Structure and Composition of a Southern Illinois Freshwater Turtle Assemblage

Michael J. Dreslik[1], Andrew R. Kuhns[1,2], and Christopher A. Phillips[1]

Abstract - We report on a six-year study (1994–1999) of a diverse turtle assemblage in Gallatin County, IL. Ten species of freshwater turtles representing four families were recorded. Species richness increased as a function of trap hours, with 3000 trap hours required to capture all species. The greatest density and biomass was for *Trachemys scripta*. *Pseudemys concinna* ranked second in density, but *Chelydra serpentina* ranked second highest in biomass. Females comprised the majority of the biomass in emydids, biomass ratios were even in *Sternotherus odoratus*, and males comprised the majority of the biomass in *C. serpentina*. Relative abundance did not significantly differ among the six years, although some uncommon species were not captured in all years.

Introduction

Community ecology began as a descriptive science and has since evolved a broad theoretical framework on such topics as niche and trophic theory (Morin 1999). For simplicity, most contemporary research focuses on assemblages, a subset of a community where the organisms are similar taxonomically or ecologically. Ecologists have long realized that organisms interact with each other and the abiotic environment to form distinct assemblages within ecosystems (Schluter and Ricklefs 1993). Biotic interactions such as competition, predation, commensalisms, and trophic cascade determine the structure of assemblages (Morin 1999). Within a particular ecosystem, the number of species present in any given assemblage is usually expressed as function of the area, amount and heterogeneity of the habitat, degree of isolation, or trapping effort (Lawton et al. 1993, Schluter and Ricklefs 1993). For many taxa and habitats, it is often difficult to have an a priori knowledge of richness. For turtles, a series of global richness maps have been produced (Iverson 1992) that can serve as an initial predictor of species richness. When the assemblage has been effectively sampled (i.e., no additional species added with subsequent sampling effort), within-assemblage relationships in relative abundance, density, and biomass can be analyzed without bias.

Organisms that occur at higher abundances often comprise a significant portion of the biomass within a particular ecosystem. Resources and nutrient

[1]Illinois Natural History Survey, Center for Biodiversity, 607 East Peabody Drive, Champaign, IL 61820. [2]Department of Biological Sciences, Illinois State University, Campus Box 4120, Normal, IL 61790-4120. Corresponding author - dreslik@uiuc.edu.

flow are limited, thus biomass decreases as trophic levels increase. Because turtles are relatively long-lived, comprise a large amount of the total biomass in a community, and have low biomass productivity (Congdon et al. 1986, Iverson 1982), turtles may restrict nutrient flow and lock nutrients into biomass longer than most organisms. Their role in the ecosystem can be significant, although many of the factors affecting the structure of turtle assemblages remain poorly understood (Bury 1979).

Several studies have found that freshwater turtle assemblage structure changes across habitat, resource, and seasonal gradients (DonnerWright et al. 1999, Moll 1990, Vandewalle and Christiansen 1996). From a temporal aspect, studies have documented turtle assemblages that have exhibited no change in structure (Congdon and Gibbons 1996), marked shifts in relative abundance (Meylan et al. 1992), and partial species turnover (Stone et al. 1993). These studies have occurred on managed reserves (Congdon and Gibbons 1996), in constructed wetlands (Stone et al. 1993), and in areas with heavy human impact (Meylan et al. 1992).

Here we report on a six-year study at a floodplain lake in southeastern Illinois. The ten turtle species recorded include the Smooth Softshell (*Apalone mutica* LeSueur), Spiny Softshell (*Apalone spinifera* LeSueur), Painted Turtle (*Chrysemys picta* Schneider), Snapping Turtle (*Chelydra serpentina* Linnaeus), Common Map Turtle (*Graptemys geographica* LeSueur), Ouachita Map Turtle (*Graptemys ouachitensis* Cagle), False Map Turtle (*Graptemys pseudogeographica* Gray), River Cooter (*Pseudemys concinna* LeConte), Stinkpot (*Sternotherus odoratus* Latreille), and Red-eared Slider (*Trachemys scripta* Schoepff). We determined species composition and compared our observed richness to that using species richness maps (Iverson 1992) and determined if relative species abundance, density, and biomass of each species also fluctuated. Finally, we compared our results to other populations and assemblages.

Methods

Study site

Round Pond is a 30-ha member of a chain of floodplain lakes located approximately 4 km west of the confluence of the Ohio and Wabash rivers. During spring flooding, Round Pond connects directly or through a system of sloughs, creeks, and agricultural drainage ditches to the Ohio River. Small cabins and trailers occupy the western shoreline, a man-made beach encompasses the southern shore, and floodplain forest and buttonbush, *Cephalanthus occidentalis* (Linnaeus), border the remaining shoreline. Three colonies of spatterdock, *Nuphar luteum* (Linnaeus), inhabit the waters off the southwestern, southeastern, and eastern shorelines.

