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Colonization of a Newly Constructed Farm Pond in Mississippi by Slider Turtles and Comparisons with Established Populations

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Abstract

Colonization by slider turtles (*Pseudemys scripta*) of a 0.3-hectare farm pond newly constructed in 1980 in Clay County, Mississippi, was recorded over five years. Population size peaked after three years at 26 individuals, then declined slightly in the next two years. Most colonists were immature animals, and population structure was strongly biased toward immatures. Turnover of individuals between years was higher in adults than in immatures and higher than in established ponds, but two individuals were present for four consecutive years. Juvenile growth rate was half that in established ponds during the pond's third year but increased to nearly comparable levels by its fifth year. Population and biomass densities remained below those of nearby established ponds.

Introduction

Freshwater turtles may move long distances overland to reach other bodies of water with better food supplies, lower population densities, or better mating opportunities (Gibbons, 1986). In the slider turtle (*Pseudemys scripta*), types of aquatic or terrestrial habitats separating local populations are less important than distance in the extent of genetic divergence between such semi-isolated populations (Scribner et al., 1986). Adult male sliders move more frequently and over greater distances than other age or sex groups (Morreale et al., 1984; Parker, 1984).

With these dispersal attributes in mind, I studied a 0.3-hectare pond constructed in 1980 in Clay County, Mis-

Table 17.1. Summary of captures and population estimates of slider turtles in a newly constructed pond and an established pond

Year	Number of sampling days/Month(s)	Individuals captured	Individuals newly marked	% new	Number of recaptures	Total captures	Population estimate
New Clay County pond							
1981	6/July	1	1	100.0	1	2	1
1982	10/Aug.	12	12	100.0	14	26	13
1983	8/July	26	20	76.9	39	65	26
1984	14/July	22	8	36.4	23	45	23
1985	17/July	14	2	14.3	14	28	20
Established Lowndes County pond (pond 1)							
1975	45/May-July	132	132	100.0	47	179	220
1976	38/May-Aug.	226	142	62.8	134	360	340
1977	33/May-Aug.	254	91	35.8	281	535	305
1978	28/May-Aug.	195	41	21.0	133	328	240
1979	29/May-July	194	51	26.3	217	411	205

Note: The new pond was constructed in 1980 in Clay County, Mississippi. Population sizes (number of turtles in pond) were estimated by the Schnabel Method (Overton, 1971).

sissippi, to observe its colonization by slider turtles (*P. scripta*). I also compared population structure, turnover rate, and biomass and population densities of this new pond with those for populations in established ponds nearby.

Materials and Methods

STUDY AREAS

The primary study area was a 0.3-hectare rectangular pond about 3 km south of West Point, Clay County, Mississippi. This pond (herein called new pond) was constructed by excavation in autumn 1980 and allowed to fill with rainwater to a depth of about 1 m. A drainage pipe eliminated overflow from excessive rain. I sampled its turtle populations each year from 1981 to 1985 (Table 17.1).

Sources of immigrating turtles were located on an aerial photograph; the nearest permanent bodies of water were 1.8 km or more away, although a seasonally flowing ditch channel was about 85 m away. The pond was located on a rural, residential corner lot, with a lawn mowed regularly up to the water's edge. Immigrating turtles would have to cross wide expanses of cultivated fields and a heavily traveled two-lane highway to the east; a moderately traveled country road and residential areas immediately to the north; open lawn, patches of woodland, cultivated fields, and other residential areas to the west and south. At my request, the owner of the pond kindly refrained from using any chemicals such as fertilizers, herbicides, or algicides in the pond during the five years of study. He did, however, introduce fingerling catfish in 1982, which were large enough by 1984 to swallow juvenile turtles. The pond was also colonized by sunfish (*Lepomis* sp.) in 1983, and these were caught in large numbers in turtle traps in 1984 and 1985. There was little obvious rooted aquatic vegetation or algal mats in the pond during any year of study. A small grove of trees near the east edge of the pond shaded it early in the day, but later the entire pond was completely insolated. There were no basking sites other than the shoreline.

