

**Cohort-Specific Growth Rates in the River Cooter,
Pseudemys concinna.**

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Abstract. Growth rates of a species are an integral component in life history studies because of the covariance between growth and life history traits such as size and age at maturity and reproductive output. We have studied a population of *Pseudemys concinna* in a southern Illinois floodplain lake for the past seven out of nine years in order to determine the environmental influences on growth rates. We were able to obtain data on ten cohorts of females and four cohorts of males. We found that growth rates were more plastic in females compared to males and this plasticity was attributed to environmental factors in the first year of growth. Furthermore, this plasticity in growth rates translated to variability in the estimated minimum age of sexual maturity on the order of nine years. The dynamics of cohort-specific growth and survival rates can have profound implications on the demography and viability of turtle populations, especially when considering the plasticity in growth rates and variability in the age of maturity we observed. Long-term study is required to examine the relationship between cohort-specific growth and survival rates.

INTRODUCTION

The principle of allocation dictates that a finite amount of energy is available to and can be assimilated by an organism (Levins, 1968; Sibly and Calow, 1986). When energy is increased to augment one process (*i.e.*, growth) a trade-off occurs whereby energy allocated to another process decreases (Levins, 1968; Sibly and Calow, 1986) such as the trade-off between growth and reproduction (Stearns, 1992, 1989; Stearns and Koella, 1986). Determining the growth of an organism is integral because life history traits such as clutch size, size and age at sexual maturity, and overall lifetime fitness co-vary with growth rates (Stearns, 1992). Growth rates are plastic, depending upon environmental conditions, energy allocation, metabolism, and genetic composition (see Sebens 1987 and Andrews, 1982 for review). Because this plasticity dictates

the maximal size attained by an organism, there is often great inter- and intra-population variation in body size (Dunham and Gibbons, 1990).

The best estimates of growth arise by following individuals over their lifetime associating size with known-age. Accruing data on known-aged turtle populations requires decades of collection (Gibbons, 1990). Since environmental perturbations are often impending, decades of data collection are a luxury. Modeling growth, however, presents the advantages of estimating biologically meaningful parameters (e.g., characteristic rate of growth), which may be represented as life history parameters, allow hypothesis testing between populations, years, and cohorts, and allows studies to be conducted over shorter terms.

The physiology of ectotherms is constrained by the environment to a narrow range of operative temperatures, therefore environmental influences affect growth rates (Sorci *et al.*, 1996; Rhen and Lang, 1995; Sinervo and Adolph, 1994). Because environmental influences vary, cohorts are differentially affected by the environment. Environmental differences can result in synergistic effects that ultimately translate to variability in the attainment of sexual maturity. For long-lived iteroparous organisms such as turtles, variability in the attainment of sexual maturity can affect population viability. For example, cohorts growing in several years of poor environmental conditions may attain sexual maturity at later age, and hence a subsequent depression in recruitment is then exhibited. No study to date has addressed cohort-specific growth patterns in turtles. The objectives of this study were to 1) define cohort-specific growth curves for the river cooter, *Pseudemys concinna*, 2) determine if there were differences in cohort-specific growth rates, 3) determine if differential environmental influences caused these differences in growth rates, and 4) predict how these differences translate to the attainment of sexual maturity.

MATERIALS AND METHODS

Study Site. Located about 4 km west of the Ohio River, Round Pond is a relatively small member (ca. 30 ha) of a chain of floodplain lakes in southeastern Gallatin County, Illinois (Figure 1). During annual spring floods, the lakes connect directly, or through a system of sloughs, to the Ohio River. Small cabins and trailers occupy the western shoreline, a man-made beach encompasses the southern shoreline and the remaining shoreline is bordered by floodplain forest. Also present are three shallow coves and the predominant submergent vegetation is spatterdock, *Nuphar luteum* and button bush, *Cephalanthus occidentalis*

Data Acquisition. We trapped Round Pond with single-set fyke nets and baited hoop traps (Vogt, 1980) between 17 May 1994 and 17 August 2002. Fyke nets were set parallel to the shoreline in 1.0 - 1.5 meters of water depth, with the wings in a V formation with a gallon jug placed in the rear of the trap. We used 12 baited hoops traps for three sessions in 2002, session one occurred from 28 July to 1 August, session two occurred from 6 August to 9 August and session three occurred from 12 August to 15 August. Hoop traps were placed parallel to the shoreline or logs in shallow water with approximately $\frac{1}{4}$ of the trap above the water surface. We baited traps with canned corn, canned string beans, fresh chicken livers, sardines in oil, and day old fish entrails. All traps were checked one to twice daily. In addition, data collected from the 1994-1999 field seasons were used in the analysis.