General procedures

We used fyke nets (Vogt 1980) to capture turtles for 108 trapping days between 17 May 1994 and 28 July 1999. In 1994, 1995, 1998, and 1999 we supplemented trapping with baited hoop traps, trammel nets, dip nets, and hand captures. For baited hoop traps, we used the following bait types: fresh chicken livers, sardines in oil, fresh and day-old cut fish, cat food, canned corn, canned green beans, and watermelon rinds in an attempt to attract a diversity of turtle species. We rotated through all bait types and bait was replaced on a three to four day cycle. We used only fyke net captures in regression analyses because they have been reported to capture more mobile turtle species and produce unbiased sex ratios (Vogt 1980). Fyke nets had either a 107 or 76 cm diameter mouth, with 7.6 or 15.2 m wings, 15.2 m leads, and 3.8 cm meshing. Smaller fyke nets were used only in 1994, and we had one to five nets active daily. We set nets parallel to the shoreline in a V-formation and placed a float in the rear chamber to prevent turtles from drowning. Turtles were weighed to the nearest gram using electronic balance or pull-spring scales, sexed using secondary sexual characteristics (Ernst et al. 1994), individually marked using scute notches (Cagle 1939), and released on-site.

Data analysis

For each species, we recorded the raw number captured, numerical rank based on the raw number captured, and relative abundance (for the entire study and by year). We used linear regression on the log-transformed variables of cumulative number of species captured and trapping hours. We tested all pair-wise groupings of the slopes using t-tests (Zar 1996) with a Bonferroni adjustment. We plotted rank abundance curves (Krebs 1989), and tested for differences among years in relative abundance using χ^2 contingency analysis. Assuming our samples were representative proportions of each species, we estimated the population size of other species as: $N_{PC}/P_{PC} = N_i/P_i$, where N_{PC} is the population estimate of the *P. concinna* for that year (Dreslik 1997, Dreslik unpubl. data), P_{PC} is the proportion of *P. concinna* captured for that year, N_i is the population estimate of the i^{th} species, and P_i the proportion of the i^{th} species of all turtles captured for that year. Because open population estimators can be sensitive to the assumption of equal catchability, we opted to use closed models to estimate the yearly population sizes separately (Pollock 1982, Pollock et al. 1990). Under this scenario, each approximately four-week trapping session per year was treated as unique. Thus although a turtle may be a recapture from a previous year, we only used within-year recaptures to estimate population size (i.e., a turtle was scored as an initial capture the first time it was captured in any given year). We chose to use the Schumacher-Eschmeyer method because it affords a ready test for equal catchability (Schumacher and Eschmeyer 1943). Equal catchability was met with the data on *P. concinna* (Dreslik 1997, unpubl. data) and we have reduced the potential bias against the closed population assumption because of the relatively narrow sampling interval. To estimate total biomass per species, we multiplied the average mass of each species (by year) by the respective population size of that species. To estimate biomass based on sex/stage class for the five most abundant species, we multiplied the average mass of each age/stage class by the estimated number of individuals comprising each age/stage class (calculated from the proportion of individuals representing that age/stage class multiplied by the population estimate for that species).

Results

Species per trap-hour regressions indicated cumulative species richness increased as a linear function of trapping effort (Table 1, Figs. 1 and 2).

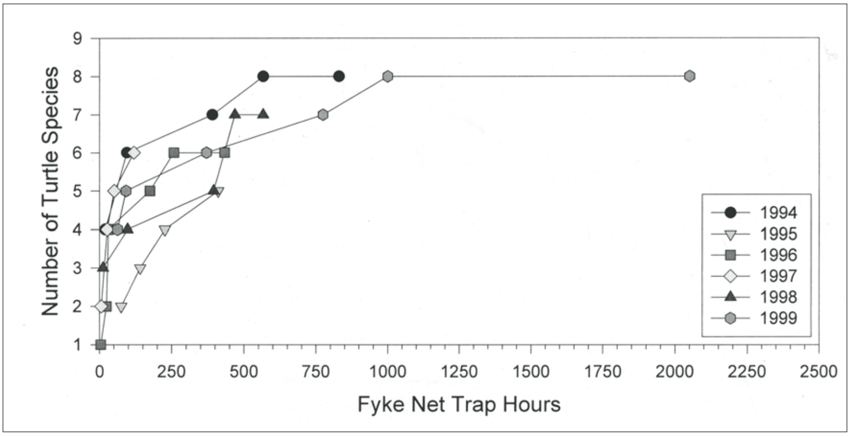

Figure 1. Curves depicting the number of fyke net trap hours versus the number of turtle species captured for 1994–1999 at Round Pond, Gallatin County, IL.

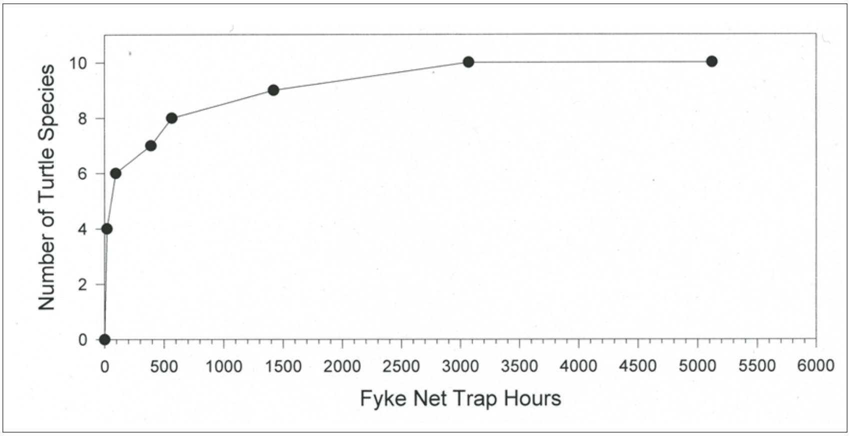

Figure 2. Cumulative fyke net trap hours per turtle species captured for the entire sampling period of 1994–1999 at Round Pond, Gallatin County, IL.