For comparison, data were used from earlier studies of turtle populations at two nearby sites from 1975 to 1982: four farm ponds (ponds 1–4) and a stream about 17.6 km west of Columbus, Lowndes County (Parker, 1984), and a fifth farm pond (pond 5) about 7 km west of Columbus. Ponds 1–4 were 14 km south-southeast, and pond 5 was 16 km east-southeast of the new pond. The numbering of ponds follows Parker (1984), and additional pond size and depth characteristics are in Table 17.4, below. Pond 1 was treated with large amounts of algicides and herbicides and possibly fertilized starting in 1977. I was unable to secure information about these activities from the owner. Pond 2 was not treated with chemicals; algal growth was extensive; the surrounding land was mostly open woodland and old fields in early stages of succession. Pond 2 was sampled briefly in 1976 and more extensively from 1980 to 1982. Ponds 3 and 4 were surrounded by open pasture, and their margins were heavily disturbed by cattle; algal growth was extensive. Pond 5 was bordered by patches of woodland and open fields in early successional stages; there was no chemical treatment; algal growth was extensive. Ponds 3, 4, and 5 were sampled in only one year (1981 or 1982). The stream was a tributary of Tibbee Creek, with steep mudbanks up to about 8 m, extensive seasonal flooding, and dense vegetation along its banks. The stream was briefly sampled in 1980 and 1981.

TRAPPING AND MARKING

A combination of wire-mesh funnel traps baited with fish parts or canned fish-flavored cat food and unbaited basking traps with hinged planks was used. Traps were checked and rebaited daily at the new pond. Trap-days (number of traps × number of trapping days) averaged 278/year (8 years) in pond 1, 60/year (3 years) in pond 2, 44/year (1 year) in pond 3, 45/year (1 year) in pond 4, 80/year (1 year) in pond 5, and 42/year (5 years) in the new pond. Captures per trap-day averaged 1.1 in pond 1 (mean for 8 annual values), 1.0 in pond 2 (3 years), 2.1 in pond 3, 1.5 in pond 4, 1.2 in pond 5, and 0.8 in the new pond (5 years).

Turtles were permanently marked by notching marginal scutes with a pocket saw. Each turtle was measured to the nearest millimeter for plastron length (PL) using vernier calipers for small turtles up to 125 mm PL and a meter stick for larger turtles. Turtles were weighed to the nearest 25 g in a plastic bucket suspended from an Ohaus spring balance. Processing was done on the shore nearest a trap, and turtles were released into the water immediately after processing. See Parker (1984) for further details.

TERMINOLOGY AND DATA INTERPRETATION

The term "juvenile" here refers to sexually immature individuals below 100 mm PL whose sex could not be determined. The term "immature" refers to all immature individuals, adding in immature females 101–159 mm PL. Sexual maturity for females was arbitrarily assigned as 160 mm PL, based on the literature and dissections of 18 females between 145 and 185 mm PL during the reproductive season. Those newly captured after the second year of study (starting in 1977) were assumed to be colonists in pond 1. In the new pond unmarked individuals were obviously colonists the first four years, because the pond was not in existence previously, recapture rates were high, and population estimates were identical to the number of individuals captured in 1983.

As an inverse indicator of annual population turnover, I used the proportion of an age group known or assumed to be in a pond more than one year. This is considered justified because the trapping effort was prolonged over eight years in pond 1, using both baited and unbaited traps to minimize sex or age bias in trapping, and allowed several subsequent years to capture individuals that may have been missed one year. In the new pond I was clearly capturing virtually all the individuals in the pond through 1983, and in 1985 I added an unbaited basking trap (not previously used) to capture individuals that may have ceased responding to baited traps. I also made daily head counts of turtles visible in the new pond; these declined in 1984 and 1985, as did the population estimates.

