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Nest site fidelity in the Slovakian population of the European pond turtle *Emys orbicularis*

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Abstract. In many places in Europe, the pond turtle *Emys orbicularis* (Linnaeus, 1758) is an endangered species. Establishing its reproductive pattern is critical for the understanding and protection of this turtle. In this study, which took place from 1998 to 2009 in the Tajba National Nature Reserve, Slovakia (48°23′N, 21°47′E), are presented the results concerning the spatial and temporal aspects of nesting habits of individual turtles. From the total monitored group of 39 turtles, eight individuals which laid eggs more than four times during the whole study period were selected for statistical evaluation. It was found that five individuals from this group demonstrated a fidelity to the nesting area, and that the egg-laying period starts in mid-May and continues until late June. During the investigation, six turtles nested twice per year with an interval of about 24 days. The average distance between the nests of an individual turtle was close to 138 metres, and the distance of the nests from water was about 349 metres. The data obtained on the space and time requirements of the European pond turtle for successful reproduction are helpful to protect this species more efficiently, not only in the Tajba National Natural Reserve, but also in other similar sites in Europe.

Keywords: Emydidae, endangered species, nesting fidelity, nesting sites, NPR Tajba.

Introduction

Site fidelity can be described as an area-restricted space use behavior (Switzer, 1993; Borger, Dalziel and Fryxell, 2008). Fidelity to the nesting area has been described for many different egg-laying animals. Numerous articles describe nesting area fidelity behaviour by birds (Harvey, Greenwood and Perrins, 1979; Krištín et al., 2007; Tryjanowski et al., 2007), fishes (Knapp, 1993; Bartlett et al., 2010) and reptiles (Iverson, Hines and Valiulis, 2004; Refsinder et al., 2010). Fidelity to nesting area behaviour of turtles is mostly known for sea turtles (Nordmoe et al., 2004; Tucker, 2010). However, there are also a few studies on the nesting fidelity of freshwater turtles (Freedberg et al., 2005; Rowe, Coval and Dugan, 2005).

The European Pond Turtle is one of a total of four native freshwater turtles. At many locations in Europe, the occurrence of this turtle is very rare, and in many places it is a critically endangered species. There is the only one population of this species able to reproduce in Slovakia. This population was identified in a pond of the Tajba National Pond Reservation (NPR), close to the town of Streda nad Bodrogom (48°23′N, 21°47′E) (Novotný, Danko and Havaš, 2004). It is also the only reptile classified by the Slovak Red list as "Critically endangered" (Kautman, Bartik and Urban, 2001). However, the published data differ in description of the nest site fidelity of the European pond turtle (Drobenkov, 2000; Meeske, Schneeweiss and Rybczynski, 2002; Mitrus, 2006; Najbar and Szuszkiewicz, 2007).

The goal of this study is to describe behaviour of the European pond turtle during the egg-laying period from the aspects of both time and location. Here, we have determined the dependence of this fidelity on the nature of the population and the studied location. The results may be useful in the management of *Emys orbicularis* and in helping to choose a more effective way to protect the pond turtles of the Tajba NPR.

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Materials and methods

Study area

The study was conducted in the Tajba National Nature Reserve (48°23′N, 21°47′E), situated in south-eastern Slovakia, 1 km north-east of the town of Streda nad Bodrogom. The protected area covers 27.36 ha and includes Tajba pond (2 km long and 100-150 m wide, oxbow shaped) and a 100 m wide buffering area.

The nesting of turtles was observed and recorded from mid-May to late June from 1998 to 2009. Over this period, 39 females were monitored in the nesting areas and were divided into groups according to the number of nests. Eight females nested more than four times (group A), 11 females nested between two and three times (group B), 17 females nested once, and three females did not lay any eggs (group C). The results obtained for group A, containing eight females, were used for the analysis of nest site fidelity (table 1).

Identification of individuals and monitoring

To identify individuals, a non-invasive method of taking photographic pictures of the carapace and plastron was employed. In particular, the unique pattern of the plastron of individual turtles was useful to establish their identity. Both radiotracking monitoring and area patrol approaches were used to record the nesting turtles. Dependent on the climatic conditions, patrol monitoring was started regularly between 7 p.m. and 9 p.m. Radiotracking detection was accomplished by using a receiver fieldmaster FM 100 and transmitter R1930 (Advanced telemetry systems, 24 g, 25 × 56 × 9 mm, 843 days by 40 ppm). "Glue on" transmitters (R1930) were attached using two-component methyl methacrylate resin (Dentacryl SpofaDental) to the side of the carapace. After egg-laying took place, the location of the nest was recorded on a map (circle, fig. 1). The nest was protected against destruction by predators using a metal net with a mesh size 2 × 2 cm. The nests that were destroyed by predators were also marked on the map (square, fig. 1).

