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Differences in Body Size Among Populations of Red-Eared Sliders (*Trachemys scripta elegans*) Subjected to Different Levels of Harvesting

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Although turtles have been exploited by man for hundreds or even thousands of years (Humane Society, 1994), quantitative studies of the effects of human predation on turtle populations have been conducted only recently (e.g., Crouse et al., 1987; Congdon et al., 1993, 1994). These studies showed that a critical consequence of the co-evolved life-history traits of long-lived organisms such as turtles is a high degree of susceptibility to changes in patterns of survival, especially changes in the survival rates of older juveniles and adults (Crouse et al., 1987; Congdon et al., 1993, 1994). In the absence of a substantial compensatory decrease in mortality rates among neonates or smaller juveniles, increases in human-induced harvesting of adults from the wild may result in sharp decreases in population size. For example, Congdon et al (1994) showed that a harvest pressure as low as 10% per year could result in a 50% reduction in adult snapping turtles (*Chelydra serpentina*) within 15 years. Furthermore, Brooks et al. (1991) found that juvenile snapping turtles showed no compensatory response to increased adult mortality. Thus, the ability of turtle populations to withstand even moderate levels of increased mortality from humans for long periods is questionable (Klemens and Moll, 1995).

The red-eared slider (*Trachemys scripta elegans*) is one of the most common freshwater turtles in North America (Ernst et al., 1994). Until 1975, large numbers of hatchlings of this species were sold as pets throughout the US, but such trade was banned by the Food and Drug Administration owing to health concerns (Williams and Helsdon, 1965; Lamm et al., 1972). However, a considerable commercial market still exists for this species in: 1) international trade in hatchlings for pets, and 2) commercial take for meat. Although interstate sales of hatchlings are illegal in the US, an estimated 26 million *T. scripta* were exported from the US to international markets between 1989 and 1994 (Humane Society, 1994). The vast majority of these turtles are thought to be hatchlings produced by turtle ranches in southern Louisiana (M. Anderson, *pers. comm.*), but some are adults (C. Warwick, *pers. comm.*). In addition, unknown numbers of adults are collected every year by turtle ranchers to replace breeding stock. We use the term "ranch" to note that turtles are not raised to maturity to support a self-sustaining program, all offspring being sold as hatchlings. Adult red-eared sliders are also harvested for meat, both for local and national consumption and for international export (Warwick and Steedman, 1988).

Few data are available to assess the impact of harvesting on populations of *T. scripta*. Warwick and Steedman (1988) compared the abundance and body size of *T. scripta* between protected populations in Texas and exploited areas in Louisiana. They found both lower overall abundance in Louisiana and a sharp reduction in the proportion of larger individuals.

From 1990 to 1991, we studied the effect of human take on red-eared sliders in southern Louisiana and western Mississippi. Our specific goals were (a) to determine whether any quantitative differences in mean population size exist between populations protected from human harvesting and those actively being harvested, and (b) to gather additional data on the extent and causes of commercial harvesting of turtles in southern Louisiana.

STUDY SITES

We collected data on mean body size of *T. scripta elegans* at eight localities in southern Louisiana and western Mississippi. Prior to initiation of sampling, we used detailed interviews with local residents or area managers to classify each site as to its harvest condition. Sites were classified as either **protected** (no known public access or harvesting), **public** (public access allowed, but no known recent commercial harvesting), or **harvested** (active commercial harvesting of turtles was occurring at the time of our study). Information about each site collected is summarized below.

Protected Sites

NASA Sites 1 and 2. — The John Stennis Space Center is located in western Mississippi, just east of Louisiana. This area has been protected from human collecting of turtles since at least 1975. NASA Sites 1 and 2 are man-made ponds ca 2.1 km apart, surrounded mainly by pine woods and old fields. Turtles were collected during late May and early June 1990.

Louisiana Land and Exploration Company. — This site is part of a large protected wetlands owned by a Louisiana-based oil company. The public is not allowed on the site, and there has been no harvesting of turtles for at least 15–20 years. Turtles were collected mainly in large man-made canals.

