

## **Reproductive ecology of the European pond turtle *Emys orbicularis* (LINNAEUS, 1758) (Testudines: Emydidae) in western Poland**

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**Abstract.** From May 1999 until June 2003, 48 nests of the European pond turtle *Emys orbicularis* were observed in the valleys of Ilanka and Pliszka rivers (western Poland). 33 nests dug by turtles were found in the vicinity of the Ilanka river, where 15 marked females laid 373 eggs. A further 13 nests were completely damaged by predators. In 2 cases (in the valley of the Pliszka river) ploughed nests were found with 19 undamaged eggs. The earliest date of egg laying was May 24<sup>th</sup> and the latest was on June 13<sup>th</sup>. Digging a chamber, egg laying and burying the nest took between 60-145 minutes, 97.7 minutes on the average. Most females started egg laying 19.20-20.30 and finished 20.55-0.55. The number of eggs varied between 5-17 (av. 11.3). The average length of the eggs was 33.8 mm, the width 19.8 mm and weight 7.8 g. 210 turtles hatched from 392 eggs (from 35 clutches) (53.58%). 160 were subsequently reared in artificial conditions. 50 young turtles were left in natural conditions. Lack of snow and low temperatures probably caused their death. 65 eggs (16.58%) were dug up and destroyed by predators, 22 eggs (young individuals during hatching) (5.61%) were damaged underground by ants. Embryos died in 38 eggs (9.69%) at different, mainly final, stages of development, 30 eggs (7.65%) had shells damaged mechanically, the remaining 27 eggs (6.89%) were not fertilized.

**Key words:** Reptilia, Testudines, Emydidae, *Emys orbicularis*, ecology, reproduction, predation, Lubuskie Province, western Poland.

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### I. INTRODUCTION

The European pond turtle, *Emys orbicularis*, is a rare species in western Poland. Its distribution has been fairly well recognised in this area, which particularly applies to the central part of the region, i.e. Lubuskie Province (MACIANTOWICZ & NAJBAR 2000, NAJBAR & MACIANTOWICZ 2001).

The reproductive biology of the turtle has been subject to analysis in various areas of its occurrence. In eastern Poland, JABŁOŃSKI & JABŁOŃSKA (1998) studied turtles in the area of Polesie Lubelskie, while ZEMANEK (1988) and MITRUS & ZEMANEK (1998) in the area of Radom (central

Poland). The current knowledge on reproduction of *E. orbicularis* was summarised by FRITZ (2003). However, information on reproduction of this species in western Poland is scarce.

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## II. THE TIME AND THE STUDY AREA

The breeding sites of the European pond turtle located in the mouth of the Ilanka (N52°16' E14°40') and Pliszka (N52°14' E14°41') rivers in the western part of the Lubuskie Province were identified at the turn of May and June 1999. Research was carried out annually in subsequent years until 2004.

The study area is located 25 m above sea level. The climate is moderate with a major impact of the ocean climate. The annual rainfall reaches 500-570 mm. The vegetative period lasts 220 days and the average annual temperature is 8.0°C. The land is covered with snow for 40-60 days a year (ZAJCHOWSKA 1972).

The egg laying sites were located on forest clearings, sandy grassland (type: Spergulo - Coryneforetum canescentis, Sedo-Scleranthetea) and farmlands oriented to the south and south-west, exposed to the sun. Typical plants found in the areas of the nests were grey hair-grass *Corynephorus canescens* (L.), colonial bentgrass *Agrostis capillaris* L., field sagewort *Atrémisia campestris* L., corn spurry *Spergula arvensis* L., common evening-primrose *Oenothera biennis* L., mouse-ear hawkweed *Hieracium pilosella* L., perennid knawel *Scleranthus perennis* L., German knotgrass *S. annuus* L., sheep fescue *Festuca ovina* L., creeping thyme *Thymus serpyllum* L. Vegetation cover was between 15-65%.

Nests were located at a distance of about 30 to 250 m from the biotopes inhabited by the turtles.