Determination of the fidelity and statistical analysis

To evaluate the nest-site fidelity, we used eight turtles from group A, that laid eggs more than four times throughout the period of the research (table 1). The distances were recorded between laying sites of individual turtles over the whole period (1998-2009), together with the distances of the nests of the individual turtles laying twice within the same year.

The statistical significance of the distances between nests of particular individuals was evaluated using an analysis of the variance according to Dunnett's post-hoc test. The measured distances between nests of individual turtles were compared to the mean value of the maximum recorded distances between nests within all studied subjects. To define the largest egg laying area, we used the maximum distances of all eight turtles during the whole study period. Loyalty to a nesting place was identified for each turtle by using the mean distances between nests that were significantly different from the mean of maximum distances. The resulting values are expressed as mean ± SD. The value of $P < 0.05$ was considered to be statistically significant in determining the fidelity of the individual.

Results

The first part of our work deals with the time aspect of the egg laying, and with the number of nests created by individual turtles during the study. Females were divided into groups A, B, C dependent on the number of nests each had (table 1). During the study period of 12 years, 39 females and 90 nests were recorded in the selected nest area. The number of recorded nests varied from 1 to 17 per year. Most of the nests were observed in 2004 when their number totalled 17; with 13 in 2002 and 12 in 2005. During this period, the minimum number of nests created by one female was one, and the maximum was eight. Table 1 shows that the earliest recorded day of laying was May 17th (#43, 2002) and the last recorded was June 26th (#30, 2005). These observations indicate that the egg laying period lasts from mid-May to late-June.

Fidelity to the nesting area

The average distance between the nests was found to be mean ± SD = 138.4 ± 70.65 m, while the average nest distance from the water was mean ± SD = 348.7 ± 48.2 m, for the whole of group A (table 2). In determination of loyalty, we considered turtles that showed a significant difference from the average maximum distance of all studied turtles. Results of analysis of the fidelity measures (ANOVA $F_{8,91} = 13.25$, $P < 0.001$), presented in fig. 2, indicated the significant fidelity measure for five turtles: #1 (Dunnett $M = 136.2$, 95% Cl [19.39, 253.0], $P < 0.05$); #5 (Dunnett $M = 133.7$, 95% Cl [25.61, 241.9], $P < 0.01$); #8 (Dunnett $M = 243.4$, 95% Cl [153.6, 333.3], $P < 0.001$); #11 (Dunnett $M = 153.4$, 95% Cl [63.52, 243.2], $P < 0.001$); #13 (Dunnett $M = 146.9$, 95% Cl [44.28, 249.4], $P < 0.01$). The strongest fidelity was found for turtle #8, for which the av-

Table 1. List of females recorded on nest areas in the period from 1998 to 2009, with dates of egg-laying and assignment to the groups.

