Frequency of successful reproduction and time of nest emergence of hatchlings of the European pond turtle in the northern part of its distribution area

Sławomir Mitrus[1], Bartłomiej Najbar[2] & Adam Kotowicz[3]

[1]*Department of Biosystematics, Opole University, Oleska 22, 45-052 Opole, Poland*

[2]*Faculty of Biological Sciences, Institute of Civil and Environmental Engineering, University of Zielona Góra, prof. Z. Szafrana 1, 65-516 Zielona Góra, Poland*

[3]*Orkana 11/9, 41-800 Zabrze, Poland*

We have analyzed long-term (1987–2011) data on the reproduction of the turtle *Emys orbicularis* in western and central Poland. In contrast to earlier evidence, which suggested that *E. orbicularis* rarely reproduces successfully in the northern part of its distribution area, we document successful reproduction in at least 16 out of the last 20 seasons, including annual reproduction since 1998. Hatchlings emerged either in late summer or autumn, or overwintered in nests and emerged between late February and May of the following year.

Key words: egg-laying time, *Emys orbicularis*, long-term data, overwintering, Poland

INTRODUCTION

The aquatic European pond turtle *Emys orbicularis* is the only native chelonian species in central Europe. Its range embraces North Africa, southern, central, and eastern Europe and adjacent Asia up to the Aral Sea. The northernmost populations occur in northeastern Germany (Brandenburg), Poland, Lithuania and Latvia (Fritz, 2003; Sommer et al., 2007). At present, the species is endangered in many parts of its distribution range (Fritz, 2003). Suboptimal climate precluding annual reproductive success has been considered as one of the main factors threatening the existence of the species in the northern parts of its range, although anthropogenic factors might have played a more prevalent role, causing local extinctions (Fritz, 1996; Sommer et al., 2007, 2009).

For successful reproduction, the European pond turtle needs summers with sufficiently high temperatures and insolation rates (e.g., Sommer et al., 2007, 2009). Research carried out in the 1980s and 1990s showed that, in the northern part of the distribution area, embryos did not complete their development or overwintering hatchlings died because of severe frost (Zemanek, 1991; Andreas & Paul, 1998; Najbar & Szuszkiewicz, 2005). Nevertheless, evidence of successful reproduction was found for example in central Poland (where hatchlings were recorded in spring, Zemanek & Mitrus, 1997) as well as in Germany (Andreas et al., 1996). Based on summer temperatures in Poland, Zemanek (1991) estimated that *E. orbicularis* could have successfully reproduced in 23 out of 57 seasons between 1931 and 1988. Mitrus (2005) assumed that the species could reproduce successfully only every second year, although reproductive success was recorded over four successive seasons (1998–2001). However, detailed data on how often the northernmost populations reproduce successfully were so far lacking, mostly due to the fact that neonates can emerge from nests during summer, autumn or the following spring (Mitrus & Zemanek, 2003; Mitrus, 2005). Here, we present a comprehensive dataset on reproductive success of *E. orbicularis* at the northern range of its distribution.

MATERIALS AND METHODS

Fieldwork was conducted in the Borowiec Nature Reserve (central Poland, CP) from 1987 to 2011, and in the Lubuskie district (western Poland, WP) from 1994 to 2011. The Borowiec Nature Reserve is situated in the Zwoleńka River valley (the Radom District; Zemanek, 1992; Mitrus & Zemanek, 2004). In WP, turtles were studied in the Ilanka river valley and the Pliszka river valley (Najbar & Szuszkiewicz, 2007).

Each year during the egg-laying season (mid-May to mid-June), females were observed when moving to

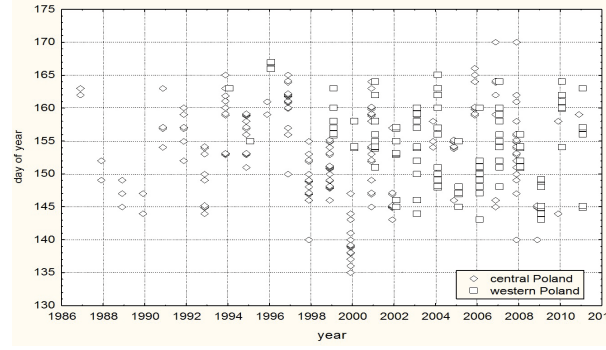

Fig. 1. Variation in egg laying time of the turtle *Emys orbicularis* in Poland. Day of year - No. of days from January 1st.