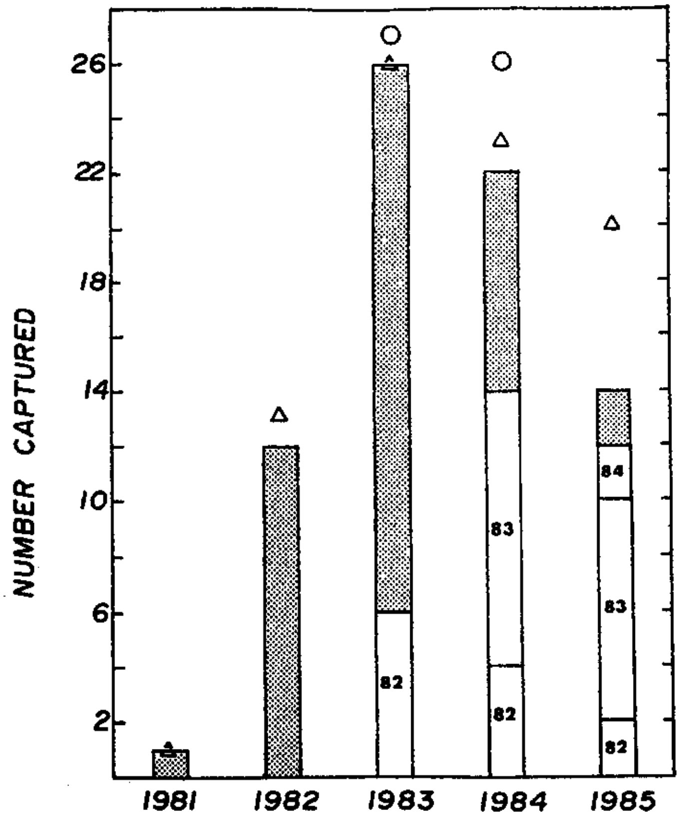

FIGURE 17.1. Captures and population estimates (using the Schnabel Method) for slider turtles captured during five years after construction of a farm pond in 1980. Histograms = actual number captured each year; open circles = number known alive based on subsequent years' captures; triangles = population estimates; stippling = newly marked individuals; numerals in histograms = year that cohort was first marked.

Results

COLONIZATION OF THE NEW POND

POPULATION SIZE AND COLONIZATION RATE. Sampling characteristics of colonization are given and compared with corresponding data for five years at an established pond in Table 17.1. All or most of the turtles in the new pond were captured several times each year, so population estimates were probably close to actual population size. After 1981 the proportion of unmarked, new turtles in the new pond followed a pattern of decline similar to that observed in the established pond.

Population size increased rapidly to a peak in 1983, then leveled off and declined slightly in 1984 and 1985 as numbers of colonists dropped off (Fig. 17.1). Population estimates were at or slightly above the number of turtles actually captured each year. Five turtles apparently remaining in the pond were not captured in one year, and assuming their presence back through 1983 or 1984 gave population sizes above the estimates based on recapture rates. Colonizing cohorts from 1982 through 1984 were each gradually reduced in subsequent years, most severely in the 1984 cohort (Fig. 17.1).

POPULATION STRUCTURE OF COLONISTS. Most turtles captured in the new pond were juveniles or immatures (Fig. 17.2). Colonists were scattered across several size-age groups, but a majority of the population was composed of one cohort of juveniles in the 61–80 mm PL size range, which arrived in 1983 and which made up an easily discernible group in 1984 and 1985 as well. Males in this group marked as juveniles in 1983 were attaining sexual maturity, as indicated by secondary sexual characteristics, by 1985. Adults, especially larger adult females, were poorly represented in all years.