F (#/G)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	∑
1A	–	2.6.	–	–	–	–	25.5., 19.6.	22.6.	–	–	–	–	4
5A	–	3.6.	–	–	19.5., 11.6.	–	17.6.	–	–	–	–	14.6.	5
8A	1.6.	4.6.	–	–	23.5., 17.6.	–	19.6.	4.6.	7.6.	–	20.6.	–	8
10A	–	2.6.	–	–	–	–	23.6.	2.6.	–	21.5.	–	10.6.	4
11A	–	1.6.	–	23.5., 19.6.	13.6.	–	31.5., 24.6.	2.6.	–	–	–	19.6.	8
13A	–	5.6.	–	–	–	14.6.	–	3.6.	9.6.	–	30.5.	–	5
14A	–	2.6.	–	16.6.	11.6.	–	–	25.6.	9.6.	–	–	–	5
51A	–	–	–	–	–	–	30.5., 23.6.	29.5., 23.6.	–	6.6.	–	–	5
3B	–	–	–	–	22.5.	–	–	–	–	23.5.	25.5.	–	3
6B	–	–	–	–	–	–	1.6.	–	–	–	19.6.	17.6.	3
31B	–	–	–	24.5.	–	–	–	–	–	7.6.	–	8.6.	3
40B	–	–	–	15.6.	12.6.	–	30.5.	–	–	–	–	–	3
42B	–	–	–	–	14.6.	–	–	–	–	–	21.6.	–	2
45B	–	–	–	–	12.6.	–	30.5., 19.6.	–	–	–	–	–	3
46B	–	–	–	–	12.6.	–	–	–	–	23.5.	–	–	2
49B	–	–	–	–	–	14.6.	1.6.	–	–	–	–	–	2
53B	–	–	–	–	–	–	9.6.	15.6.	–	–	–	24.5.	3
54B	–	–	–	–	–	–	14.6.	15.6.	–	–	–	–	2
67B	–	–	–	–	–	–	–	–	–	20.5.	25.5.	–	2
4C	–	29.5.	–	–	–	–	–	–	–	–	–	–	1
7C	–	–	–	–	–	–	–	–	–	–	–	–	0
9C	–	–	–	–	–	–	–	–	–	–	–	–	0
12C	–	29.5.	–	–	–	–	–	–	–	–	–	–	1
15C	–	2.6.	–	–	–	–	–	–	–	–	–	–	1
20C	–	–	28.5.	–	–	–	–	–	–	–	–	–	1
25C	–	–	–	–	–	25.5.	–	–	–	–	–	–	1
30C	–	–	–	–	–	–	–	26.6.	–	–	–	–	1
32C	–	–	–	24.5.	–	–	–	–	–	–	–	–	1
34C	–	–	–	28.5.	–	–	–	–	–	–	27.5.	–	2
41C	–	–	–	–	–	–	–	–	–	–	–	–	0
43C	–	–	–	–	17.5.	–	–	–	–	–	–	–	1
44C	–	–	–	–	12.6.	–	–	–	–	–	–	–	1
48C	–	–	–	–	–	13.6.	–	–	–	–	–	–	1
52C	–	–	–	–	–	–	9.6.	–	–	–	–	–	1
65C	–	–	–	–	–	–	–	28.5.	–	–	–	–	1
66C	–	–	–	–	–	–	–	25.6.	–	–	–	–	1
69C	–	–	–	–	–	–	–	–	–	–	25.5.	–	1
71C	–	–	–	–	–	–	–	–	–	–	30.5.	–	1
73C	–	–	–	–	–	–	–	–	–	–	1.6.	–	1
∑	1	10	1	7	13	4	17	12	3	6	10	6	90

– catalogue number of female; G – group.

erage distance between nests was mean ± SD = 9.85 ± 5.28 m. In contrast, the lowest degree of fidelity was observed for turtle #14. For this turtle, the average distance between nests was mean ± SD = 256.54 ± 104.74 m, that is, approximately 26 times larger compared to that of turtle #8. The maximum distance between the nests of one turtle was 416.2 m (turtle #14) and the minimum was 3.7 m (turtle #8) (table 2).

Double egg laying

Within the study period, "double egg-laying" was recorded eight times for six turtles. The average time interval between egg laying was mean ± SD = 24.13 ± 1.9 days (20-27 days),

