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Do European pond turtle females continue to grow on reaching maturity?

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Abstract: Data on the straight carapace length (SCL) and plastron length (PL) of eight European pond turtle (*Emys orbicularis*) females were collected in central Poland in 1999 or 2000, and again in 2006 or 2007. All of the individuals were mature – each of them was observed during egg laying in 1993 or earlier, and in the following seasons. Differences in lengths between the studied periods have been found for PL, but not for SCL. There was no correlation between final plastron length and the growth rate.

Key Words: *Emys orbicularis*, growth rate after maturity, long-term study

Introduction

Many animals (e.g. fishes, snakes, turtles, tortoises, clams) and plants continue to growth after maturity. Life-history theory predicts that such investment in growth should be compromised by further investment in reproduction (e.g. as size-related fecundity) or survival (Stearns 1992; Czarnołęski and Kozłowski 1998; Heino and Kaitala 1999). Turtles are animals characterized with delayed reproduction, longevity and iteroparity (repeated cycles of reproduction). Their mortality rate is high during embryonic development and for young individuals, but very low for adults. The growth rate of young turtles is rather high, but it slows greatly as maturity is reached (Bury 1989; Wilbur and Morin 1998). Indeterminate growth could be important in increasing the reproductive output of older turtles, because for many species it has been shown that larger females produce larger eggs or larger clutches of eggs, or that the annual clutch size, especially in populations that lay multiple clutches, is higher for bigger females (Iverson 1992; Wilbur and Morin 1998). Such data are available for the European pond turtle also, with bigger females were laying more eggs per clutch, whilst for larger ones the annual clutch size was higher (e.g. Zuffi and Odetti 1998; Zuffi et al. 1999;

2007; Mitrus 2002; Najbar in press). However, adult individuals of some turtle species do not appear to grow at all (Bury 1989; Wilbur and Morin 1998): the Painted turtles (*Chrysemys picta*) exhibit indeterminate growth, whereas for another freshwater turtle – the Blanding's turtles (*Emydoidea blandingii*) – such growth has been not observed (the Blanding's turtle is closely related to the European pond turtle; Feldman and Parham 2002) (Pappas et al. 2000; Congdon et al. 2001; Congdon et al. 2003). For adult turtles there is no information, on whether growth is present throughout their entire lifespan, or only during – for example – several or a dozen years after maturity, and if growth rates are similar for females and males.

As the growth rate of mature turtles is not recorded or is very low, to check if individuals from any species or in a specific population grow, then data concerning the size of adult turtles at larger intervals should be collected. Gathering such data is difficult, turtles have to be marked permanently, and measurement errors should be minimized (it would be best if animals were measured by the same person). It is important also to gather data about older individuals, to check if growth appears throughout their lifecycle. However, for most studies, information is only available concerning the presence or absence of sexual characters. Thus, in the group of animals described as "adults", individuals could be included which have just matured, as well as older ones. During the study, I gathered data on the size of older females only, to check whether, if after a long period after attaining sexual maturity, the turtles still grow.

Materials and methods

From 1999 to 2000 and from 2006 to 2007, fieldwork were conducted in the Borowiec Nature Reserve (the Zwoleńka River valley, the Radom district, central Poland). Location of the study site is presented in Mitrus and Zemanek (2004), with more information about the reserve – in Zemanek (1992). During spring and summer (from the end of April to late August), turtles were collected by dip netting, and also observed on their way to nesting sites and during nesting (in such cases females have been measured after nesting). Before 1991, during previous studies, numbers on the third vertical scute of the carapace were engraved (Mitrus and Zemanek 1998). Thus, for individual recognition of the females, these numbers were used.

Straight carapace length (SCL) and plastron lengths (PL) of captured turtles were obtained to 0,1 mm using clippers, according to methods described by Fritz (1995). All turtles were measured by the same person (SM), using the same clippers during both the study periods. After measurement, the turtles were released in the place where they were captured.