Each turtle was marked with a unique combination of marginal scute notches (Cagle 1939) and measured with metric vernier calipers. Standard measurements were maximum, carapace length (CL; mm), carapace width (CW; mm), plastral length (PL; mm), and shell height (SH; mm). Males were identified as having elongated fore-claws and a cloacal vent extension beyond the posterior carapace margin. Turtles exceeding the CL of the smallest confirmed male,

but lacking male sex characteristics, were categorized as females. Individuals that were non-sexable are referred to as juveniles. Ages were assigned by counting scute rings on the left pectoral scute. These plastral scute rings are annually deposited in *P. concinna* from Round Pond (Dreslik 1997). Finally, cohorts were then assigned based on age.

Data Analysis. Parameter estimates were made using sequential quadratic programming in SPSS. We chose the most widely used growth equation (von Bertalanffy):

$$PL = A(1 - be^{-kt}),$$

where t is the age of the organism, PL is the plastral length at age t , A is asymptotic size, b is a parameter related to the amount of growth remaining, k is the characteristic growth rate, and e is the base of the natural logarithms. We constructed models by cohort for both sexes and individuals that were too immature to sex (less than 4 yrs) were included in both male and female models. Asymptotic sizes and the parameter b were constrained, because of small sample sizes, to values reported from the literature for this population (Dreslik 1997). Mean sizes of sexual maturity were derived from previous study of *P. concinna* at Round Pond (Dreslik 1997), with females maturing at an average of 214 mm PL and males at 149 mm PL. Ages of sexual maturity were then interpolated from the growth models by rearranging the growth equation to represent age (Dreslik 1997).

We obtained climatological data from the NOAA database for Evansville, Indiana from 1987 to 1997. Environmental data were summarized by mean monthly temperature and total annual precipitation. We used multiple regression analysis with growth rate as the dependent variable and environmental variables in the first year of growth as the independent variables (*i.e.* growth rate for the 1987 cohort paired with the 1987 environmental data). Variables were removed from the regression analysis using a backward stepping method with a removal

probability of 0.10. We calculated the variance inflation factor to determine if multicollinearity was present. All nominal α values were set at 0.05

RESULTS

Trapping Efficiency. We trapped for 4680 hrs during the study, 1690 for fyke net and 2989 for hoop trap hrs (Table 1). We made 472 turtles capture representing the following nine species; the number in parentheses represents the total number captured, *Apalone spinifera* (15), *Chelydra serpentina* (39), *Chrysemys picta* (2), *Graptemys geographica* (2), *G. ouachitensis* (14), *G. pseudogeographica* (1), *Pseudemys concinna* (31), *Sternotherus odoratus* (48), and *Trachemys scripta* (320). Fyke nets were the most effective at capturing *P. concinna* with a rate of one capture per 60.37 hrs, whereas the capture rate for hoop traps was one capture every 996.44 hrs (Table 1). For 2002, *P. concinna* represented 6.6% of the community.

Cohort Specific Growth. Of the 153 individual *P. concinna* captured between 1994-2002, 45 were too large or lacked scute rings and could not be classified to a cohort. There were 108 individuals (70.6%) that could be classified to a cohort, with 1981 being the oldest cohort represented. For females, ten 10 cohorts had a large enough sample size to conduct growth analyses, whereas only four cohorts could be used for males (Table 2). All regression models were significant ($p < 0.05$) and the characteristic growth rate varied considerably in both sexes (Table 1). Female growth rates were more variable ranging from 0.057 to 0.105 compared to male growth rates which ranged from 0.120 to 0.155 (Table 1; Figure 2). Multiple regression analysis was only conducted for females because sample size was low for males. The regression of environmental variables was significant ($r^2 = 0.99$, $F = 1393.7$, $p = 0.021$). Variance inflation factors indicated no multicollinearity (Table 3). Growth rate was positively related to the mean monthly temperatures of February, July, August, October, and November and negatively related

to precipitation, May and December temperatures (Table 3). All variables except for mean May temperature had significant individual effects (Table 3).

Estimated Variation in Sexual Maturity. The overall estimated mean age of sexual maturity for all female cohorts was 14 yrs (Table 4). When we excluded the oldest (19 yrs for the 1988 cohort) and youngest ages (10 yrs for the 1995 cohort), estimated mean age of sexual maturity ranged from 12 to 15 yrs (Table 4). The overall mean estimated age of sexual maturity for males averaged seven yrs, varying from six to eight yrs (Table 4).

DISCUSSION

Trapping Efficiency. Although fyke nets are more costly, cumbersome, and take more time to set, their benefit outweighs precluding them from routine use in chelonian studies (Vogt, 1980). Fyke nets were the most efficient trapping method with capture rates twice that of baited hoop traps. Even when we rotated bait types, hoop traps still produce a biased sample with respect to community composition. Nine species of turtles were captured in fyke nets as compared to five species in baited hoop traps. The four species not captured in the baited hoop traps were *Apalone spinifera*, and all *Graptemys* species. Moreover, once fyke nets are set, they require less attention than baited hoop traps.