Relative detection rate of species differed between years with inflated detection rates exhibited for years with reduced trapping effort (Table 2, Figs. 1 and 2). This was because of the greater probability in capturing more abundant species (1996 and 1997 in Table 2, Fig. 1). The reverse trend is evident for years with more intense trapping effort (1994 and 1998 in Table 2, Fig. 1). Nonetheless, it took over three thousand trap hours to capture all ten species (Table 2, Fig. 2). Because detection rates were highly variable, we focused our analysis only on total captures.

Of the ten species captured, *Trachemys scripta* was numerically dominant in all years (Table 3). Although some species were not captured in all years (Figs. 1 and 3, Table 3), we found no significant difference among years in relative species abundance ($\chi^2_{0.05,45} = 56.44$, $\chi^2_{crit.} = 64.66$, $p > 0.10$). The majority of turtle biomass was composed of *T. scripta,* and although *P. concinna* was the second most abundant species, *Chelydra serpentina* was greater in overall biomass (Table 3). Of the five most abundant species, female *T. scripta* comprised the greatest proportion of the total estimated biomass followed by male *T. scripta* and male *C. serpentina* (Table 4; $\chi^2_{0.05,8} = 22.95$, $\chi^2_{crit.} = 15.51$, $0.005 > p > 0.001$). Our density and biomass estimates for

Table 1. Regression analysis conducted on the number of turtle species captured perr trap hour for the 1994–1999 field seasons at Round Pond, Gallatin County, IL.

Year	r^2	Slope	Y-int.	F	*p*
1994	0.966	0.186 ± 0.020	0.868 ± 0.111	84.9	0.0027
1995	0.950	0.489 ± 0.056	-1.333 ± 0.324	75.4	0.0010
1996	0.895	0.384 ± 0.066	-0.374 ± 0.291	34.2	0.0043
1997	0.972	0.375 ± 0.045	0.077 ± 0.162	70.4	0.0139
1998	0.840	0.227 ± 0.057	0.467 ± 0.303	15.7	0.0209
1999	0.945	0.195 ± 0.023	0.284 ± 0.062	69.3	0.0011
Fyke Net I	0.868	0.414 ± 0.118	-0.273 ± 0.246	12.3	0.0249
Fyke Net II	0.859	0.459 ± 0.093	-0.373 ± 0.190	24.4	0.0078
Fyke Net III	0.955	0.265 ± 0.029	0.174 ± 0.059	85.5	0.0008
Fyke Net IV	0.896	0.332 ± 0.057	-0.041 ± 0.114	34.5	0.0042
1994–1998	0.977	0.177 ± 0.014	0.903 ± 0.083	170.2	0.0002
Sequential	0.965	0.166 ± 0.014	0.419 ± 0.040	139.3	0.0001

Table 2. Matrix of differences in slopes (upper sections) and q-stats (lower sections) for multiple comparisons on the species per trap hour curves by year. Significant q-scores are in bold and a Bonferonni penalty was taken resulting in a nominal alpha value of 0.025. * = P < 0.001, † = 0.005 < P < 0.010, ‡ = 0.01 < P < 0.05.

	1994	1995	1996	1997	1998	1999
1994	-	0.303	0.198	0.189	0.041	0.009
1995	**9.349***	-	-0.105	-0.114	-0.262	-0.294
1996	**5.369†**	-3.011	-	-0.009	-0.157	-0.189
1997	3.923	-2.443	-0.180	-	-0.148	-0.180
1998	1.166	**-7.929***	**-4.194‡**	-3.045	-	-0.032
1999	0.285	**-10.060***	**-5.540‡**	-3.905	-0.992	-

Table 3. Number captured, percent of capture, density (turtles/ha), biomass (kg/ha), and rank (according to abundance) of trap captures of turtles from Round Pond, Gallatin County, IL, over the summers of 1994 to 1999 by year and all years combined for all capture methods (fyke net, trammel net, hoop traps and by hand). Biomass estimates are calculated only when ten or more individuals were captured. *A.m.* = *Apalone mutica*, *A.s.* = *Apalone spinifera*, *C.p.* = *Chrysemys picta*, *C.s.* = *Chelydra serpentina*, *G.g.* = *Graptemys geographica*, *G.o.* = *Graptemys ouachitensis*, *G.p.* = *Graptemys pseudogeographica*, *P.c.* = *Pseudemys concinna*, *S.o.* = *Sternotherus odoratus*, and *T.s.* = *Trachemys scripta*.