Only data gathered for older individuals was analysed. There is no information about the true age of the turtles. However, each of the females was captured during previous studies between 1987 and 1990, and according to sexual characteristics (cf. Zuffi and Gariboldi 1995) were then described as "adult". What's more: each of the females was observed during egg laying in 1993 or earlier. During studies from 1987 to 1998, the females were watched during egg laying on average 6.2 times (2 to 8 times for different individuals). Thus, I am sure, that for the analysis, only females which had obtained maturity some years before the start of the research have been taken.

To check if there are no differences in size between the two periods I used the Wilcoxson test for data for SCL and PL respectively, gathered during the initial capture of each turtle in the years 1999-2000, and the last in years 2006-2007. The growth rate [mm

/year] (= mean seasonal change of carapace or plastron lengths) was calculated from the equation:

$$\text{growth rate} = \frac{\text{change in length between capturing}}{\text{number of months between capturing}} \times 12 \text{ months}$$

Statistical analyses were completed using the software package Statistica, ver. 6.1. (StatSoft Inc. 2004).

Results

I have gathered data on the SCL and PL of eight females of the European pond turtle, measured over an interval of about 6 to 8 years. The final mean carapace length of the females (based on measurements done on 2006-2007) was 185.11 mm (*SD* = 6.31, min-max: 172.9-192.4), and the mean plastron length: 178.01 mm (*SD* = 7.15, min-max: 169.3-188.2 mm). There were differences in the plastron length between measurements taken in 1999-2000 and in 2006-2007 (Wilcoxon's test: $T = 1$, $p = 0{,}017$, $n = 8$), however such differences were not observed for length of the carapace (Wilcoxon's test: $T = 11$, $p = 0{,}33$, $n = 8$) (Fig. 1).