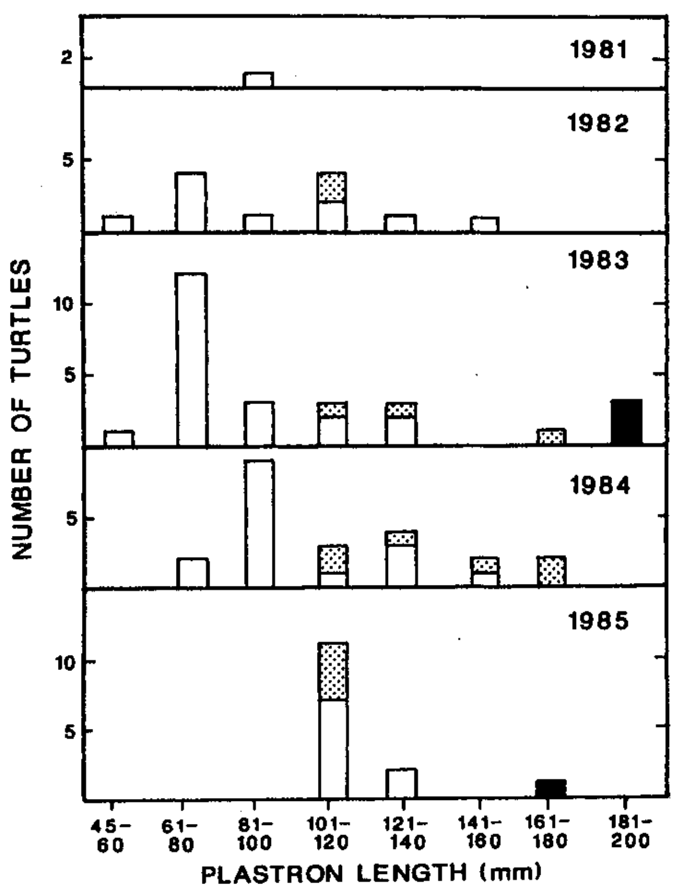

FIGURE 17.2. Plastron lengths of slider turtles captured in each of five years of colonization of the new pond. Unshaded areas = immature turtles, shaded = adult females, stippled = adult males.

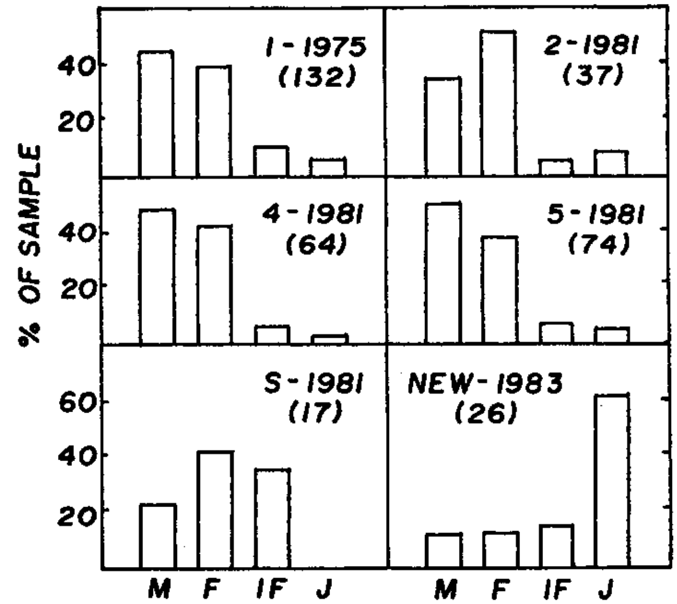

FIGURE 17.3. Comparative population structure in four ponds (1, 2, 4, 5) and a stream (S) in Lowndes County, Mississippi, and a new pond in Clay County, Mississippi, for the years indicated. Pond numbering follows Parker (1984). Numbers in parentheses are total number of individuals captured. Juveniles (J) < 90 mm PL; immature females (IF) = 90–159 mm PL. Mature males (M) and mature females (F) are also shown.

COMPARISONS WITH ESTABLISHED POPULATIONS

POPULATION STRUCTURE. Ratios of mature to immature individuals were similar in four established ponds whose populations had 84.1% to 90.6% adults and 9.4% to 15.9% immatures (Fig. 17.3). A small sample from a stream population contained only 64.7% mature turtles. The new pond was substantially different, with a reverse age structure of 23.0% matures and 76.9% immatures in 1983.