	A.m.	*A.s.*	*C.p.*	*C.s.*	*G.g.*	*G.o.*	*G.p.*	*P.c.*	*S.o.*	*T.s.*	Total
1994											
# captured	1	3	2	10	0	9	2	46	7	154	234
% of capture	0.4	1.3	0.9	4.3	0	3.8	0.9	19.7	3.0	65.8	
Rank	9	6	7.5	3	-	4	7.5	2	5	1	
Density	0.11	0.33	0.22	1.11	-	1.00	0.22	5.09	0.77	17.04	25.89
Biomass	-	-	-	5.01	-	0.12	-	2.34	0.12	11.79	19.99
1995											
# captured	1	3	0	9	0	7	0	21	5	96	142
% of capture	0.1	2.1	0	6.3	0	4.9	0	14.8	3.5	67.6	
Rank	7	6	-	3	-	4	-	2	5	1	
Density	0.25	0.75	-	2.25	-	1.75	-	5.24	1.25	23.97	35.46
Biomass	-	-	-	7.29	-	0.17	-	4.84	0.21	13.66	27.07
1996											
# captured	0	1	1	4	0	2	0	16	0	112	136
% of capture	0	0.7	0.7	2.9	0	1.5	0	11.8	0	82.4	
Rank	-	5.5	5.5	3	-	4	-	2	-	1	
Density	-	0.49	0.49	1.96	-	0.98	-	7.84	-	54.90	66.67
Biomass	-	-	-	10.12	-	0.35	-	6.35	-	31.27	41.19
1997											
# captured	0	0	0	6	0	1	1	5	4	42	59
% of capture	0	0	0	10.2	0	1.7	1.7	8.5	6.8	71.2	
Rank	-	-	-	2	-	5.5	5.5	3	4	1	
Density	-	-	-	11.39	-	1.90	1.90	9.49	7.59	79.75	112.01
Biomass	-	-	-	24.54	-	-	-	2.99	-	21.80	55.03
1998											
# captured	0	3	0	18	1	3	0	25	11	90	151
% of capture	0	2.0	0	11.9	0.7	2.0	0	16.6	7.3	59.6	
Rank	-	5.5	-	3	7	5.5	-	2	4	1	
Density	-	1.04	-	6.23	0.35	1.04	-	8.66	3.81	31.17	52.30
Biomass	-	-	-	22.71	-	0.09	-	2.57	0.61	15.01	42.43
1999											
# captured	0	4	1	46	0	13	3	48	17	228	360
% of capture	0	1.1	0.3	12.8	0	3.6	0.8	13.3	4.7	63.3	
Rank	-	6	8	3	-	5	7	2	4	1	
Density	-	0.61	0.15	6.99	-	1.98	0.46	7.30	2.58	34.67	54.74
Biomass	-	-	-	17.97	-	0.73	-	5.11	0.40	19.13	39.95
Overall											
# captured	2	14	4	93	1	35	6	161	44	722	1082
% of capture	0.2	12.9	0.4	8.6	0.1	3.2	0.6	14.9	4.1	66.7	
Rank	9	6	8	3	10	5	7	2	4	1	
Ave. density	0.06	0.39	0.14	4.99	0.06	1.44	0.43	7.27	2.67	40.22	57.63
Ave. biomass	-	0.53	-	19.01	-	0.16	-	4.51	0.42	26.14	50.77

T. scripta, P. concinna, C. serpentina, and *Sternotherus odoratus* are comparable to other populations; however, several studies reported density and biomass estimates an order of magnitude greater (Table 5).

Discussion

Species detection

We required 3000 trap hours to capture ten freshwater turtle species at Round Pond. In some years when trapping effort was reduced due to flooding (1995 and 1996), we had an inflated species detection rate. This was because common species were captured rapidly, whereas uncommon species

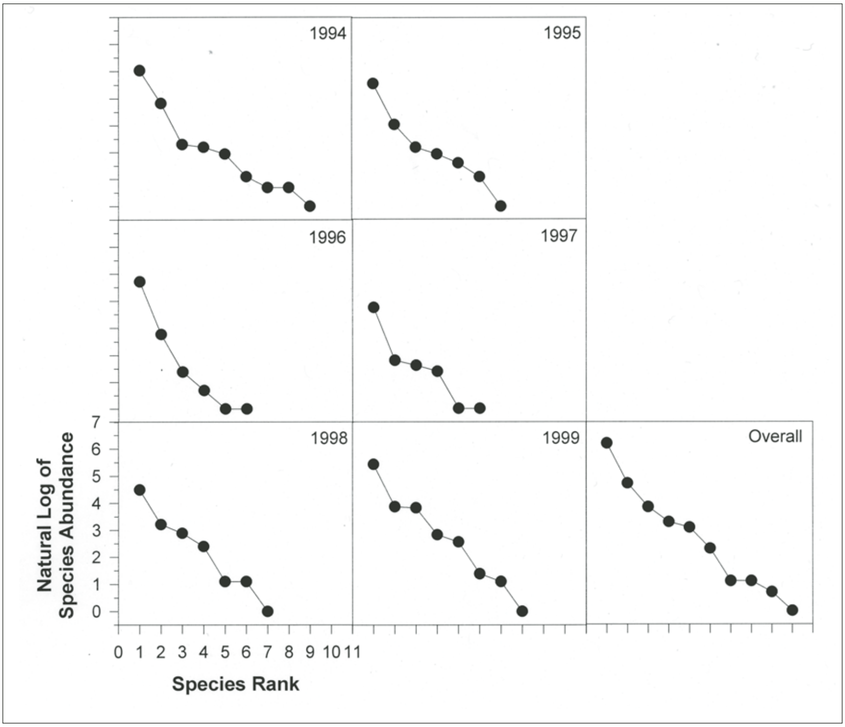

Figure 3. Composite rank-abundance curves for all turtle species captured for all methods by year, and for all years combined at Round Pond, Gallatin County. Species identification for each rank for each line can be cross-referenced in Table 1.