Correspondence: Sławomir Mitrus, Department of Biosystematics, Opole University, Oleska 22, 45-052 Opole, Poland; *E-mail:* smitrus@uni.opole.pl

nesting sites and during nesting. Nests were marked by placing pegs at the corners of a 50 cm square centred on the nest, and checked irregularly from May to mid-August for signs of predation. We also checked the marked nests sporadically in autumn, winter and the next spring (Mitrus, 2005; Najbar & Szuszkiewicz, 2005).

From 1989 (CP) and 1999 (WP) onward, all known nests, or part of them, were opened and hatchlings or eggs were transferred for artificial rearing in late summer (Zemanek, 1992; Mitrus, 2005; Najbar, 2005; Najbar & Szuszkiewicz, 2005). We therefore do not know, however, if hatchlings would have overwintered in the nest or emerged in late summer or autumn.

In CP, turtles were also captured in a water reservoir, and the age of unmarked one-, two-, or three-year-old turtles was determined by counting the annual growth rings on the carapace (Zug, 1991; Mitrus, 2009). Data concerning such individuals, as well as data on the numbers of live and road-killed hatchlings between nesting areas and water reservoirs are also included in this study. Statistical analyses were carried out using the software package Statistica 6.1. (StatSoft Inc., 2004).

Table 1. Data on incubation success and hatchlings nest emergence of the turtle *Emys orbicularis* in Poland.

	western Poland [Lubuskie district]				central Poland [Zwoleńka river valley]			
	summer / autumn		following spring		summer / autumn		following spring	
year	nest opened / with live hatchlings*	date of emergence (No. of nests)	date of emergence (No. of nests)	nest opened / with live hatchlings	nest opened / with live hatchlings*	date of emergence (No. of nests)	date of emergence (No. of nests)	nest opened / with live hatchlings
1987								2/0 [beginning Jun]
1988								2/0 [beginning Jun]
1989					3/3			
1990					1/1			
1991					2/2	before 13 Sep (1)		
1992					2/2	between 7–14 Sep (4)		
1993					6/2			
1994			1st half of May (1)		8/4	5 Sep (1)		
1995				1/0 [~10 May]	7/5			
1996				3/0 [~30 Apr]	2/0			
1997					20/18			
1998					9/5		before 28 Mar (1), 28 Mar (1), between 28 Mar–5 Apr (2)	1/1 [16 Apr]
1999	8/8				3/3	24 Aug (1), 25 Aug–11 Sep (10), 16 Oct–6 Nov (1)	between 25 Mar–7 Apr (2), 12 Apr (1)	3/1 [30 Apr]
2000	3/3				5/2	before 7 Sep (1), 18–20 Sep (1), ~10 Oct (1), between 10 Oct–26 Nov (1)	between 13–27 Apr (1)	
2001	9/9					between 14–21 Sep (1)	before 22 Feb (1), between 26 Mar–4 Apr (1), 11 Apr (1)	1/1 [17 Mar], 9/1 [1–2 May]
2002	6/6			2/0 [~10 May]		between 2 Sep–2 Oct (1)		
2003	7/7			4/0 [~10 May]		between 7–17 Sep (5), 1–3 Oct (1)		1/0 [4 May]
2004			since 1st half Apr (12)**			before 1 Oct (1)		2/1 [3 and 26 May]
2005		2nd half Sep (1)	2nd half of Apr (4)				before 4 Apr (1), between 15 Apr–11 May (2)	
2006		2nd half Sep (1)	2nd half of Apr (7)		1/1	between 19 Aug–9 Sep (1), 14–30 Sep (1), 7–21 Oct (1)	between 17 Mar–1 Apr (2)	1/1
2007	4/4		since middle Apr (8)				before 31 Mar (2)	6/2 [12 Apr]
2008	5/5		since 19 Apr (1)			between 23 Aug–11 Oct (2)		6/0 [4 Apr]
2009	2/2	since 1 Sep (1) and since 3 Sep (1)	since 5 Apr (2), 9 Apr (1) and 12 Apr (1)		3/2		before 5 Apr (3)	
2010	4/4		since 30 Mar (2)				before 8 Apr (2) ***	
2011		before 2 Oct (2), between 2–16 Oct (4)				before 20 Sep (1)		

* - 1st half of Sep (except for central Poland in 1999 - 17 Sep, and 1989, 2009 - mid Oct); ** - before 13 Apr (1); since: 13 Apr (1), 16 Apr (1), 17 Apr (1), 20–22 Apr (6), 1 May (1), 3 May (1); *** - two other nests with signs of emergence found in end of May.

Table 2. Reproductive success of the turtle *Emys orbicularis* in Poland.