Only 6.6% of the turtles captured in 2002 were *Pseudemys concinna* as opposed to previous years (1994 = 19.7%, 1995 = 14.8%, 1996 = 11.8%, 1997 = 8.5%, 1998 = 16.6%, and 1999 = 13.3%; Dreslik 1996, Dreslik unpubl. data). There may be a seasonal bias in captures, or there may be an actual reduction in the population. Female turtles often move to shallower waters prior to nesting (Moll and Legler 1971) and are more readily captured than other times during the year. However, we have sampled different seasons. From 1994 to 1997, trapping effort primarily occurred in the spring whereas in 1998 and 1999 it occurred in the summer.

Further work needs to be conducted in one year across all season to determine if the compositional fluctuation is due to a decrease in *P. concinna* population.

Since the inception of this study in 1994, we have documented the recruitment of 48 individuals (4 males, 22 females, 22 unsexable juveniles). The oldest of these classes recaptured are three 8 yr old females and a 7 yr old male. In order to determine age or stage specific survival rates additional more intense research should focus on obtaining large samples of juvenile turtles that can be aged. Additionally, it is important to document the size and age of primiparity to obtain a better perspective on the age and size of sexual maturity (Condgon and van Loben Sels 1993.). Moreover, equally sampling throughout the activity season within the year should be conducted to determine when hatchings reach the water and how fast they grow within a year.

Cohort Specific Growth. Individuals from the 1998-2002 cohorts may have escaped capture with fyke nets either because of differential habitat use in juveniles or biases inherent in the size of the fyke nets we used. Although ten cohorts were represented for females, and four for males, our sample sizes are small and results should be considered preliminary. A previous study for Round Pond reported a growth rate of 0.087 for females and 0.136 for males (Dreslik 1997a). When considering the mean growth rate of all cohorts our results are similar to those previously reported for Round Pond, however we have the ability to look at yearly effects. This is important because ectotherms are tied to the environment from physiological and resource aspects. This in turn forms a causative chain to body size and ultimately to reproductive output.

Since *P. concinna* are primarily herbivorous, grazing on the periphytic algae *Cladophora* and *Oedogonium* (Dreslik 1997b, 1999) at Round Pond, environmental relationships to growth probably correspond to seasonal changes in algal or macrophyte abundances. We found the

growth rate of a particular cohort of females was related to environmental variation. Years with high precipitation will in turn cause greater run-off and sediment loads in addition to flooding in the Ohio and Wabash River valleys. These flooding events could disrupt algal productivity in the floodplain lakes translating into a temporary depression of resources. An increase in suspended sediments has been found to depress the biomass of the periphytic algae *Cladophora glomerata* (Wilson et al. 1999). Furthermore, because there is an increase in the total aquatic area resources could be more dispersed and difficult to obtain.

Because the metabolic rate of ectotherms is directly related to temperature, we should and did observe an increase in growth rate with environmental temperature. A warmer temperature at the onset and conclusion of the activity season corresponds to an increased duration of the activity season. In general, most freshwater turtle species between 40° and 43° latitude exhibit an activity season from April to September (Bury 1989). Since Round Pond is at 38° latitude, the activity season may extend into March and October. Cohorts experiencing a favorable extension of the activity season should show a subsequent increase in growth rate. This explains the trend we observed in increased growth rates with increased mean temperatures of February, October, and November.

Warmer temperature in the mid-late summer signals an increase in resources. Water temperatures between 20-25°C are optimum for the growth of *Cladophora glomerata* (McNaught 1964). Mean monthly temperatures for Round Pond averaged 20.4°C for July and 18.9°C for August across all years examined. Rapid growth of *Cladophora glomerata* occurs in June and by mid-July (Herbst 1969; Mason 1965) and maximum productivity of *Oedogonium* occurred in July (McCracken 1974). We showed a corresponding relationship to an increase in

cohort-specific growth rates with mean July and August temperatures, which we believe corresponds to an increased abundance in food resources.

The negative trend observed for the mean monthly temperatures of May and December are perplexing. We can offer no outright explanations for the relationship in either. However, the trend with mean May temperature might be related to the timing of hatchling emergence and the utilization of yolk reserves.

Estimated Variation in Sexual Maturity. Turtle species are relatively long lived (Gibbons 1987) and most species typically have high juvenile mortality rates (Congdon et al. 1993, 1994; Iverson 1991a; Frazer et al. 1990). Conversely adult mortality is low, thus maturation is delayed to older ages (Congdon et al. 1993, 1994; Iverson 1991a; Frazer et al. 1990). Age at sexual maturity is a life history characteristic subject selection pressures (Stearns 1992). The viability of turtle populations hinges upon the survival of mature adults because of delayed sexual maturity (Congdon et al. 1993, 1994).