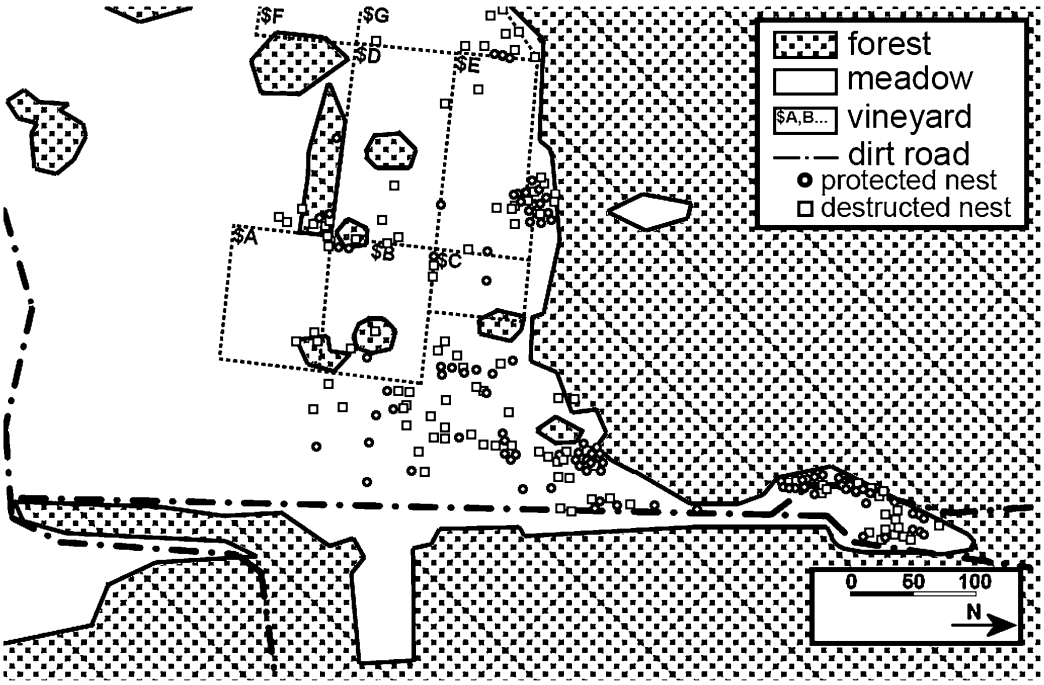

Figure 1. Schematic representation of the nesting area (○-protected nest, □-destructed nest).

Table 2. Distances between nests and between nests and water.

Female #	Distance between nests min/max (aver.) [m]	Distance between nests and water min/max (aver.) [m]
1	9.8/217 (117,1)	231/425 (359)
5	5/314.4 (127.6)	541/229 (395)
8	3.7/20.5 (9.9)	367/390 (376.6)
10	39/258.4 (196.2)	425/206 (267.5)
11	4.9/205.4 (99.9)	208/379 (272.5)
13	9/234 (106.4)	251/442 (368)
14	82.5/416.2 (256.5)	188/508 (349.2)
51	53.6/307.6 (193.7)	237/530 (401.5)
Total	25.9/253.3 (138.4)	188/530 (348.7)

– catalogue number of female.

with the average distance in the same year being mean $\pm$ SD $= 116.9 \pm 109.1$ m (from 12.5 m to 357 m) (table 3).

Discussion

Our results are related to the spatial and the temporal aspects of egg laying. This period is the most critical in the annual lifecycle of adult female turtles. A female must leave its natural water environment if it is to lay its eggs successfully to ensure the reproduction of the species.

The turtle egg laying period lasts from mid-May to late-June in the Tajba NPR. These findings correspond to previous data of Novotny, Danko and Havas (2004) who performed similar investigations in the period 1999-2003 for this area. This period of nesting approximately coincides with observations in neighbouring countries. In Austria, laying begins in late-May and

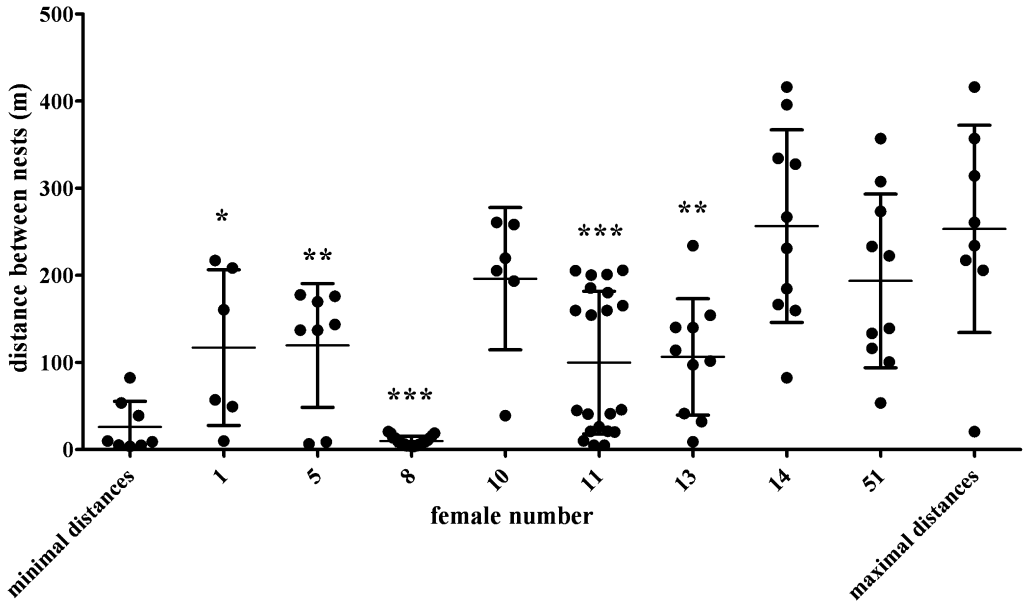

Figure 2. Graphical expression of the degree of fidelity of eight turtles from group A. Each mark represents distance in metres between two nests that belongs to the same individual female. The columns "maximal distances" and "minimal distances" contain pool of maximal and minimal distances between the nests of all eight turtles during the whole study. Measured distances between the nests of each individual turtle were compared with the data in the column "maximal distances". The statistical significance was evaluated by ANOVA according to Dunnett's post-hoc test and the value of P for the fidelity of the individuals is expressed using asterisks ($*P < 0.05$, $**P < 0.01$, $***P < 0.001$). The error bars are the mean ± SD.