Eggs laid in year	Found nest emergence			Other data on reproductive success
	western	central		(collected in the Zwoleńka river valley, central Poland)
1987			?	in spring 1988 found destroyed nests with parts of eggshells, eggs with dead embryones, and dead hatchlings (Zemanek, 1992)
1988				
1989			?	in spring 1990 found destroyed nests with parts of eggshells, eggs with dead embryones, and dead hatchlings (Zemanek, 1992)
1990				
1991		yes	yes	migrating hatchling found on 03.06.1992 (Zemanek & Mitrus, 1997)
1992		yes		
1993				
1994	yes	yes	yes	migrating hatchling found on 23.04.1995; two dead hatchlings found (25.04 and 01.05.1995) on road (between nesting area and water reservoirs) (Zemanek & Mitrus, 1997)
1995				
1996				
1997				
1998		yes	yes	in 2000 and 2001 in water reservoirs young, non-marked turtles were caught, based on the annual growth rings they were hatched from eggs laid in 1998 (7 individuals), 1999 (3) and 2000 (2); one dead hatchling found on road on 19.09.1999 (A. Kotowicz - unpubl. data)
1999		yes	yes	
2000		yes	yes	
2001		yes		
2002		yes		
2003		yes	yes	in July and August 2006 in water reservoirs have been cought young, non-marked turtles: based on the annual growth rings several of them have been hatched from eggs laid in 2003 and 2004, and one from eggs laid in 2005; two dead hatchlings found on ground road on 30.04.2005 (A. Kotowicz - unpubl. data)
2004	yes	yes	yes	
2005	yes	yes	yes	
2006	yes	yes	yes	migrating hatchling found on 19.09.2006 (A. Kotowicz - unpubl. data)
2007	yes	yes		
2008	yes	yes		
2009	yes	yes	yes	alive hatchling found on road on 13.05.2010 (A. Kotowicz - unpubl. data)
2010	yes	yes	yes	in spring and summer 2011 in water reservoirs three young, non-marked turtles were caught: based on the annual growth rings they were hatched from eggs laid in 2010 (A. Kotowicz - unpubl. data)
2011	yes	yes		

RESULTS

We gathered data on 205 clutches in CP from 1987 to 2011, and 108 clutches in WP from 1992 to 2011 (Fig. 1). Variation of nesting time is considerable, with the earliest recorded nesting on May 14, 2000 (CP), and the latest on June 19 (CP, 2008 and 2007). The egg-laying season can last longer than two weeks (e.g., in 2001 and 2008 in CP, and 2004 in WP; Fig. 1). There was no difference in the median dates of egg laying in CP and WP (*t*-paired test, t=0.020, df=9, P=0.98; for which we have three or more seasons data on egg layings). No multiple clutch deposits were recorded for any female in the same season.

In the first half of September, hatchlings were present in most of the opened nest chambers (in 42 out of 63 opened in CP, and in all 48 in WP, Table 1). Hatchlings left the nest chambers from late August (e.g., August 24, CP, 1999) to autumn (October 16–November 6, CP, 1999; Table 1). Hatchlings also overwintered in the nest chamber, emerging from it between late February and May (Table 1). In any season, hatchlings from some of the nests emerged in late summer and other hatchlings overwintered in the nest (Table 1). In CP we recorded annual successful reproduction between 1998 and 2011, and in western Poland between 2004 and 2011 (Table 2).

DISCUSSION

In Poland, European pond turtles have reproduced successfully every year during the last fourteen seasons (1998–2011), and in at least 16 out of the last 20 seasons (Table 1). This contrasts to previous data which suggested that reproduction is rare (e.g., Młynarski, 1971; Zemanek, 1991). However, natural history data for *E. orbicularis* were limited, and a denser monitoring commenced only in the 1990s (Ota, 1999; Hödl & Rössler, 2000; Fritz, 2003). More frequent observations of reproductive success could result from increased monitoring efforts, or from increasing temperatures leading to more favourable climatic conditions (cf. Walther et al., 2002; Synthesis Report, 2009).

Early life stages of turtles are greatly affected by temperature, affecting energy reserves and fitness (e.g., Freedberg et al., 2001; Willette et al., 2005) as well as sex ratio (e.g., Vogt & Bull, 1984). Our data are insufficient to determine whether egg laying dates of *E. orbicularis* in Poland are correlated with

temperature (e.g., for part of seasons only small proportions of nesting females were found). Increasing global temperatures could also lead to hatchlings which more frequently emerge from their nest during summer/autumn rather than during the following spring.