Many reproductive characteristics in turtles co-vary with body, such as clutch size and body size in *Pseudemys concinna* (Iverson 2001). Cohorts that grow faster will attain sexual maturity and a larger body size at an earlier age, hence faster growing individuals have a greater per capita reproductive output compared to their slower growing counter parts. For example, compare the earlier maturing 1995 cohort to the later maturing 1988 cohort. If we assume that one instance of nesting occurs and clutch size averages 14 eggs (Iverson 2001) and extend this till each cohort reaches 30 yrs, then the earlier maturing cohort has a 55% greater reproductive output in terms of egg production compared to the later maturing cohort. This increase in reproductive output is further exacerbated when considering the capacity to lay multiple clutches. Although we lack the data for Round Pond, work in Florida suggests that *Pseudemys*

concinna can lay up to five or six clutches with annual egg production averaging 70 eggs (Jackson and Walker 1997).

Except for these two extreme cohorts, most cohorts are predicted to mature between 12 and 15 yrs suggesting. Although there are still some comparative differences between earlier maturing and later maturing cohorts, it is lessened. Variation between the extremes suggests age at sexual maturity may also be a variable characteristic. Because the plasticity in growth rates is dictated by environmental and genetic variation in ectotherms, this variation is transferred to the age of sexual maturity. Such variability in ages of sexual maturity have been found through long-term data collected on *Emydoidea blandingi*, where the range of sexual maturity spanned seven years (Congdon and van Loben Sels 1993).

Growth rates are responsive of climactic conditions and this trend appears strong for the first year of growth, where survival rates are the lowest. Survival rates of juvenile turtles through their first year of growth seldom exceed 50% (Congdon et al. 1993, 1994; Iverson 1991 a, b; Frazer et al. 1990), thus turtles exhibit a type III survival curve whereby mortality decreases with age (Iverson 1991b). A predicted mechanism to increase survivability is to grow rapidly through periods of high mortality (Williams 1966). However, the relationship between cohort-specific growth rates and cohort-specific survivability (i.e. do faster growing cohorts exhibit higher survival rates) in turtle populations is unknown. The dynamics of cohort-specific growth and survival rates can have profound implications on the demography and viability of turtle populations, especially when considering the plasticity in growth rates and variability in the age of maturity we observed.

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Table 1: Capture records and effort for Fyke nets (roman numerals) and hoop traps for all turtles species during trapping at Round Pond, Gallatin, County, Illinois, from 27 July 2002 to 17 August 2002.

Species	Sex	I (498)		II (494)		III (470)		IV (229)		Totals (1690)		Hrs.
		Num.	Effort	Num.	Effort	Num.	Effort	Num.	Effort	Num.	Effort	
<i>A. mutica</i>	Male	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Female	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Juvenile	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Unknown	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Total	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
<i>A. spinifera</i>	Male	0	0.0000	0	0.0000	2	0.0043	1	0.0044	3	0.0018	563.44
	Female	0	0.0000	4	0.0081	3	0.0064	2	0.0087	9	0.0053	187.81
	Juvenile	0	0.0000	0	0.0000	1	0.0021	0	0.0000	1	0.0006	1690.33
	Unknown	0	0.0000	1	0.0020	1	0.0021	0	0.0000	2	0.0012	845.17
	Total	0	0.0000	5	0.0101	7	0.0149	3	0.0131	15	0.0089	112.69
<i>C. serpentina</i>	Male	4	0.0080	0	0.0000	4	0.0085	0	0.0000	8	0.0047	211.29
	Female	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	
	Juvenile	13	0.0261	3	0.0061	0	0.0000	1	0.0044	17	0.0101	99.43
	Unknown	12	0.0241	1	0.0020	1	0.0021	0	0.0000	14	0.0083	120.74
	Total	29	0.0582	4	0.0081	5	0.0106	1	0.0044	39	0.0231	43.34
<i>C. picta</i>	Male	0	0.0000	0	0.0000	1	0.0021	0	0.0000	1	0.0006	1690.33
	Female	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Juvenile	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Unknown	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Total	0	0.0000	0	0.0000	1	0.0021	0	0.0000	1	0.0006	1690.33
<i>G. geographica</i>	Male	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Female	0	0.0000	0	0.0000	0	0.0000	2	0.0087	2	0.0012	845.17
	Juvenile	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Unknown	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Total	0	0.0000	0	0.0000	0	0.0000	2	0.0087	2	0.0012	845.17

Table 1: Cont.