Public Sites

Kraemer. — This site is part of an extensive swamp system located south of New Orleans, Louisiana. Although human harvesting of turtles is known to occur nearby, the specific site we sampled has been protected informally from collecting by local landowners. Turtles were collected during late June and early July 1990.

Turtle Cove Field Station. — This area is part of the Manchac Wildlife Management Area, just south of Hammond, Louisiana. Although the site is open to the public, active harvesting has not been reported by local residents or by the area managers in the recent past. Turtles were collected in natural and man-made canals during June 1991.

Reno's Fish Market. — This site is located adjacent to the Joyce Wildlife Management Area, just south of Hammond, Louisiana. The area immediately behind this fish market is open to the public, and may be occasionally used for collecting turtles by local residents, but the exact level of harvesting is unknown. Turtles were collected from an open marsh during June 1991.

Harvested Sites

Mermentau Basin. — This site is part of the extensive Atchafalaya Swamp system, about 50 km west of Baton Rouge, Louisiana. Turtles are heavily harvested throughout the area, both incidentally by fishermen, and deliberately by turtle hunters. Turtles were collected during August 1990.

Cecilia. — This area is located near the Atchafalaya Basin. Turtles at this site are collected actively, at least by local fish markets. We collected turtles during April 1991.

METHODS

Collecting. — Turtles at most sites were collected using standard hoop traps baited with chicken necks, cat food, catfish heads, or beef melt. Traps were checked at least twice daily, and no turtles were injured during the study. Because of safety concerns (local trappers were very suspicious of outsiders) and because our traps were likely to be stolen, we were unable to successfully use our own traps at the Mermentau Basin and Cecilia sites. Turtles from those areas were either collected for us by commercial turtle hunters (who used techniques similar to ours) or purchased at local fish markets. We were careful to question both dealers and trappers concerning both the source and the methods used to capture these turtles. In no cases do we have reason to believe that trappers mislead us concerning the size of the turtles they collected; indeed, trappers have incentives to capture large turtles, since turtles are often sold by size class. Thus, any sample bias, if present, would likely favor larger turtles.

We measured the carapace and plastron length of all turtles captured to the nearest 0.1 cm using tree calipers. All turtles captured by us were given an individual mark and released at the point of capture as were live turtles purchased from dealers.

Assessment of Causes of Harvesting. — To assess the degree of human harvesting of turtles, we interviewed a variety of local residents throughout southern and central Louisiana, Mississippi, and Alabama, including local commercial and recreational fishermen, trappers, store owners, and commercial collectors. Because of the nature of these contacts, we did not attempt to conduct systematic interviews or collect questionnaires, but we were careful to avoid asking leading questions such as "have turtles around here declined?" We also surveyed a series of markets in the Chinatown section of San Francisco, California, to document the sizes and sexes of sliders and other turtles being sold outside of Louisiana.

RESULTS

Comparison of Body Size. — We measured 289 *T. scripta* during our study; the mean body sizes are shown in Table 1. We found a significant difference in the body size of females among the three harvest conditions (nested ANOVA, $F = 45.6$, $df = 2, 171$, $p < 0.001$). Significant differences also occurred among sites within a particular harvest condition ($F = 5.5$, $df = 5, 171$, $p < 0.001$), indicating that even when harvest effects are controlled, there was variation in size structure among sites. A Tukey's multiple range test showed that females from the harvested sites were significantly smaller than all other turtles, but there was considerable overlap in body size between females from protected and public sites.

Figure 1 compares the body size of female sliders from each harvest condition. The most conspicuous difference among the populations was the virtual absence of turtles greater than 22 cm carapace length from the harvested sites; in essence, the entire upper end of the size distribution had been eliminated (Fig. 1). By contrast, differences between the protected and the public sites were minor, although the protected sites had more large turtles than did the public sites.

A somewhat different pattern was found for males. A nested ANOVA showed that male size also differed significantly among harvest conditions ($F = 24.6$, $df = 2, 104$, $p < 0.001$), but no differences in male body size were evident among sites within harvest conditions ($F = 0.35$, $df = 3, 104$, $p > 0.75$). The largest male turtles were from the two protected NASA sites, and these were significantly larger than males from all other sites.