## III. METHODS

Egg laying females were looked for at the breeding sites from the second decade of May until the end of June in the years 1999-2003. Observations were carried out mainly in the afternoon and at night (17-02) and in a few cases in the morning (5-9). Once the nests were found, the eggs were counted within 1-24 hours and subsequently placed in the nests. Eggs were measured by means of a slide calliper and weighed with a 1212 Tanita Digital Scale within 24 hours from the moment of egg laying. Between the years 1999-2002, all nests were left in the natural environment until the end of August or beginning of September, at which time eggs or newly hatched turtles were collected. Eggs from which turtles had not hatched yet were placed in incubators. After hatching, they were transferred to aqua-terrariums where they remained until the middle of May of the following year.

In 2002-2003 out of 17 nests found, 4 were transferred for rearing in artificial conditions, whereas the remaining ones were left in their natural environment.

Eggs from which turtles did not hatch were assessed for developmental stage, possible causes of non-fertilization, physical damage to the shells and to nests by animals.

The locations of nests in particular years were marked with wooden sticks.

The humidity of the ground as well as the temperature in the nests (at a depth of 7-10 cm) immediately on the surface of the ground and 2 m above ground between autumn 2003 and the spring of 2004, were examined with AZ Instruments Data Loggers, models 8828 and 8829.

The results were analysed by means of the STATISTICA for Windows 5.5 (StatSoft, Inc., 1999) software.

#### IV. RESULTS

In the years 1999-2003 a total of 48 nests of the European pond turtle were found. 33 involved observations near the Ilanka river, where nests were dug by previously marked females. A further 13 cases from this area were nests dug by unidentified females. Their content was plundered by predators, which made it impossible to establish the actual number of eggs. The remaining two cases from the valley of the Pliszka river were nests on ploughed fields, which were subsequently transferred to a safe place.

#### E g g l a y i n g

Between the years 1998-2003, 26 mature females of *E. orbicularis* were collected in the research area. Between 1999-2003, 33 nests were found in which 15 females laid their eggs (Table I). The egg laying period can be extended in time depending on weather conditions and in particular on temperature. The first females started their journeys to breeding sites in the third decade of May following a period of rain and storms, usually on warm and sunny days, when the temperature exceeded 20-25°C. Journeys and egg laying at a temperature of 15-17°C, heavy rain, thunderstorms and strong wind were observed on three occasions.

Table I

The number of eggs laid by European pond turtles in the valley of the Ilanka river (1) and times of excavation and chamber burying (2)

No of the female	Year									
	1999		2000		2001		2002		2003	
	1	2	1	2	1	2	1	2	1	2
8	12	20 <sup>25</sup> -22 <sup>40</sup>	11	18 <sup>50</sup> -20 <sup>55</sup>	13	19 <sup>30</sup> -21 <sup>20</sup>	11	21 <sup>05</sup> -22 <sup>30</sup>	12	20 <sup>15</sup> -21 <sup>45</sup>
11	8	20 <sup>55</sup> -22 <sup>20</sup>					9	19 <sup>30</sup> -21 <sup>45</sup>		
14	9	20 <sup>30</sup> -22 <sup>00</sup>								
12	14	23 <sup>40</sup> -0 <sup>55</sup>	14	19 <sup>20</sup> -21 <sup>05</sup>			12	21 <sup>35</sup> -23 <sup>25</sup>	13	19 <sup>50</sup> -21 <sup>35</sup>
10			10	19 <sup>45</sup> -21 <sup>15</sup>						
31					10	21 <sup>15</sup> -22 <sup>45</sup>			12	20 <sup>35</sup> -22 <sup>15</sup>
32					8	20 <sup>40</sup> -22 <sup>25</sup>	10	21 <sup>10</sup> -22 <sup>30</sup>	15	19 <sup>35</sup> -21 <sup>50</sup>
33					7	21 <sup>35</sup> -22 <sup>50</sup>				
13					5	20 <sup>05</sup> -21 <sup>05</sup>	8	20 <sup>25</sup> -22 <sup>25</sup>	9	21 <sup>45</sup> -22 <sup>55</sup>
34					15	21 <sup>25</sup> -22 <sup>55</sup>	12	20 <sup>40</sup> -22 <sup>50</sup>		
28					10	20 <sup>40</sup> -22 <sup>20</sup>	11	21 <sup>15</sup> -22 <sup>45</sup>	12	20 <sup>30</sup> -22 <sup>05</sup>
29					17	20 <sup>20</sup> -22 <sup>45</sup>			14	20 <sup>10</sup> -22 <sup>25</sup>
30					12	20 <sup>20</sup> -22 <sup>25</sup>	14	20 <sup>45</sup> -22 <sup>15</sup>		
37									15	21 <sup>05</sup> -22 <sup>35</sup>
46									9	19 <sup>20</sup> -21 <sup>30</sup>