Species	Sex	I (498)		II (494)		III (470)		IV (229)		Totals (1690)		
		Num.	Effort	Num.	Effort	Num.	Effort	Num.	Effort	Num.	Effort	Hrs.
<i>G. ouachitensis</i>	Male	1	0.0020	5	0.0101	1	0.0021	0	0.0000	7	0.0041	241.48
	Female	0	0.0000	4	0.0081	2	0.0043	0	0.0000	6	0.0035	281.72
	Juvenile	0	0.0000	1	0.0020	0	0.0000	0	0.0000	1	0.0006	1690.33
	Unknown	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Total	1	0.0020	10	0.0203	3	0.0064	0	0.0000	14	0.0083	120.74
<i>G. pseudogeographica</i>	Male	0	0.0000	1	0.0020	0	0.0000	0	0.0000	1	0.0006	1690.33
	Female	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Juvenile	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Unknown	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Total	0	0.0000	1	0.0020	0	0.0000	0	0.0000	1	0.0006	1690.33
<i>P. concinna</i>	Male	1	0.0020	2	0.0041	3	0.0064	0	0.0000	6	0.0035	281.72
	Female	5	0.0100	7	0.0142	9	0.0192	0	0.0000	21	0.0124	80.49
	Juvenile	0	0.0000	1	0.0020	0	0.0000	0	0.0000	1	0.0006	1690.33
	Unknown	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Total	6	0.0120	10	0.0203	12	0.0255	0	0.0000	28	0.0166	60.37
<i>S. odoratus</i>	Male	1	0.0020	3	0.0061	1	0.0021	0	0.0000	5	0.0030	338.07
	Female	3	0.0060	3	0.0061	2	0.0043	0	0.0000	8	0.0047	211.29
	Juvenile	2	0.0040	4	0.0081	0	0.0000	0	0.0000	6	0.0035	281.72
	Unknown	3	0.0060	10	0.0203	3	0.0064	0	0.0000	16	0.0095	105.65
	Total	9	0.0181	20	0.0405	6	0.0128	0	0.0000	35	0.0207	48.30
<i>T. scripta</i>	Male	42	0.0843	32	0.0648	42	0.0894	6	0.0262	122	0.0722	13.86
	Female	45	0.0904	44	0.0891	56	0.1192	6	0.0262	151	0.0893	11.19
	Juvenile	3	0.0060	9	0.0182	5	0.0106	0	0.0000	17	0.0101	99.43
	Unknown	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	-----
	Total	90	0.1807	85	0.1722	103	0.2192	12	0.0525	290	0.1716	5.83
Grand Total	135	0.2711	135	0.2734	137	0.2916	18	0.0787	425	0.2514	3.98	

Table 1: Cont.

Species	Sex	Hoop Traps (2989)		Grand Total (4680)	
		Num.	Effort Hrs.	Num.	Effort Hrs.
<i>A. mutica</i>	Male	0	0.0000	0	0.0000
	Female	0	0.0000	0	0.0000
	Juvenile	0	0.0000	0	0.0000
	Unknown	0	0.0000	0	0.0000
	Total	0	0.0000	0	0.0000
<i>A. spinifera</i>	Male	0	0.0000	3	0.0006 1559.89
	Female	0	0.0000	9	0.0019 519.96
	Juvenile	0	0.0000	1	0.0002 4679.67
	Unknown	0	0.0000	2	0.0004 2339.83
	Total	0	0.0000	15	0.0032 311.98
<i>C. serpentina</i>	Male	0	0.0000	8	0.0017 584.96
	Female	0	0.0000	0	0.0000
	Juvenile	3	0.0010 996.44	20	0.0043 233.98
	Unknown	5	0.0017 597.87	19	0.0041 246.30
	Total	8	0.0027 373.63	39	0.0083 119.99
<i>C. picta</i>	Male	0	0.0000	1	0.0002 4679.67
	Female	0	0.0000	0	0.0000
	Juvenile	1	0.0003 2989.33	1	0.0002 4679.67
	Unknown	0	0.0000	0	0.0000
	Total	1	0.0003 2989.33	2	0.0004 2339.83
<i>G. geographica</i>	Male	0	0.0000	0	0.0000
	Female	0	0.0000	2	0.0004 2339.83
	Juvenile	0	0.0000	0	0.0000
	Unknown	0	0.0000	0	0.0000
	Total	0	0.0000	2	0.0004 2339.83

Table 1: Cont.