POPULATION TURNOVER. The proportion of turtles in a cohort remaining in a pond for two or more years was used as an inverse indicator of turnover rate. Turnover by this measure was higher in the new pond than in the established pond in all three years of measurement (Table 17.2). When considered by age and sex groups, turnover was virtually identical among juveniles in the two pond types but higher for all other age or sex groups from the new pond. Among adults, turnover was nearly complete; only 2 of 12 were present in more than one year. In pond 1 the highest turnover and recapture rates occurred among adult males (42% of 1,136 total captures were recaptures); the lowest occurred among adult females (33% of 632 total captures were recaptures).

Table 17.2. Colonizing slider turtles present more than one year at a newly constructed pond and an established pond

	New pond		Established pond	
Age group	N (Year)	Proportion present more than one year	N (Year)	Proportion present more than one year
–	12 (1982)	.58	131 (1975)	.81
–	20 (1983)	.65	138 (1976)	.85
–	8 (1984)	.20	88 (1977)	.67
Juveniles (plastron length < 90 mm)	21	.76	198	.78
Immature females	8	.50	59	.80
Maturing males (matured during study)	7	.71	65	.92
Mature females	3	0.0	97	.72
Mature males	9	.22	170	.58

Note: Year and age group indicate when turtles were first marked. The new pond was constructed in 1980 in Clay County, Mississippi. The established pond was pond 1, studied in Lowndes County for eight years (Parker, 1984). Data exclude turtles that drowned in traps in the established pond.

JUVENILE GROWTH RATES. Sample sizes for growth records were unavoidably small during the first years of colonization of the new pond, but differences from established ponds were still apparent (Table 17.3). Growth rates by age interval and sex were generally lower among juveniles from the new pond than among juveniles from the established pond, but significantly so (t test, $p < .01$) only among juvenile females in the 1-to-2-year-old class.

Table 17.3. Comparative growth rates in individuals first captured as juveniles in an established farm pond and a newly constructed pond

	Growth rate by age interval or year interval		
Sex and pond	1-2 years old	2-3 years old	3-4 years old
Juvenile males			
Established pond	21.65 (26) (12-37)	16.9 (38) (6-33)	10.2 (24) (2-17)
New pond	9.0 (1)	20.1 (2) (14-26.2)	–
Juvenile females			
Established pond	22.96* (26) (14-42)	23.4 (26) (12-35)	20.2 (18) (7-34)
New pond	11.3* (3) (9.2-14.5)	18.7 (6) (14.3-28.6)	19.8 (5) (14.0-28.7)
	1982-83	1983-84	1984-85
Sexes and ages combined by year for new pond	11.2 (3) (9.0-14.5)	16.6 (8) (14.0-26.2)	21.2 (6) (14.0-28.7)

Note: Growth rates are expressed in mm of plastron length (PL) per year. Means are followed by sample sizes and extremes in parentheses. Groups were compared by t tests or F tests; significant differences were found only with t tests. Individuals were sexed on the basis of later captures at sizes greater than 100 mm PL. The new pond was constructed in 1980 and was studied from 1981 to 1985; the established pond (pond 1) was studied from 1975 to 1982.
*$p < .01$ (t test).

Combining the three age groups by years of capture showed almost a doubling of juvenile growth rate as the pond aged from its third to its fifth year, despite an increase in the average age of the individuals involved. However, these differences were not significant (F test).

POPULATION AND BIOMASS DENSITIES. Density figures for three established ponds and the new pond in four years are given in Table 17.4, where population estimates for pond 1 and the new pond were based on data in Table 17.1. As was expected on the basis of previous results, both population and biomass densities of turtles in the new pond were well below those in established ponds. The average weight of individual turtles in the new pond was less than half that in established ponds, resulting in biomass densities that were generally less than one-fifth the density in established ponds. The average weight of individual turtles in the new pond increased between 1982 and 1983 but leveled off and declined slightly in 1984 and 1985.