May 24th (in 2003) was the earliest observed date of egg laying, whereas June 13th (in 2001) was the latest. The largest number of nests was observed between June 1<sup>st</sup> and 8<sup>th</sup> (23 nests i.e. 69.7%) (Fig. 1).

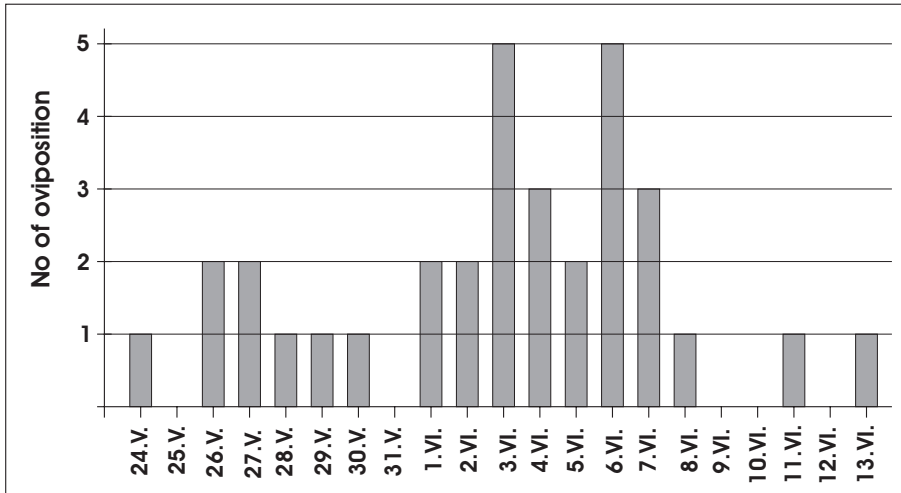


Fig. 1. Temporal distribution of *Emys orbicularis* oviposition at the Ilanka river valley in western Poland from 1999 to 2003 (n=33).

Egg laying occurs only once a year in the research area. In subsequent years females tended to construct their nests in the vicinity of the nests built in previous years. The largest distance between the nests constructed by particular individuals was 8.5 m, whereas the smallest was 0.75 m (2.0-4.5 m on the average; n = 19).

Both active and potential breeding sites were located in relative proximity from the water reservoirs inhabited by the turtles in the study area. The females, ready for oviposition, left the reservoirs at different times of the day, usually between 15-18 (n = 11). The closest breeding sites were reached within 20-30 minutes (n= 6). In case of more remote sites, the journeys took up to 1-5 hours (n = 5). On entering the sites, females made circles around the selected areas, frequently cutting their tracks. Every several dozen metres they would stop, observe the surroundings or lower their heads as if 'sniffing' the ground. Such behaviour lasted between 30-150 minutes (n = 21). In the meantime they excavated 1-6 shallow chambers 2.5-5.5 cm deep (n = 21), and eventually selected the most appropriate place, excavating a pear-shaped chamber 6.9-10.3 cm deep, 6.2-9.0 cm wide at the base and 4.9-6.1 cm wide at the surface (n = 17). The excavation of a proper chamber lasted between approximately 35-120 minutes (n = 17), most often 40-75 minutes (n = 13). While excavating, the females took breaks of several minutes.