Table 4. Biomass(kg/ha) estimates of each sex/stage class for the five most abundant species captured at Round Pond, Gallatin County, IL, during the 1994–1999 field seasons. *C.s.* = *Chelydra serpentina*, *G.o.* = *Graptemys ouachitensis*, *P.c.* = *Pseudemys concinna*, *S.o.* = *Sternotherus odoratus*, and *T.s.* = *Trachemys scripta*

Sex	*T.s.*	*C.s.*	*P.c.*	*S.o.*	*G.o.*
Males	7.63	6.87	1.90	0.19	0.08
Females	17.87	2.61	4.23	0.20	0.52
Juveniles	1.04	2.22	0.33	0.10	0.03

required greater trapping effort. In 1994 and 1999, when trapping effort was greatest, species detection rates were lower. This suggests that intense sampling is required to effectively sample most turtle communities. However, Round Pond is a relatively large (≈ 30 ha) open body of water; smaller ponds, marshes, and swamps undoubtedly would require fewer trap hours.

Comparison of species richness, density, and biomass

Round Pond is an ecotone inhabited by riverine and lacustrine species, making it one of the most species-rich communities within the upper Mississippi River basin. Other studies in the region have reported as few as three (Cagle 1942) to as many as ten (Gritters and Maudlin 1994)

Table 5. Comparative literature survey of density and biomass estimates for the four most abundant turtles captured at Round Pond, Gallatin County, IL. † - represents studies where biomass was estimated from average turtle weight and density estimate. ‡ represents studies where biomass was estimate by Iverson (1982).

Species/locality	Density (turtles/ha)	Biomass (kg/ha)	Source
Trachemys scripta			
Ellenton Bay, SC	61.5	33.6	Congdon et al. 1986
Risher Pond, SC	41.8	37.1	Congdon et al. 1986
Capers Island, SC	353.0	877.3	Congdon et al. 1986
Alachua County, FL	361.4	282.6‡	Auth 1975
Río Chagres, Panama	190.3	40.5‡	Moll and Legler 1971
Round Pond, IL	40.2	26.4	This study
Pseudemys concinna			
Rainbow Run, FL	170.0	384.2‡	Marchland 1942
New River, WV			
Site 1	2.3	11.1†	
Site 2	0.7	3.3†	
Site 3	1.4	6.6†	Buhlmann and Vaughan 1991
Round Pond, IL	7.3	4.5	This study
Chelydra serpentina			
LaCreek Refuge, SD	1.2	9.1‡	Hammer 1969
Knox County,TN	59.0	10.2‡	Froese and Burghardt 1975
Ellenton Bay, SC	8.0	21.6	Congdon et al. 1986
Risher Pond, SC	7.3	20.6	Congdon et al. 1986
East Marsh, MI	12.8	33.9	Congdon et al. 1986
Southwest Reserve, MI	13.3	30.0	Congdon et al. 1986
George and Burt Ponds, MI	6.8	15.9	Congdon et al. 1986
Blue Creek, NE	50.7	254.0	Iverson 2000
Round Pond, IL	5.0	19.0	This study
S*ternotherus odoratus*			
FL	700.0	41.7	Iverson 1982
Dewart Lake, IN	79.5	8.4‡	Wade and Gifford 1964
Honey Creek, OK	150.0	10.2‡	Mahmoud 1969
Ellenton Bay, SC	7.5	1.2	Congdon et al. 1986
Risher Pond, SC	21.8	1.4	Congdon et al. 1986
Northern AL	148.5	10.6	Dodd 1989
VA	—-	13.6	Mitchell 1988
Round Pond, IL	2.7	0.4	This study

species in an assemblage. Most studies have reported assemblages averaging approximately five species (Moll 1977, Pierce 1992, Wade and Gifford 1964).

Of the turtle species inhabiting the region (Iverson 1992), we captured all but two, *Macrochelys temminckii* (Troost) and *Kinosternon subrubrum* (Lacépède). The rarity of reports, sightings, and captures of *M. temminckii* in Illinois (Phillips et al. 1999) and Round Pond's unsuitable habitat composition (Pritchard 1989) explains the absence of *M. temminckii*. Because of its rarity in Illinois (Smith 1961) and its preference for small shallow swamps (Ernst et al. 1994), the absence of *K. subrubrum* is to be expected. However, the possibility still exists that individuals of either species may occur at Round Pond in extremely low densities.