Species	Sex	Hoop Traps (2989)		Grand Total (4680)	
		Num.	Effort Hrs.	Num.	Effort Hrs.
<i>G. ouachitensis</i>	Male	0	0.0000	7	0.0015 668.52
	Female	0	0.0000	6	0.0013 779.94
	Juvenile	0	0.0000	1	0.0002 4679.67
	Unknown	0	0.0000	0	0.0000
	Total	0	0.0000	14	0.0030 334.26
<i>G. pseudogeographica</i>	Male	0	0.0000	1	0.0002 4679.67
	Female	0	0.0000	0	0.0000
	Juvenile	0	0.0000	0	0.0000
	Unknown	0	0.0000	0	0.0000
	Total	0	0.0000	1	0.0002 4679.67
<i>P. concinna</i>	Male	1	0.0003 2989.33	7	0.0015 668.52
	Female	0	0.0000	21	0.0045 222.84
	Juvenile	2	0.0007 1494.67	3	0.0006 1559.89
	Unknown	0	0.0000	0	0.0000
	Total	3	0.0010 996.44	31	0.0066 150.96
<i>S. odoratus</i>	Male	4	0.0013 747.33	9	0.0019 519.96
	Female	1	0.0003 2989.33	9	0.0019 519.96
	Juvenile	3	0.0010 996.44	9	0.0019 519.96
	Unknown	5	0.0017 597.87	21	0.0045 222.84
	Total	13	0.0043 229.95	48	0.0103 97.49
<i>T. scripta</i>	Male	10	0.0033 298.93	132	0.0282 35.45
	Female	13	0.0043 229.95	164	0.0350 28.53
	Juvenile	7	0.0023 427.05	24	0.0051 194.99
	Unknown	0	0.0000	0	0.0000
	Total	30	0.0100 99.64	320	0.0684 14.62
Grand Total	47	0.0157 63.60	472	0.1009 9.91	

Table 2: Characteristic growth rates (k) derived from non-linear regression analysis using the von Bertalanffy growth equation with data partitioned into cohorts for male and female *Pseudemys concinna* captured between 1994-2002. Mean asymptotic values for k , standard errors (S.E.), sample size and 95% confidence intervals (C.I.) are also depicted.

Cohort	Females				Males			
	k	S.E.	95% C.I.	n	k	S.E.	95% C. I.	n
1987	0.072	0.005	$0.059 \leq k \leq 0.085$	9				
1988	0.057	0.013	$0.087 \leq k \leq 0.026$	8				
1989	0.073	0.008	$0.051 \leq k \leq 0.095$	6				
1990	0.083	0.007	$0.105 \leq k \leq 0.061$	5	0.138	0.031	$0.269 \leq k \leq 0.007$	4
1991	0.075	0.005	$0.087 \leq k \leq 0.064$	12				
1992	0.091	0.010	$0.118 \leq k \leq 0.064$	6				
1993	0.084	0.005	$0.106 \leq k \leq 0.062$	4				
1994	0.092	0.007	$0.106 \leq k \leq 0.078$	19	0.120	0.016	$0.165 \leq k \leq 0.075$	6
1995	0.105	0.005	$0.117 \leq k \leq 0.093$	9	0.155	0.008	$0.189 \leq k \leq 0.121$	4
1997	0.072	0.019	$0.112 \leq k \leq 0.032$	17	0.155	0.015	$0.191 \leq k \leq 0.120$	9
Mean	0.080	0.004	$0.071 \leq k \leq 0.0090$		0.142	0.005	$0.127 \leq k \leq 0.157$	

Table 3: Environmental variables used in the analysis collected by a National Weather Service weather station in Evansville, Indiana. Precipitation is in cm and all temperatures are in °C.

Year	Precip	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1987	88.0	-4.1	-1.3	2.3	5.3	14.9	18.9	19.9	18.6	13.6	2.8	3.4	-0.6	7.8
1988	98.0	-6.2	-4.4	1.3	5.5	11.1	16.1	19.8	19.7	14.2	3.3	1.6	-3.4	6.5
1989	120.7	-1.0	-3.8	1.8	6.9	11.2	17.4	20.2	19.1	14.4	7.0	1.7	-10.4	7.1
1990	133.9	0.4	1.3	4.6	5.7	12.1	17.6	18.7	17.8	15.5	5.9	3.3	-2.1	8.4
1991	83.3	-3.8	-1.3	3.0	9.2	16.3	19.1	20.1	17.8	14.5	8.3	1.9	-0.4	8.7
1992	91.3	-2.5	-0.3	2.4	8.2	11.8	16.2	20.8	17.2	14.2	7.4	4.1	-2.1	8.1
1993	116.9	-1.7	-4.7	1.1	6.4	13.6	18.2	22.9	20.4	14.0	6.7	2.1	-1.3	8.1
1994	93.7	-6.9	-2.4	1.3	8.4	10.9	19.9	20.6	17.7	13.3	8.5	5.7	1.2	8.2
1995	118.5	-2.1	-3.1	3.5	7.8	13.6	18.4	21.5	22.7	13.8	8.6	-1.0	-2.8	8.4
1997	121.3	-6.2	-0.3	2.6	3.7	9.9	17.8	19.1	18.1	13.1	7.5	0.8	-2.3	7.0
Mean	106.6	-3.4	-2.0	2.4	6.7	12.5	18.0	20.4	18.9	14.1	6.6	2.4	-2.4	7.8

Table 4: Multiple regression output for growth rate and environmental relationships for cohorts of female *P. concinna* at Round Pond, Gallatin County, Illinois.