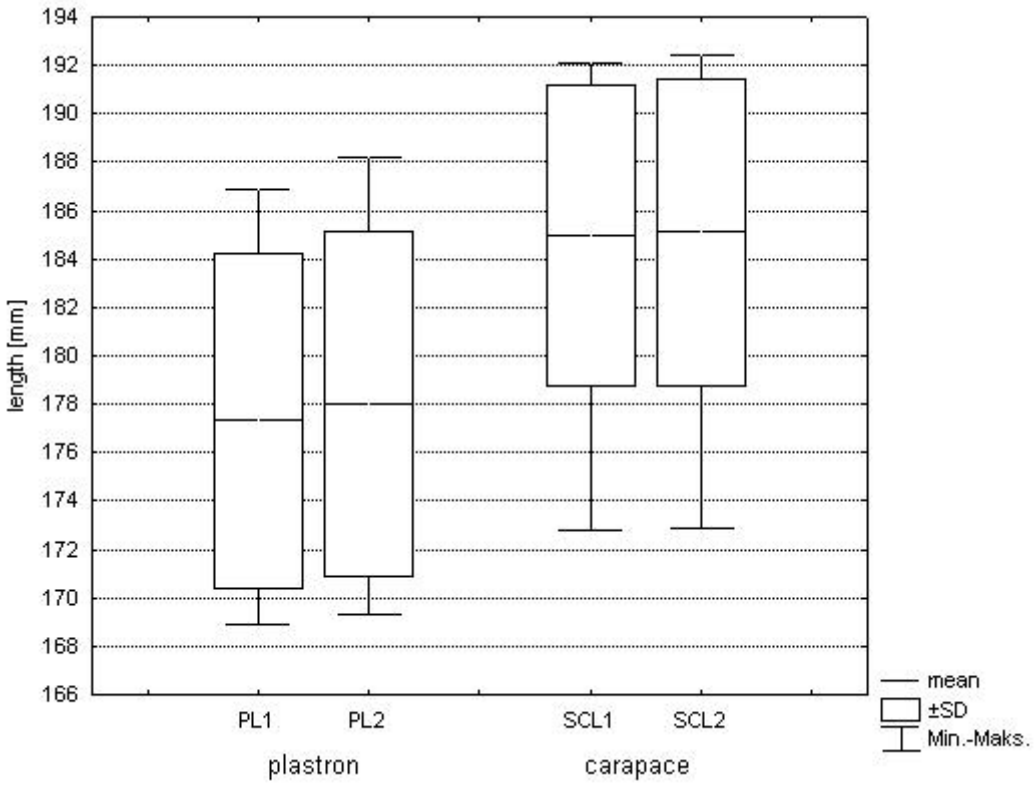

Fig. 1. Initial data (obtained in year 1999 or 2000) and final (year 2006 or 2007) plastron and carapace lengths, of eights adults females of the European pond turtle (*Emys orbicularis*), from central Poland. Intervals between measurements of plastron and carapace lengths are about 6 to 8 years for different individuals.

Mean seasonal change of the carapace length was 0.019 mm/year with 95% confidence intervals (*C.I.*): -0.023–0.062 (*SD* = 0.051, min–max: -0.06–0.10 mm/year), and mean seasonal change of the plastron length: 0.101 mm/year with *C.I.*: 0.046–0.156

(*SD* = 0.066, min–max: -0.01–0.19 mm/year). Thus, the mean change of length during one season was about 0.010% and 0.056% respectively, for the carapace and plastron lengths.

There was no correlation between final plastron length and mean seasonal change in the plastron length ($r = 55$, $p = 0.16$, $n = 8$) (Fig. 2).