The time when the hatchlings of the European pond turtle emerge from their nest differed from year to year. It is well documented that hatchlings of some freshwater turtle species spend their first winter in or below the nest cavity, while hatchlings of other species emerge during summer or autumn and probably hibernate underwater (Ultsch, 2006). Hatchlings of the European pond turtle exhibit both behaviours (Mitrus & Zemanek, 2003; Mitrus, 2005; this study). Overwintering of hatchlings in the nest could have ecological and evolutionary implications (Gibbons & Nelson, 1978; Costanzo et al., 2008). During strong winters, mortality rates of hatchlings overwintering on land may be very high (Andreas & Paul, 1998; Najbar & Szuszkiewicz, 2005); data on survival rates for hatchlings which overwinter in water reservoirs are as yet not available.

The European pond turtle is rare in many regions across its range, and conservation programmes are carried out across its European range (e.g., Germany: Schneeweiss, 1998; Lithuania: Meeske, 2000; Italy: Ferri et al., 1998; Zuffi & Ballasina, 1998; Spain: Mascort, 1998; Poland: Jabłoński, 1992; Zemanek, 1992). It is often assumed that *E. orbicularis* has difficulties to reproduce in the wild in northern parts of its distribution area, whereas the present study showed that annual successful reproduction was possible over the past 16 years.

ACKNOWLEDGEMENTS

We are grateful to M. Zemanek for providing access to the pre-1990 data she collected on nest site locations in central Poland, and to all our colleagues who helped with the fieldwork, especially M. Zemanek and E. Szuszkiewicz. Two reviewers provided valuable comments on previous drafts of the manuscript. Turtles were collected with permits from the Polish Ministry of the Environment.

REFERENCES

Andreas, B. & Paul, R. (1998). Clutch size and structure of breeding chambers of *Emys o. orbicularis* in Brandenburg. In *Proceedings of the EMYS Symposium Dresden 96. Mertensiella* 10, 29–32.

Andreas, B., Paul, R., Zimmermann, P. & Schneeweiss, N. (1996). Freilandbeobachtungen zum Wanderverhalten frischgeschlüpfter Europäischer Sumpfschildkröten (*Emys orbicularis*) in Brandenburg. *Artenschutzreport* 6, 34–36.

Costanzo, J.P., Lee Jr., R.E. & Ultsch, G.R. (2008). Physiological ecology of overwintering in hatchling turtles. *Journal of Experimental Zoology Part A: Ecological Genetics and Physiology* 309, 297–379.

Ferri, V., Di Cerbo, A.R., & Pellegrini, M. (1998). "Serranella Emys Project" – preservation initiatives of *Emys orbicularis* populations in Abruzzo. In *Proceedings of the EMYS Symposium Dresden 96. Mertensiella* 10, 95–101.

Freedberg, S., Ewert, M.A. & Nelson, C.E. (2001). Environmental effects on fitness and consequences for sex allocation in a reptile with environmental sex determination. *Evolutionary Ecology Research* 3, 953–967.

Fritz, U. (1996). Zur innerartlichen Variabilität von *Emys orbicularis* (Linnaeus, 1758). 5b. Innerartliche Hierarchie und Zoogeographie. *Zoologische Abhandlungen, Museum für Tierkunde Dresden* 49, 31–71.

Fritz, U. (2003): *Die Europäische Sumpfschildkröte*. Bielefeld: Laurenti Verlag.

Gibbons, J.W. & Nelson, D.H. (1978). The evolutionary significance of delayed emergence from nest by hatchling turtles. *Evolution* 32, 297–303.

Hödl, W. & M. Rössler (2000). *Die Europäische Sumpfschildkröte*. Land Oberösterreich, OÖ. Landesmuseum, Linz.

Jabłoński, A. (1992). Próba aktywnej ochrony żółwia błotnego *Emys orbicularis* (L.). In *Czynna Ochrona Zwierząt*, 107–115. Olaczek, R. & Tomiałojć, L. (eds). Warszawa: PWN.

Mascort, R. (1998). Distribution and status of the European pond turtle, *Emys orbicularis*, in Catalonia. In *Proceedings of the EMYS Symposium Dresden 96. Mertensiella* 10, 177–186.

Meeske, M.A.C. (2000). Die Europäische Sumpfschildkröte (*Emys orbicularis*) an der nördlichen Grenze ihrer Verbreitung in Litauen. *Elaphe* 8, 57–63.

Mitrus, S. (2005). Headstarting in the European pond turtles – does it work? *Amphibia-Reptilia* 26, 333–341.