Results of Interviews. — Based on 19 interviews, we found evidence of commercial harvesting of turtles for the following seven reasons: 1) replacement of breeding stock for turtle ranches; 2) in-state consumption; 3) sustenance hunting; 4) interstate consumption; 5) international trade for meat; 6) interstate sales for research or pets; and 7) incidental by-catch by fishermen.

Almost all dealers and local residents we interviewed reported a large local decrease in the past few years in the numbers of turtles, most notably in red-eared sliders, alligator snapping turtles (*Macroclemys temminckii*), common

Table 1. Mean carapace lengths (in cm) of red-eared sliders collected at harvested, public, and protected sites during 1990 to 1991. No males were collected from public sites. Means are followed by 1 SD. See text for statistical analysis.

	Females	*n*	Males	*n*
Protected Sites	22.9 ± 1.95	64	19.0 ± 1.50	29
Public Sites	22.4 ± 2.42	53	———	—
Harvested Sites	18.4 ± 1.83	55	17.1 ± 1.44	68

snapping turtles (*Chelydra serpentina*), and softshells (*Apalone* spp.). The general opinion among collectors was that habitat destruction, pollution, increased predation from raccoons and opossums, and incidental mortality from fishing were the major causes of these declines.

The apparent decrease in the availability of red-eared sliders has impacted local collectors and businesses. For example, one dealer in central Louisiana noted that he must now import sliders from Mississippi, Arkansas, and Texas, whereas he once could collect all his turtles from local areas. In Henderson, Louisiana, *T. scripta* meat is considered desirable, and commands a price comparable to that paid for snapping turtles. Several local markets supply turtle meat, but in the two groceries and three fresh fish markets we visited, only frozen turtle meat from out of town was available (from Jonesville, in northern Louisiana). When asked why the meat was frozen, not fresh, and why it was from out of town, the answer was invariably "the turtles are all fished out here." Fresh turtle was available occasionally, but not on a consistent or reliable basis; the local peak turtle season (for red-eared sliders at least) is when the "females congregate to lay" in the spring (April–June).

The fish market dealers with whom we spoke were consistent in their opinion that there had been a large decline in turtle numbers over the past few years, as well as a decline in the size of the turtles. One long-time Henderson resident whose family business was one of the major fish markets noted that in addition to turtles, frogs and snakes were declining as well. One turtle trapper noted that to catch large turtles, one needed to trap in remote, unharvested areas.

Fish Market Surveys. — In August 1991, we inspected seven seafood markets in the Chinatown section of San Francisco, California, and found turtles for sale in all. All turtles were either red-eared sliders or softshells (*Apalone* spp.). When asked where the turtles came from, the marketers either said that they did not know or that the turtles were from "the east" or "New York." The sliders sold for $5–6 each, the softshells for $6 per pound. Many turtles were in deplorable condition; bacterial and fungal infections were rampant, as were signs of weakness and dehydration. Most of the sliders examined were of moderate size, with only one individual larger than 18 cm carapace length. Of 53 turtles that were sexed, 38 were females and 15 males. This is significantly different from a 1:1 sex ratio ($\chi^2 = 9.98$, df = 1, $p < 0.01$) and differs strongly from the sex ratios seen in natural populations (Gibbons, 1990).

A second survey of seafood markets in San Francisco was conducted during December 1994; all six markets visited had red-eared sliders for sale, none of which were large adults. This sample consisted of both sexes, but we were not able to sex sufficient numbers for statistical comparisons.

DISCUSSION

Our data show that populations of sliders from protected sites are larger than turtles from harvested sites (Table 1). Public sites not being actively harvested had mean body size structures comparable to those of turtles from protected sites. This is consistent with harvesting pressure that targets large adults (especially females) for either meat or breeding stock (Warwick and Steedman, 1988).