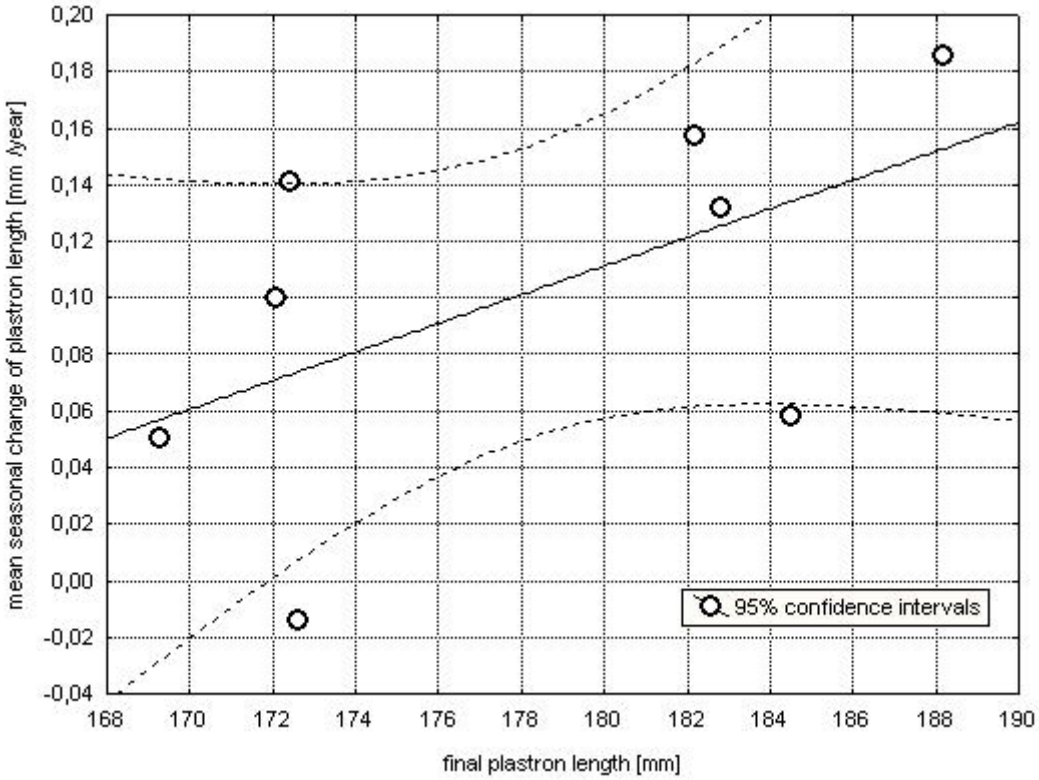

Fig. 2 The relationship between the mean growth rate (mm /year) and shell straight plastron length of adult individual turtles (*Emys orbicularis*) from central Poland. Intervals between measurements are about 6 to 8 years for different individuals. No correlation was found.

Discussion

To understand turtles' life history, it is necessary to study the data about e.g. lifespan and growth rate after maturity. As turtles are considered as long-living organisms (Gibbons and Semlitsch 1982; Wilbur and Morin 1988; Shine and Iverson 1995), research on their ecology requires long-term studies. However, there is very little information about the true age of adult turtles, and in many studies only indirect data is available. For many turtle species, it is possible to check if any individual is "mature" using sexual characters, but there is lack of data confirming whether it has attained sexual maturity many years earlier, or just recently.

For turtles, the growth rate slows greatly at maturity (Bury 1989; Wilbur and Morin 1998), but data on the growth rate of older individual is very scarce. For the European pond turtle, most information about the growth of adult turtles is presented as: "not observed", "slow", or "very slow". For example, in France no shell growth was observed in reproductive females (Baron and Duguy 2000; Naulleau 2000); in western Poland for some turtles, growth was "very small" or "was not observed", although one female

did grow 0.55 cm during a period of 7 years, and later during 4 years, no growth was recorded (Najbar in press). In central Poland, the mean growth rate based on short term studies of "adult" females with a SCL longer than 175 mm, was low (0.44 mm/year, min–max -0.76–10.44 mm) (Mitrus 2002). Individuals of the turtle from central Poland have several to a dozen or so wide growth rings and a series of narrow ones (Mitrus and Zemanek 2004). These patterns might be associated with sexual maturity (Zug 1991), in that the narrow rings are formed after maturity, and the wide ones before. The presence of the narrow rings suggest that after maturity the turtle still grows, but based only on the pattern, it is not possible to say if they grow throughout their life.

The data cited above for the European pond turtle are presented for "adult" turtles, without information about their true ages, and so consequently whether the individuals were old, or just past the mature stage. In this study only the data for females with maturity confirmed at least several years before start of the research was used. For the individuals concerned, the difference in size after 6-8 seasons, were found for the plastron length. Thus, European pond turtle females in central Poland, continue to grow for some time after maturity. However, the grow rate is very small (Fig. 1, 2), thus this during short period it is difficult to notice.

On the other hand, differences in size of the individuals were not found for the carapace length. It is possible that the carapace length does not increase, even if the plastron length is bigger, as for example, carapaces of the turtles could be taller not longer (during the study precise data about shell height was not gathered). It is also possible, that differences in length were not found, in spite of growth being present, because of damages to a part of the carapaces (edging part of carapace of older turtles could be rubbed out). It could also be an error during measurements – in some cases it is easier to measure precisely, the plastron length than carapace length, because of the presence of asymmetries in the shell of individual turtles (personal observations).

The research shows that based on data for plastron length, in central Poland, European pond turtle females appear to grow for many years after reaching sexual maturity. I have no such data for male turtles, which typically are smaller than females, and mature earlier (Mitrus and Zemanek 2004). It is possible that the growth rate after maturity could be higher for them, because females allocate energy mostly to eggs, whereas males could allocate bigger part of them to growth even in maturity (cf. Czarnołęski and Kozłowski 1998; Heino and Kaitala 1999). Gathering such data in order to check if the growth rate of adult females and males of turtles is similar requires long term studies, but such data could be important for understanding the life history of turtles and problems of delayed reproduction and longevity.

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