Mitrus, S. (2009). Growth rings in young turtles *Emys orbicularis* – marking is the only reliable criterion for distinguishing between wild and headstarted animals. *Herpetological Journal* 19, 107–109.

Mitrus, S. & Zemanek, M. (2003). European pond tortoise, *Emys orbicularis*, neonates overwintering in the nest. *Herpetological Journal* 13, 195–198.

Mitrus, S. & Zemanek, M. (2004). Body size and survivorship of the European pond turtle *Emys orbicularis* in Central Poland. *Biologia* 59(Suppl.), 103–107.

Młynarski, M. (1971). Żółw błotny. In *Nasze gady*, 50–65. Warszawa: PZWS.

Najbar, B. (2005). Aktywna ochrona żółwia błotnego *Emys orbicularis* (L.) na Ziemi Lubuskiej w latach 1998-2004. *Przegląd Zoologiczny* 49, 61–69.

Najbar, B. & Szuszkiewicz, E. (2005). Reproductive ecology of the European pond turtle *Emys orbicularis* (Linnaeus, 1758) (Testudines: Emydidae) in western Poland. *Acta Zoologica Cracoviensia* 48A, 11–19.

Najbar, B. & Szuszkiewicz, E. (2007). Nest-site fidelity of the European pond turtle *Emys orbicularis* (Linnaeus, 1758) (Testudines: Emydidae) in western Poland. *Acta Zoologica Cracoviensia* 50A, 1–8.

Ota, H. (1999). A review of the European pond turtle, *Emys orbicularis* (Testudines: Emydidae), as a subject for integrative population studies. *Japanese Journal of Herpetology* 18, 30–36.

Schneeweiss, N. (1998). Status and protection of the European pond turtle (*Emys o. orbicularis*) in Brandenburg, Northeast Germany. In *Proceedings of the EMYS Symposium Dresden 96. Mertensiella* 10, 219–226.

Sommer, R.S., Persson, A., Wieseke, N. & Fritz, U. (2007). Holocene recolonization and extinction of the pond turtle, *Emys orbicularis* (L., 1758), in Europe. *Quaternary Science Reviews* 26, 3099–3107.

Sommer, R.S., Lindqvist, C., Persson, A., Bringsøe, H., Rhodin,

A.G.J., Schneeweiss, N., Široký, P., Bachmann, L. & Fritz U. (2009). Unexpected early extinction of the European pond turtle (*Emys orbicularis*) in Sweden and climatic impact on its Holocene range. *Molecular Ecology* 18, 1252–1262.

StatSoft Inc. (2004). STATISTICA, data analysis software system, version 6. www.statsoft.com.

Synthesis Report from Climate change. Global Risks, Challenges & Decisions. (2009). International Scientific Congress University of Copenhagen 2009, 10–12 March. Second edition.

Ultsch, G.R. (2006). The ecology of overwintering among turtles: where turtles overwinter and its consequences. *Biological Reviews* 81, 339–367.

Vogt, R.C. & Bull, J.J. (1984). Ecology of hatchling sex ratio in map turtles. *Ecology* 65, 582–587.

Walther, G.R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T.J.C., Fromentin, J.M., Hoegh-Guldberg, O. & Bairlein, F. (2002). Ecological responses to recent climate change. *Nature* 416, 389–395.

Willette, D.A.S., Tucker, J.K. & Janzen, F.J. (2005). Linking climate and physiology at the population level for a key life-history stage of turtles. *Canadian Journal of Zoology* 83, 845–850.

Zemanek, M. (1991). Występowanie żółwia błotnego, *Emys orbicularis* (L.) w Polsce i zagadnienia jego ochrony. *Przegląd Zoologiczny* 35, 337–347.

Zemanek, M. (1992). Rezerwat przyrody Borowiec w dolinie Zwoleńki. *Ochrona Przyrody* 50, 173–195.

Zemanek, M. & Mitrus, S. (1997). Biologia i ochrona żółwia błotnego *Emys orbicularis* w województwie radomskim. *Chrońmy Przyrodę Ojczystą* 53(1), 67–83.

Zuffi, M.A.L. & Ballasina, D.L.Ph. (1998). Contribution to the knowledge of regional polymorphism of *Emys orbicularis* in Italy, and notes on the husbandry activities at the CARAPAX Centre. In *Proceedings of the EMYS Symposium Dresden 96. Mertensiella* 10, 279–286.

Zug, G.R. (1991). Age determination in turtles. Society of the Study Amphibians and Reptiles. *Herpetological Circular* No 20. 29 pp.

Accepted: 24 July 2012