, BW
Kinosternon subrubrum subrubrum	Eastern Mud Turtle	C, BW
Pseudemys rubriventris rubriventris	Red-bellied Turtle	H, BA
Terrapene carolina carolina	Eastern Box Turtle	O, TR
Trachemys scripta scripta	Yellow-bellied Slider	H, BA

Table 2. Freshwater turtle trapping success in Back Bay National Wildlife Refuge, Virginia. Three trapping sessions are reported: May 1983 (22 chickenwire funnel traps), June 1983 (25 chickenwire funnel traps and 2 fyke nets), and August 1989 (23 chickenwire funnel traps and 5 fyke nets). The number represents the number of captures per trap day.

Species	May 1983	June 1983	August 1989	
			Chickenwire	Fyke nets
C. picta	0.36	0.19	0.15	0.10
C. serpentina	0.04	0.06	0.02	0.40
K. subrubrum	0.32	0.24	0.11	0.00
P. rubriventris	0.00	0.02	0.00	2.40
T. scripta	0.77	0.20	0.15	3.00
C. guttata	0.05	0.00	0.00	0.00
No. of trap days	**22**	**54**	**46**	**10**