Red-eared Sliders (*Trachemys scripta*) and River Cooters (*Pseudemys concinna*) were the most frequently captured species. Our estimates are low compared to the southeastern United States (Congdon et al. 1986, Marchand 1942) and may signify less optimal habitat. Optimal habitats for sliders are between 0.5–2.0 m in water depth with low water velocity (Morreale and Gibbons 1986). Round Pond typically has little to no velocity, except during times when the Ohio River floods. However, only the perimeter, northern two coves, and eastern cove are less than 2.0 m deep. Although *P. concinna* inhabits lentic systems (Dreslik 1997, 1998; Smith 1961), the species is more associated with riverine and floodplain wetland habitats (Ernst et al. 1994). Throughout its range, *T. scripta* comprises < 70% of the freshwater turtle assemblage and accounts for the majority of turtle biomass (Cagle and Chaney 1950, Congdon et al. 1986). Our biomass estimates for *T. scripta* are comparable for those of Ellenton Bay and Risher Pond, SC (Congdon et al. 1986); Chiapas, Mexico (Iverson 1982 from R.H. Dean, unpubl. data); and Panama (Moll and Legler 1971). For *P. concinna,* our density and biomass estimates are higher than in the New River, WV (Buhlmann and Vaughan 1991). Given enough suitable habitat, *T. scripta* (Congdon et al. 1986, Iverson 1982 from Auth 1975) and *P. concinna* populations (Iverson 1982 from Marchand 1942) are capable of reaching large densities and biomasses.

Our biomass estimates for *Chelydra serpentina* and *Sternotherus odoratus* may be biased for two reasons. First, both are benthic species in which males may have home ranges in shallow waters (Ernst 1986, Galbraith et al. 1987, Mahmoud 1969). If *C. serpentina* and *S. odoratus* at Round Pond exhibit finite spatial distributions in shallower waters, then we will only capture turtles with home ranges that overlap the sampling area. Second, our reliance on passive capture methods may bias our results. When we used more baited traps in 1994 and 1998, we captured relatively more *S. odoratus*. Similarly, a trapping study on *Chrysemys picta* found that different methods yielded different sex ratios and size structures and thus recommended using multiple trapping methods to obtain population structural parameters (Ream and Ream 1966). However, in our study, fyke nets were the only methods that produced captures of all ten species. Nevertheless, our biomass estimates for *C. serpentina* are larger than or comparable to several populations (Congdon et al. 1986, Froese and Burghardt 1975, Iverson 1982 from Hammer 1969). There are four estimates for *C. serpentina* greater than Round Pond (Congdon et al. 1986, Iverson 1982 from Froese and Brughardt 1975, Iverson 2000). All other published *S. odoratus* estimates were greater than Round Pond (Congdon et al. 1986, Iverson 1982 from Mahmoud 1969, Wade and Gifford 1964).

We believe our low *Chrysemys picta* density estimate may reflect the higher abundance of *T. scripta* within the assemblage. When *C. picta* and *T. scripta* co-occur in Illinois, *T. scripta* dominates in southern assemblages, whereas *C. picta* dominates northern assemblages (E.O. Moll, professor emeritus, Eastern Illinois University, pers. comm.). Had we estimated the biomass of *C. picta* it would be orders of magnitude lower than all other published records (Congdon et al. 1986, Iverson 1982).

Riverine species probably occur because of persistent inundation and subsequent isolation from the Ohio River. Currently, no studies address the relative abundance, population size, and density of *Graptemys ouachitensis* and *G. pseudogeographica.* Although *G. ouachitensis* is fifth in abundance, it is not common, and *G. pseudogeographica* and *G. geographica* occur in low abundance. However, we have recaptured individuals of all three species, suggesting some individuals are residents. Both *Apalone spinifera* and *A. mutica* occur in low densities in Round Pond. Although *Apalone* occur in variable abundances in lacustrine habitats (Cagle 1942, Cagle and Chaney 1950), these habitats are sub-optimal (Plummer 1977, Plummer et al. 1997, Smith 1961). Finally, we have never recaptured any individuals of either *Apalone* species during the study.

Although several studies have focused on the biomass of freshwater turtles (Congdon et al. 1986, Iverson 1982), little is known about intraspecific biomass structure. At Round Pond, the majority of emydid biomass was attributable to females, whereas males comprised the majority of biomass in *C. serpentina.* An increase in female body size corresponds to an increase in clutch size (Congdon and Gibbons 1983) in some species. Therefore, selective factors favor an increase in female size and concurrently, an increase in female biomass, as shown in *T. scripta*, *P. concinna*, and *G. ouachitensis*. Because male *C. serpentina* patrol home ranges and engage in aggressive interactions (Galbraith et al. 1987), intra-sexual competition may have selected larger male body sizes.