Discussion

CAUSES AND RESULTS OF DISPERSAL

Colonization of a newly created habitat, such as described here for slider turtles, may be dependent upon numerous factors affecting dispersal of neonates from hatching sites and older individuals from suitable aquatic habitats. Dispersal in animals found in patchy habitats may be caused by reproductive motivations (searching for nest sites by females, searching for mates by males), variations in hab-

Table 17.4. Comparative population and live-weight biomass densities of slider turtles in a variety of pond habitats

Pond	Year	Area (ha)	Maximum depth (m)	Population estimate	Population density (turtles/ha)	Individual mean weight (g)	Biomass (kg/ha)
Established ponds							
Pond 1	1975	0.9	2-3	225	250	–	–
	1976	0.9	2-3	300[a]	333	648.5 (156)	215.9
	1978	1.3	3	261	201	683.6 (176)	137.4
	1981	2.8	3-4	215	77	672.5 (119)	51.8
Pond 2	1980	0.2[b]	2-3	37	185	697.3 (28)	129.0
Pond 5	1981	0.9	2-3	162	180	912.4 (73)	164.2
New pond	1982	0.3	1	13	43	255.0 (9)	10.9
	1983	0.3	1	26	87	305.2 (25)	26.6
	1984	0.3	1	23	77	305.6 (22)	23.5
	1985	0.3	1	20	67	285.0 (13)	19.1

Note: Sample sizes are given in parentheses following mean weight. Population estimates are based on the data in Table 17.1.

[a]Estimate adjusted below that given in Table 17.1, to the number known alive based on subsequent years' captures.

[b]Area at summer low point, not taking area of entering stream into account.

itat quality or resultant nutritional status, overcrowding, low social status, or inherent factors (Horn, 1983; Swingland, 1983; Gibbons, 1986). Such multiple causes of dispersal may be typical in many vertebrates (Dobson and Jones, 1985). Successful dispersal may depend on the distance to other adequate habitat and its quality (in terms of food, shelter, mates, etc.) and may result in increased nesting or mating success, more rapid growth if nutrition is improved, occupation of more open and less crowded habitat, and acquisition of higher social status. For the entire population these results may increase overall population densities and decrease inbreeding through genetic homogenization of local populations (Horn, 1983).

The capability of slider turtles for long dispersal movements (greater than 4 km) was documented by Morreale et al. (1984), so my results of successful, rather rapid colonization of open habitat 1.8 km from the nearest source populations are not surprising. In fact, the questions addressed here have more to do with the retention of individuals that have located a new habitat than with the search for and location of new habitat. Because I was able to sample for only a few weeks a year, any short-term flux of individuals was not detectable. Instead, my captures mostly represent individuals that became established in the new pond. Below, I discuss my results as specifically related to the causes and results of dispersal identified above.

Male search for mates. Adult male slider turtles move longer distances and in greater numbers than do adult females, which are more philopatric (Morreale et al., 1984; Parker, 1984). Presumably these movements maximize male reproductive success, although this is yet to be demonstrated. Larger, dominant males drive smaller, subordinate males away from mature females (Cagle, 1950; Lardie, 1983) and may be the only breeders in captivity (Rundquist, 1985), although females still control culmination of mating (Berry, 1984). Only three adult females were captured in the new pond (Fig. 17.2), and none of them was present more than one year (Table 17.2). Among nine males first captured as adults, only two (104–133 mm PL) were captured more than one year, and all five of the largest males (148–173 mm PL) were captured in only one year. The largest males probably do not remain where there are few or no adult females. However, it is less clear why any mature males or males reaching maturity in the new pond would remain longer. Lower turnover in maturing males than in adult males was also noted in the established population (Table 17.2). Risks to smaller males during dispersal movements may be too great even if there is a high likelihood of remaining subordinate to larger males in large ponds or encountering no adult females in small ponds.