From our limited data we cannot determine whether the differences in mean body size observed among sites were, in fact, the result only of different levels of harvesting. We

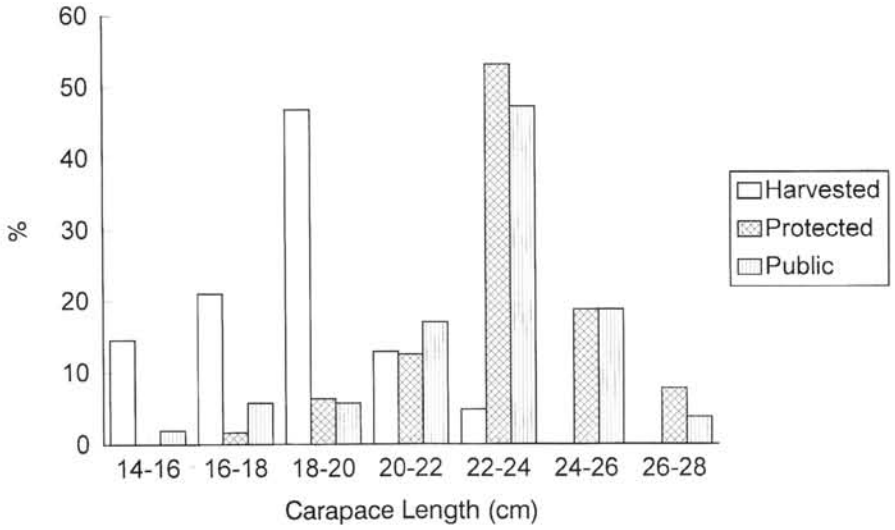

Figure 1. Comparison of size distribution of female red-eared sliders from harvested, public, and protected sites. Note the absence of turtles in the larger sizes classes (> 22 cm carapace length) from the harvested sites. See text for details of collecting sites and statistical analysis. Sample sizes were: protected ($n = 64$), public ($n = 53$), and harvested ($n = 55$).

recognize that differences in habitat quality, food availability, and local genetic variation could also partially account for the differences observed (see Mitchell and Pague, 1990, for a recent review). We also recognize that only an experimental approach can show definitively that human harvesting causes differences in mean body size among sites. However, our data are among the first to implicate human harvesting as a direct contributing factor causing differences in mean body size among populations of turtles. The potential consequences of these differences are discussed below.

We identified seven reasons why turtles are harvested in this part of the US. Of these, four are directly related to the interstate or international trade in turtles. For at least three, possibly four of these reasons, larger individuals (females) are probably preferred by collectors. Of the two non-trade reasons for take, incidental by-catch by fishermen (who set out traps to catch bait-fish and accidentally catch and drown turtles) is probably the most important factor. Based on interviews with local residents, incidental by-catch is suggested as a major factor responsible for declining populations of turtles. However, no quantified data exist to support this contention.

Our data support the hypothesis that harvesting of adult sliders is having an impact on turtle populations in southern Louisiana, at least in terms of mean body size. Whether such differences in body size can lead to declines in slider populations is unknown, since we lack sufficient data to determine how population dynamics of *T. scripta* are affected by harvesting. Although models developed by Congdon et al (1993, 1994) suggest that harvesting should have a strongly negative effect on most turtle populations, we lack data on harvesting pressure, i.e., the percent of the population harvested each year. However, the fact that local collectors are generally no longer able to supply commercial markets with turtle meat suggests that harvesting is having a major impact on some populations.

Recently, Mississippi banned the commercial sale of native turtles, with the exception of *Chelydra serpentina* (B. Jones, *pers. comm.*). Thus, except for snapping turtles, turtle meat can no longer be legally exported from Mississippi to satisfy the demand for turtle meat in Louisiana, California, or overseas. This potential for increased harvesting pressure on Louisiana amphibians and reptiles led to an official request by the Louisiana Department of Wildlife and Fisheries to reconsider the ban on commercial sales by other states; however, it is unlikely that the ban will be lifted (B. Jones, T. Johnson, *pers. comm.*). Whether there is indeed an increase in harvesting pressure on Louisiana turtle populations is unknown, but our data suggest that higher levels of harvesting are likely to have negative consequences for local populations of red-eared sliders.

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