Temporal changes in species composition

Round Pond's turtle assemblage structure did not significantly differ between years. Although we captured a few individuals of *Graptemys geographica, G. pseudogeographica, Chrysemys picta, Apalone spinifera*, and *A. mutica*, they were rare enough that their presence or absence did not cause a temporal shift in the assemblage structure. Congdon and Gibbons (1996) considered *A. spinifera* and *G. geographica* rare because they never recaptured individuals. Although we recaptured individuals of some rare species, they occur at such low densities that viable populations may not exist at Round Pond. A study detailing two turtle assemblages from central Alabama found the composition of common, uncommon, and rare species to differ with time (Stone et al. 1993). Coupled with our data and the previous two studies, rare species averaged approximately one-third (33.3% at E.S. George, 28.5% in east central Alabama, and 40% in Round Pond) of a turtle assemblage.

Obtaining accurate measures of turtle species richness and relative abundances requires intense sampling effort (in our case 3000 trap hours). The high number of turtle species inhabiting Round Pond is likely due to the site being a lacustrine-riverine ecotone. Rarer species were not encountered in all years and their presence or absence did not result in temporal fluctuations of the Round Pond freshwater turtle assemblage.

Acknowledgments

Funding for this research was provided by the Illinois Endangered Species Protection Board, E.I.U. Council on Faculty Research, E.I.U. Honors Program Undergraduate Research Award, the Linnaeus Fund of the Chelonian Research Foundation, and the E.I.U. Graduate Summer Research Assistantship Award. We thank E.L. Bryant, B.C. Jellen, J.K. Warner, J.R. Dreslik, P.A. Jellen, S.D. Sudkamp, T. Sudkamp, D.J. Olson, D.B. Shepard, and J.R. Johnson for their assistance in the field, and J.M. Mui, D.B. Shepard, and L.M. Page for their comprehensive reviews and suggestions toward the improvement of this manuscript. Scientific permits were issued by the Illinois Department of Natural Resources to M.J. Dreslik, and all research was conducted under the guidelines ofthe University of Illinois approved IACAUC protocol #00105.

Literature Cited

Auth, D.L. 1975. Behavioral ecology of basking in the Yellow-bellied Turtle, *Chrysemys scripta scripta* (Schoepff). Bulletin of the Florida State Museum: Biological Science 20:1–45.

Buhlmann, K.A., and M.R. Vaughan. 1991. Ecology of the turtle *Pseudemys concinna* in the New River, West Virginia. Journal of Herpetology 25:72–78.

Bury, R.B. 1979. Population ecology of freshwater turtles. Pp. 571–602, *In* M. Harless and H. Morlock (Eds.). Turtles: Perspectives and Research. John Wiley and Sons, New York, NY. 695 pp.

Cagle, F.R. 1939. A system for marking turtles for future identification. Copeia 1939:170–173.

Cagle, F.R. 1942. Turtle populations in southern Illinois. Copeia 1942:155–162.

Cagle, F.R., and A.H. Chaney. 1950. Turtle populations in Louisiana. American Midland Naturalist 43:383–388.

Congdon, J.D., and J.W. Gibbons. 1983. Relationships of reproductive characteristics to body size in *Pseudemys scripta*. Herpetologica 39:147–151.

Congdon, J.D., and J.W. Gibbons. 1996. Structure and dynamics of a turtle community over two decades. Pp. 137–159, *In* M.L. Cody and J.A. Smallwood (Eds.). Long-term Studies of Vertebrate Communities. Academic Press, San Diego, CA. 597 pp.

Congdon, J.D., J.L. Greene, and J.W. Gibbons. 1986. Biomass of freshwater turtles: A geographic comparison. American Midland Naturalist 115:165–173.

Dodd, C.K. 1989. Population structure and biomass of *Sternotherus odoratus* (Testudines: Kinosternidae) in a northern Alabama lake. Brimleyana 15:47–57.

DonnerWright, D.M., M.A. Bozek, J.R. Probst, and E.M. Anderson. 1999. Response of turtle assemblages to environmental gradients in the St. Croix River in Minnesota and Wisconsin, USA. Canadian Journal of Zoology 77:989–1000.

Dreslik, M.J. 1997. Ecology of the River Cooter (*Pseudemys concinna*) in a southern Illinois floodplain lake. Herpetological Natural History 5:134–145.

Dreslik, M.J. 1998. Current status and conservation of the River Cooter (*Pseudemys concinna*) in southern Illinois. Linnaeus fund research report. Chelonian Conservation and Biology 3:135–137.

Ernst, C.H. 1986. Ecology of the turtle, *Sternotherus odoratus*, in southeastern Pennsylvania. Journal of Herpetology 20:341–352.

Ernst, C.H., R.W. Barbour, and J.E. Lovich. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, DC. 578 pp.

Froese, A.D., and G.M. Burghardt. 1975. A dense natural population of the Common Snapping Turtle (*Chelydra serpentina*). Herpetologica 31:204–208.

Galbraith, D.A., M.W. Chandler, and R.J. Brooks. 1987. The fine structure of home ranges of male *Chelydra serpentina*: Are Snapping Turtles territorial? Canadian Journal of Zoology 65:2623–29.

Gritters, S.A., and L.M. Mauldin. 1994. Four years of turtle collections on Navigation Pool 13 of the Upper Mississippi River. Report to the National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin. LTRMP 94-S010. 7 pp.

Hammer, D.A. 1969. Parameters of a marsh Snapping Turtle population, Lacreek Refuge, South Dakota. Journal of Wildlife Management 33:995–1005.