Nutrition and growth. Growth rates in freshwater turtles may be positively affected by high-protein diets (Gibbons, 1967b; Parmenter, 1980) and/or elevated water temperatures (Christy et al., 1974) and may be negatively affected by increased salinities (Novak and Morreale, 1985). Carnivorous habits extend into the second year of life in *P. scripta* (Clark and Gibbons, 1969) and may continue when high-protein food sources such as fish carrion are present (Parmenter, 1980).

Productivity of farm ponds may vary widely; biomasses of consumer organisms frequently increase with increasing primary production (Arruda, 1979). My results of (1) a reduced growth rate among turtles during their first two years in the new pond relative to those in an established pond (Table 17.3), and (2) an increase in growth rate as the new pond aged, both presumably reflect a correlation between growth rates and food availability or quality, although the prey organisms and pond productivity were not measured.

A few turtles at the new pond were clearly undernourished relative to similar-aged individuals in established ponds. Slower growth early in life could have affected health and survivorship and perhaps delayed sexual maturity. It is not clear why some turtles would stay under such conditions, but growth rates (and presumably food supply) increased to near normal levels as the pond aged and primary production apparently increased. Chemical removal of much of the food supply in an established pond seemed to increase the dispersal rate (Parker, 1984). Perhaps the threshold for nutritionally induced dispersal movements varies among individuals.

POPULATION STRUCTURE AND TURNOVER. Proportions of immature turtles were generally lower in my larger samples (9.4% to 15.9%, Fig. 17.3) than in populations sampled by Cagle (1942, 1950) in the United States and Moll and Legler (1971) in Panama (27% to 37%, excluding small samples below 60 individuals). Populations in newer, smaller, and/or shallower ponds may have much higher proportions of immatures. Cagle (1942) sampled a 0.025-hectare stock pond in Illinois two years after its construction; 13 of 63 turtles in the pond were *P. scripta*. Among those 13, 76.9% (10) were immatures, a figure similar to my result in the new pond (83.3%) at the same age.

Colonization rate was also almost identical between the two studies two years after pond construction (13 in Illinois, 12 in Mississippi), although Cagle's pond was much smaller and had 53 turtles of other species, whereas my new pond was larger and had only 9 turtles of one other species (*Kinosternon subrubrum*). Cagle's pond was "distant" from colonization sources, but the distance was not given.

BIOMASS AND POPULATION DENSITIES. My biomass and population densities for *P. scripta* in Table 17.4 all fall well within figures for other populations of this species in a literature summary by Iverson (1982) and in a more localized interhabitat comparison by Congdon et al. (1986). The new pond I studied was expectedly at the lower end of this range; as it ages more, perhaps it will approach the higher figures found at pond 2, an older pond of similar size but greater depth (Table 17.4). Decreasing densities in pond 1 were more from pond expansion by beaver damming than from a decrease in population size. The densities I recorded in established ponds were mostly toward the high end of the range for this species, perhaps partially as a result of lower numbers of sympatric populations of other turtle species. Only small numbers of one or two other species (*Chelydra serpentina* and *K. subrubrum*) occurred in any of my study areas.

FUTURE WORK

Closely controlled farm pond systems are potentially ideal for developing an understanding of dispersal dynamics in freshwater turtles such as *P. scripta*. Ponds newly constructed in good habitat could be standardized for size, depth, and distance from sources of colonization. A relatively rapid colonization such as reported here could lead to stabilized populations in only a few years. Manipulations of populations could include varying available food and observing its effect on dispersal and reproduction. Population densities could be artificially increased or decreased. Social status (dominance) in both sexes could be determined through behavioral observations, and its role in dispersal could be identified. A series of such field experiments would enhance our understanding of the mechanisms by which such freshwater turtles have achieved their conspicuous success at frequently high population and biomass densities.

Acknowledgments

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