Variable	B	SE B	Tolerance	VIF	T	Sig T	Part. r ²
August	0.0112	2.01E-04	0.15	6.84	55.56	0.012	0.9996
December	-8.15E-04	0.0001	0.47	2.11	-13.67	0.047	-0.9946
February	0.0070	1.41E-04	0.21	4.82	49.16	0.013	0.9996
July	0.0041	2.12E-04	0.25	3.94	19.23	0.033	0.9974
May	-8.63E-04	9.15E-05	0.49	2.04	-9.43	0.067	-0.9888
November	0.0058	1.35E-04	0.26	3.92	43.11	0.015	0.9994
October	0.0037	7.74E-05	0.64	1.56	48.17	0.013	0.9996
Precipitation	-1.70E-04	1.22E-05	0.36	2.79	-13.96	0.046	-0.9948
Constant	-0.2112	0.00			-55.03	0.012	

Table 5: Cohort-specific variation in ages of sexual maturity for female and male *Pseudemys concinna* derived from cohort specific analyses. Sizes of sexual maturity were derived from published literature (Dreslik 1997).

Cohort	Females	Males
1987	15	
1988	19	
1989	15	
1990	13	7
1991	14	
1992	12	
1993	13	
1994	12	8
1995	10	6
1996		
1997	15	6
Mean	14	7
S.E.	0.783	0.434
95% C.I.	8.4 ≤ n ≤ 19.4	4.5 ≤ n ≤ 9.3

FIGURE LEGENDS

Figure 1: Map of study locations in southeaster Gallatin County, Illinois.

Figure 2: Growth trajectories for the 1987-1997 cohorts of female *Pseudemys concinna* captured at Round Pond, Gallatin County, Illinois.

Figure 3: Growth trajectories for four cohorts of male *Pseudemys concinna* captured at Round Pond, Gallatin County, Illinois.