The earliest time of excavation of a proper chamber was observed at 18.50 and the latest at 23.40, yet most females started digging at about 19.20-20.30 and finished between 20.55 and 0.55 (CET /+1 GMT/) (Table I). Eggs were laid at various time intervals, usually every 1 -2 minutes, but also below 1 minute or above 4-5 minutes. The shortest egg laying period (5 eggs) lasted approximately 15 minutes, the longest (17 eggs) approximately 45 minutes. The complete process, from excavation until chamber burying, lasted between 60 -145 minutes (97.7 minutes on the average /n = 33/). The number of eggs laid in the population in the years 1999-2003 fluctuated between 5 and 17 (n = 33) (Table I) the average number of eggs per one laying totalled 11.3. The number of eggs laid depended on the size of the female,  $r = 0.54$ ,  $p = 0.039$ ,  $n = 15$ .

The females were very vigilant while selecting an appropriate place and excavating the chamber on the breeding sites. In reaction to movement caused by a toad, *Bufo bufo* (L.), or a blackbird, *Turdus merula* L., they would remain still for a long period of time and subsequently continue digging. In case of the appearance of a badger, *Meles meles* L., raccoon dog *Nyctereutes procyonoides* (Gray), or a man they would abandon further digging. When frightened ( $n = 6$ ), they would seek shelter in litter in the nearby bushes or under a pile of branches, where they would remain until late afternoon (17.00-18.30) of the following day and then would start excavating again ( $n = 3$ ). Otherwise they would go back to the water reservoir and return to the breeding site after one ( $n = 1$ ), two ( $n = 1$ ) or three days ( $n = 1$ ). Egg laying in the morning or before noon was not observed.

From the moment the females started laying eggs, their reaction to movement was limited, and observation from short distances was possible.

The characteristics of eggs

Newly laid eggs were snow-white and oval, yet in each nest had slightly different characteristics: they varied in length, width and weight (Table II). They were surrounded by a slightly rough, hard shell which in the final stage of the incubation period grew soft, and had grey, grey-black or brown colouring on the surface.

Table II

Dimensions and the weight of the eggs of the European pond turtles from the valley of the Ilanka river ( $n = 373$ )

Year	Number of nests	Number of eggs	Size of eggs														
			length [mm]					width [mm]					weight [g]				
			min.	max.	$\bar{X}$	$\bar{X}$	S.D.	min.	max.	$\bar{X}$	$\bar{X}$	S.D.	min.	max.	$\bar{X}$	$\bar{X}$	S.D.
1999	4	43	29.1	37.3	32.8		0.2	18.7	20.5	19.6		0.03	5.9	9.2	7.5		0.8
2000	3	35	27.8	35.9	32.3		0.1	18.1	20.5	19.3		0.02	5.8	8.7	7.1		0.4
2001	9	97	28.6	38.4	34.6	33.8	0.1	18.1	22.3	20.0	19.8	0.07	5.6	10.1	8.3	7.8	0.6
2002	8	87	29.1	39.1	34.7		0.2	18.0	21.8	20.0		0.06	5.7	9.6	8.0		0.9
2003	9	111	29.1	38.6	34.8		0.1	18.3	21.2	19.9		0.04	6.4	9.4	8.2		0.6

### B r e e d i n g s u c c e s s

In the 35 nests examined, females laid a total of 392 eggs. Two hundred ten turtles hatched from these, out of which 160 were transferred for rearing in artificial conditions and a further 50 left in their nests (in the seasons 2002/2003 and 2003/2004) died as a result of freezing. Sixty five eggs were dug up and damaged by predators. Twenty two eggs (individuals during hatching) were attacked by ants during the hatching process which resulted in the killing of the young turtles. This was observed while digging the nests between 2001-2003. Dead embryos were found in the case of a further 38 eggs. In 11 cases death occurred at initial stages of development and in 27 cases the embryos were completely or almost completely developed. The shells of 30 eggs were damaged mechanically and at the time of collection, their shells were overgrown with mildew fungi. Twenty seven eggs were not fertilized. The impact of the above factors on the breeding success of the turtle in subsequent years is presented in Table III.