Iverson, J.B. 1982. Biomass in turtle populations: A neglected subject. Oecologia 55:69–76.

Iverson, J.B. 1992. Species richness maps of the freshwater and terrestrial turtles of the world. Smithsonian Herpetological Information Service No. 88.

Iverson, J.B. 2000. *Chelydra serpentina* (Common Snapping Turtle). Density and biomass. Herpetological Review 31:238.

Krebs, C.J. 1989. Ecological Methodology. Harper Collins Publishers, New York, NY. 654 pp.

Lawton, J.H., T.M. Lewinsohn, and S.G. Compton. 1993. Patterns of diversity for the insect herbivores on bracken. Pp. 178–184, *In* R.E. Ricklefs and D. Schluter (Eds.). Species Diversity in Ecological Communities: Historical and Geographical Perspectives. University of Chicago Press, Chicago, IL. 414 pp.

Mahmoud, I.Y. 1969. Comparative ecology of the kinosternid turtles of Oklahoma. Southwestern Naturalist 14:31–66.

Marchand, L.J. 1942. A contribution to a knowledge of the natural history of certain freshwater turtles. Unpubl. M.Sc. Thesis, University of Florida, Gainesville, FL.

Meylan, P.A., C.A. Stevens, M.F. Barnwell, and E.D. Dohm. 1992. Observations on the turtle community of Rainbow Run, Marion Co., Florida. Florida Science 55:219–228.

Mitchell, J.C. 1988. Population ecology and life histories of the freshwater turtles *Chrysemys picta* and *Sternotherus odoratus* in an urban lake. Herpetological Monographs 2:40–61.

Moll, D.L. 1977. Ecological investigations of turtles in a polluted ecosystem: The central Illinois River and adjacent flood plain lakes. Unpubl. Ph.D. Dissertation, Illinois State University, Normal, IL.

Moll, D.L. 1990. Population sizes and foraging ecology in a tropical freshwater stream turtle community. Journal of Herpetology 24:48–53.

Moll, E.O., and J.M. Legler. 1971. The life history of a Neotropical Slider Turtle, *Pseudemys scripta* (Schoepff) in Panama. Bulletin of the Los Angeles County Museum of Natural History 11:1–102.

Morreale, S.J., and J.W. Gibbons. 1986. Habitat suitability index models: Slider Turtle. US Fish and Wildlife Service Biological Report 82(10.125). 14 pp.

Morin, P.J. 1999. Community Ecology. Blackwell Sciences, Inc., Malden, MA. 424 pp.

Phillips, C.A., R.A. Brandon, and E.O. Moll. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Natural History Survey Manual 8:1–300.

Pierce, L. 1992. Diet content and overlap of six species of turtles along the Wabash River. Unpubl. M.Sc. Thesis, Eastern Illinois University, Charleston, IL.

Plummer, M.V. 1977. Activity, habitat, and population structure in the turtle, *Trionyx muticus*. Copeia 1977:431–440.

Plummer, M.V., N.E. Mills, and S.L. Allen. 1997. Activity, habitat, and movement patterns of Softshell Turtles (*Trionyx spiniferus*) in a small stream. Chelonian Conservation and Biology 2:514–520.

Pollock, K.H. 1982. A capture-recapture design robust to equal probability of capture. Journal of Wildlife Management 46:757–760.

Pollock, K.H., J.D. Nichols, C. Browne, and J.E. Himes. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs 107:1–97.

Pritchard, P.C.H. 1989. The Alligator Snapping Turtle: Biology and Conservation. Milwaukee Public Museum, Milwaukee, WI. 104 pp.

Ream, C., and R. Ream. 1966. The influence of sampling methods on the estimation of population structure in Painted Turtles. American Midland Naturalist 75:325–338

Schluter, D., and R.E. Ricklefs. 1993. Species diversity: An introduction to the problem. Pp 1–12, *In* R.E. Ricklefs and D. Schluter (Eds.). Species Diversity in Ecological Communities: Historical and Geographical Perspectives. University of Chicago Press, Chicago, IL. 414 pp.

Schumacher, F.X., and R.W. Eschmeyer. 1943. The estimation of fish populations in lake and ponds. Journal of the Tennessee Academy of Sciences 18:228–249.

Smith, P.W. 1961. The amphibians and reptiles of Illinois. Illinois Natural History Survey Bulletin 28:1–298.

Stone, P.A., J.B. Hauge, A.F. Scott, C. Guyer, and J.L. Dobie. 1993. Temporal changes in two turtle assemblages. Journal of Herpetology 27:13–23.

Vandewalle, T.J., and J.L. Christiansen. 1996. A relationship between river modification and species richness of freshwater turtles in Iowa. Journal of the Iowa Academy of Science 103:1–8.

Vogt, R.C. 1980. New methods for trapping aquatic turtles. Copeia 1980:368–371.

Wade, S.E. and C.E. Gifford. 1964. A preliminary study of the turtle population of a northern Indiana lake. Proceedings of the Indiana Academy of Science 74:371–374.

Zar, J.H. 1996. Biostatistical Analysis. 3rd Edition. Prentice Hall, Upper Saddle River, NJ. 662 pp.