Figure 1

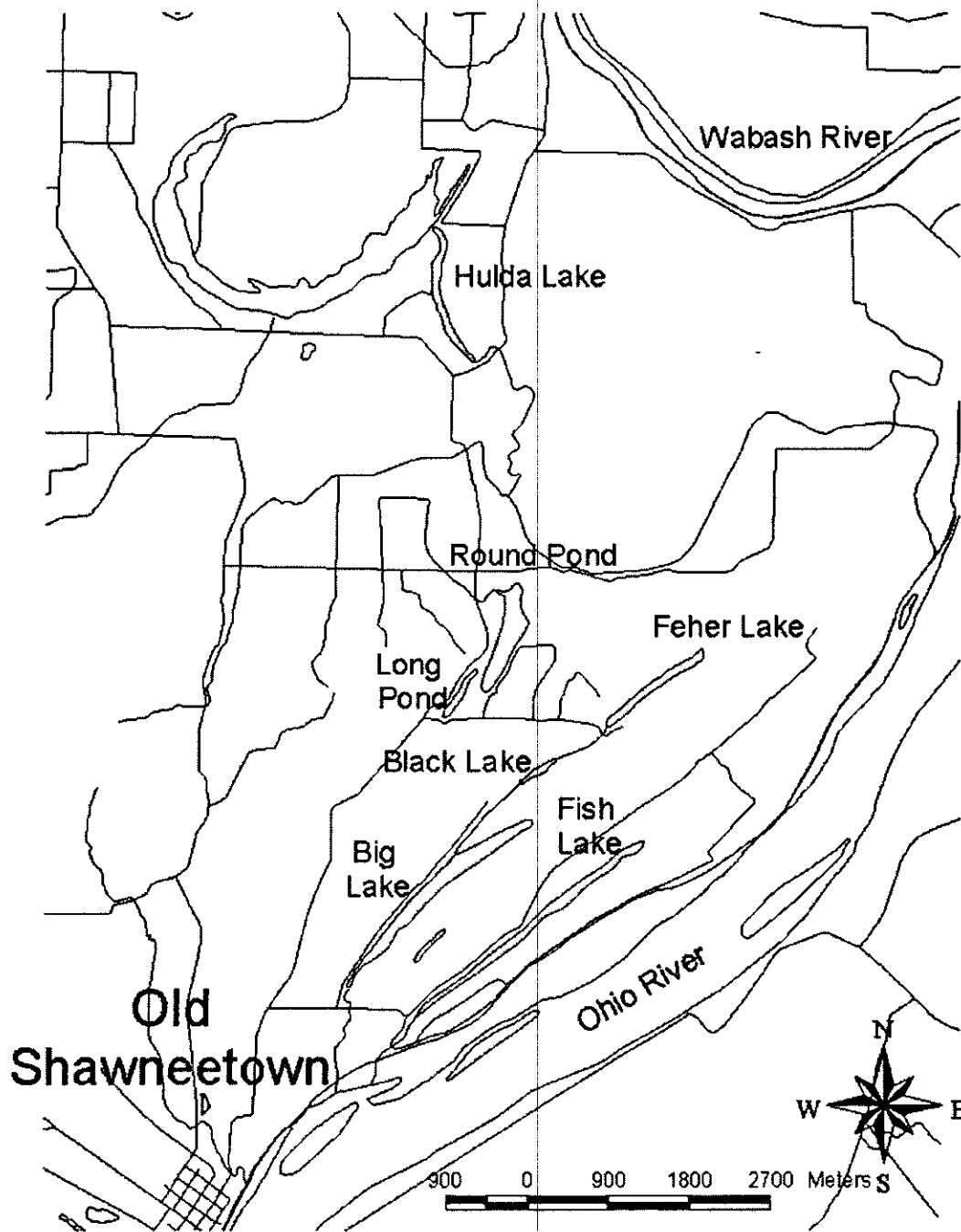


Figure 2

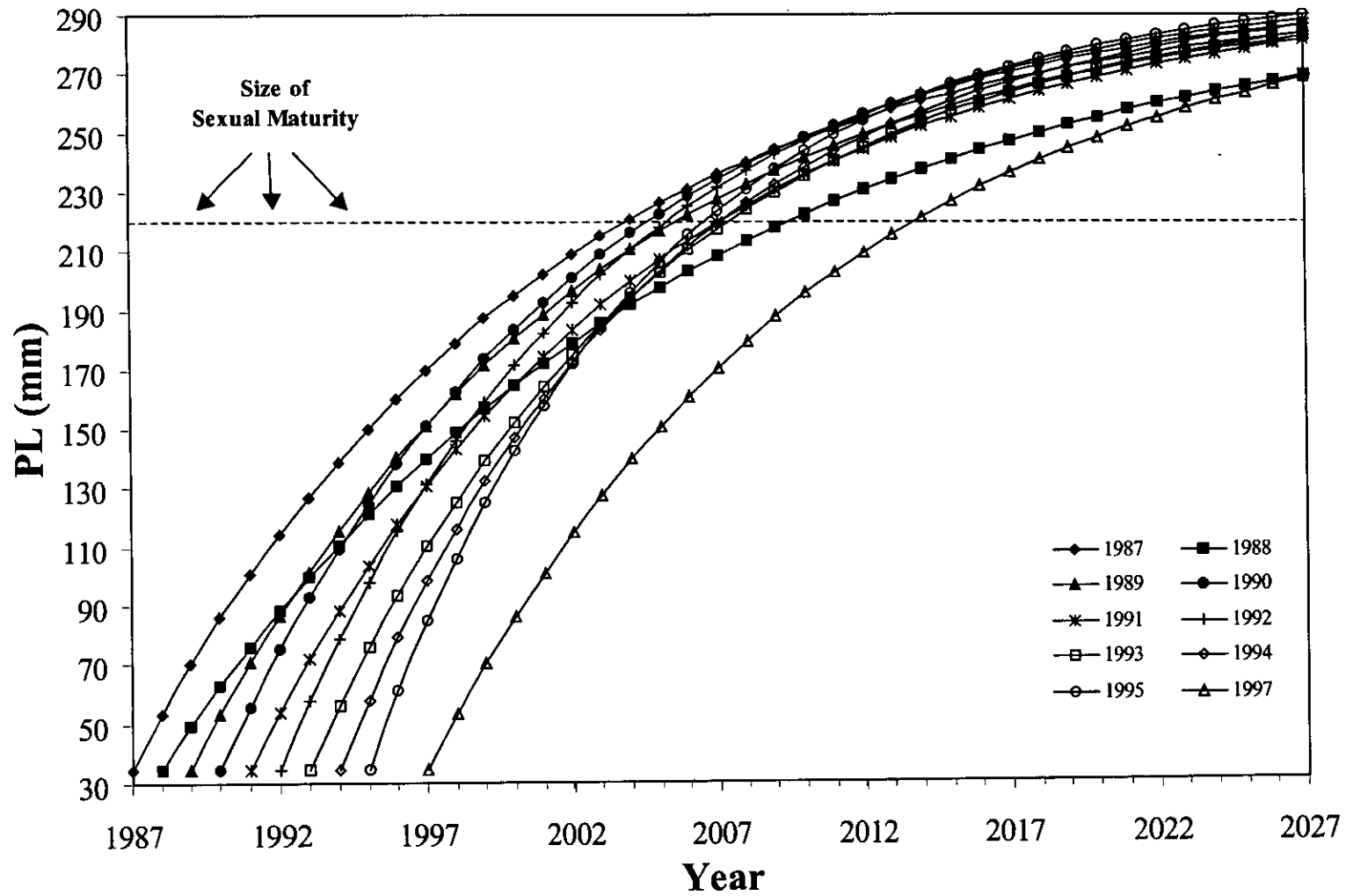


Figure 3