The rate of development of the embryos depends on the temperature in the nest during incubation (EWERT 1989). Under the environmental conditions in the Lubuskie Province between the years 1999-2003, the earliest date of egg laying was May 24<sup>th</sup> (in 2003) and the latest was on June

13<sup>th</sup> (in 2001). Depending on the date of egg laying, hatching took place in the second decade of August and first decade of September. In 4 cases during the period between June 1-3 to September 5<sup>th</sup>, the average incubation temperature was 23.6°C (min. 15.5, max 32.5; *S.D.* = 3.6), the average humidity was %RH = 89.8 (min. 79.6, max 100.0; *S.D.* = 3.3). The development of embryos in the above case lasted from 86 to 104 days (av. 96.5 days; *S.D.* = 7.9 days).

Table III

The fate of nests and of 392 eggs of the European pond turtle recorded in the period V-VI.1999 - III.2004

Total No of nests	Total No of destroyed nests with an insignificant number of eggs	Total No of eggs	No of destroyed eggs					No of hatched individuals	
			No of not fertilized eggs	No of damaged eggs	Dead embryos	No of eggs damaged by predators		No of turtles frozen in nests	No of individuals transferred for rearing
						Digging	Underground damage		
1999 / 2000									
7	1	62	5	3	7	–	–	–	47
2000 / 2001									
7	4	35	1	14	5	–	–	–	15
2001 / 2002									
12	3	97	11	12	15	22	10	–	27
2002 / 2003									
10	2	87	5	–	7	–	–	21	54
2003 / 2004									
12	3	111	5	1	4	43	12	29	17
total									
48	13	392	27	30	38	65	22	50	160
%									
100	27.08	100	6.90	7.65	9.69	16.58	5.61	12.75	40.82

In the seasons 2002/2003 and 2003/2004, 2 nests were left at the breeding sites in which we observed 50 dead turtles in spring. Most probably temperatures below 0°C in winter caused their freezing. A particularly cold period with no snow occurred between December 7<sup>th</sup> and 16<sup>th</sup> 2002. Several week cold periods were observed until March with the air and ground temperature falling to -15.0°C, -20.0°C (Fig. 2). The first cold period already led to a gradual lowering of temperature inside both nests, which on December 7<sup>th</sup> 2002 fell to -0.6°C, -0.8°C and three days later reached -4.2°C, -4.6°C. During the coldest period (winter 2002/2003), when the air and ground temperature fell below -21.6°C, the temperature inside both nests on January 8<sup>th</sup> was -8.4°C, -8.6°C.

There was an analogical situation in the winter of 2003/2004 when the coldest period occurred in December (Fig. 2). Then, due to a lack of snow, on December 22<sup>nd</sup> the temperature inside the nests fell to -6.6°C, -6.8°C.

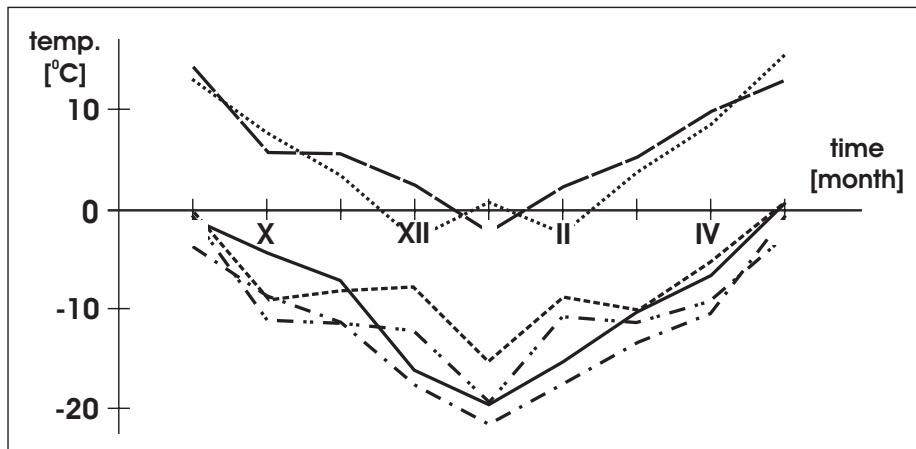


Fig. 2. The air and ground temperature in the study area:

- ..... average air temperature from September 2002 to May 2003
- minimum air temperature from September 2002 to May 2003
- - - - - average ground temperature from September 2002 to May 2003
- average air temperature from September 2003 to May 2004
- ..... minimum air temperature from September 2003 to May 2004
- · - · - average ground temperature from September 2003 to May 2004

## V. DISCUSSION

Journeys of females from local water reservoirs inhabited by turtles to their breeding sites were observed in the study area. Not all of these individuals were observed in the water reservoirs outside of the breeding season, thus it is quite likely that they travelled from more remote reservoirs. It is known that in order to find an appropriate breeding site, females can cover distances even several kilometres long (ZEMANEK 1988, JABŁOŃSKI 1998).

The egg laying periods in the study area are to a large extent similar to those of turtle populations in middle Poland (Mitrus & ZEMANEK 2000) and Brandenburg (SCHNEEWIESS et al. 1998). At the same time in eastern Poland these periods are more extended in time and can last from the middle of May and to after June 20<sup>th</sup> (JABŁOŃSKI 1998).

As it has already been mentioned, particular females located their nests in the vicinity of nests built in previous years, which confirms JABŁOŃSKI's (1998) observations in eastern Poland or MITRUS and ZEMANEK's (2000) observations in the central part of the country. Thus, considering the limited and constantly decreasing number of potential breeding sites, as well as the tendency of females to lay eggs in the same locations, immediate identification and recognition of these sites seems to be of crucial importance.

The average number of eggs per nest (11.3), is slightly smaller than in other areas of Poland. In central Poland the number is 14.4 (7-23 eggs) (MITRUS & ZEMANEK 2000, 2001), while in the east it is 15 (9-19 eggs) (JABŁOŃSKI 1998). Both the dimensions as well as weight of the eggs are comparable with the data presented by the above mentioned authors.

The breeding success of the turtle in western Poland is limited by various environmental factors. Local climatic conditions seem to crucially affect the young turtles in their nests in autumn and in winter. At this time, both air and ground temperatures frequently fall below -20°C (Fig. 2). During



the study period, the temperature inside the nests fell below  $-8^{\circ}\text{C}$ , but it is possible that temperatures can be even lower, which is confirmed by the observations in Brandenburg by SCHNEEWEISS et al. (1998).

The negative impact of climatic factors on the breeding success of the turtles in the research area was in most cases eliminated in view of the annual collection of eggs from the nests at the end of the summer (at the turn of August and September). As it was mentioned above, in the seasons 2002/2003 and 2003/2004, 4 nests were left in their natural environment and as a result of unfavourable climatic conditions this led to the death of the turtles. It could be argued that leaving the nests in their natural environment in winter during the previous years of research would have contributed to the death of some or even all turtles.

Thus considering the need to increase the number of turtles in the area, collecting them from their nests before autumn, rearing them and releasing at particular sites seems to be justified, at least over some period of time.

Significant losses are also caused by the activity of predators, which varies in Poland in different regions. JABŁOŃSKI (2001) classifies predation as one of the major threats, claiming that at some of the sites (in eastern Poland) losses can reach 98%. In central Poland such losses are minor (MITRUS 2000). In the Lubuskie Province it was observed that between 1999-2003, 8 nest(16.70%) s containing 87 eggs (22.19%) and a further 13 nests with an insignificant number of eggs (total 21 nests i.e. 43.75%) were destroyed by predatory mammals or insects. Most probably badgers and raccoon dogs observed at the breeding sites are the main predators. They dig up the nests at various periods, particularly 12 hours to 8 days following egg laying (18 nests) and at the moment of hatching and emergence of the young turtles on the surface (4 nests).

As far as invertebrates are concerned, whole nests (4; 8.3%) are damaged by ants *Formica rufa* which find turtle nests while driving tunnels in the ground. While hatching, young turtles are attacked and killed.

It was also observed that females would lay eggs in places where they came across underground corridors made by ants while digging the egg chamber, yet they would not abandon digging. Eggs laid in such places, if not collected previously, were damaged by ants during hatching.

The remaining factors impacting the breeding success of turtles in the study area are less significant in terms of percentage, yet their significance could grow in particular years (Table III).

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