Table 3. The time interval between lays with the distance between nests placed in one year.

Female # (year)	Days	Distance (m)
1 (2004)	25	57
5 (2002)	23	137.2
8 (2002)	25	20.5
11 (2001)	27	205.8
11 (2004)	24	45
45 (2004)	20	12.5
51 (2004)	24	100.5
51 (2005)	25	357
Aver.	24.13	116.9

– catalogue number of female.

ends in mid-July (Rössler, 1999). In Hungary, this period lasts from June to the first days of July (Farkas, 2000). In Poland, nesting lasts from late-May to mid-June (Schneeweiss and Jablonski, 2000).

Our results demonstrated that five turtles from the group of eight showed fidelity to the nesting area. The degree of this fidelity was determined as the difference from the average maximum distance of all studied turtles over the period of 1998-2009. To establish the biggest egg laying area, we used as a criterion the maximum distances recorded during the period. This approach ensured that all environmental factors were taken into account. Turtle loyalty to nesting place was identified for each turtle by reviewing the mean distances between nests that were significantly different from the mean of maximum distances. Based on these data, it was possible to determine the degree of turtle fidelity for each population objectively, with respect to habitat. Mitrus (2006) classified two turtles as loyal to the nesting place as they nested on the same site throughout the study period. Additionally, the loyal turtles were also described as individuals that placed their eggs in the same location for a number of years. In his study, distances between nests in chronological order were taken into consideration. Similarly to Najbar and Szuszkiewicz (2007) and Mitrus (2006), we assumed that changes in the envi-

ronment, such as those caused by farming, forest logging, or by natural changes, could cause changes in the behaviour of animals leading to subsequent changes in nest sites. Therefore, mutual distances of all nests were considered in the analysis. Some turtles had two favoured nest sites, even they were evaluated as being loyal to a nest site. Drobenkov (2000) recorded that 60-85%, mostly older, turtles placed the eggs at a distance of 3 to 50 m from the previous nest. Meeske, Schneeweiss and Rybczynski (2002) found that 31% of turtles showed fidelity within a radius of 20 m in south-western Lithuania. The different geographical and climatic conditions of the natural locations, the different approaches in the evaluation and definition of fidelity, and in the application of different statistical methods, could also be reasons for the different results.

Based on the fidelity test using ANOVA according to Dunnett's post-hoc test, the maximum distance between the nests of an individual turtle was found to be 416.2 m (turtle #14), and 3.7 m was the minimum distance (turtle #8). The maximum distance between the nests of one turtle within two consequent years was 394 m (2005-2006, #14) and the minimum was 6.4 m (2005-2006, #8). Najbar and Szuszkiewicz (2007) found the maximum distance between laying sites to be 53.9 m, and the minimum to be 0.75 m, within two consequent years, while the average distance of the nest from the water body was only 77 m. In Tajba, the average distance of the nest from the meander river arm is 348.7 m, which is 4.5 times larger than that in the above study. In Belarus, the distance between the nest and the water body is between 12 and 30 m (Drobenkov, 2000). Our findings suggested that the larger spread of the nests may be caused by significant differences in the distance from the water. It also indicated that fidelity should be evaluated individually for each population, and with consideration of the habitat conditions of the animals. It appears that a comparison of the distances of the nests between two different populations is not a suitable method to assess the differences in fidelity for this species.

Our findings identified the mutual relationship of the degree of fidelity with changes in the environmental features. In 2009, major forest logging in near proximity to Tajba has affected a large area between the meander river arm and the nesting area. In the same year, turtle #5 placed eggs in the new glades created by the logging that were precisely on the probable path taken to the nesting area. Turtle #10 also nested there. More attempts at nesting in these glades were also noticed. Unfortunately, additional nests were not found. Najbar and Szuszkiewicz (2007) and Mitrus (2006) mentioned that if a location is overshadowed by vegetation, the turtle will search for a better location. Our observations showed that a favourable change in the environment can cause a turtle to use a new nesting place if it is on the path to the former nesting area.

The recorded double egg-laying throughout the research identified the time span of 24.1 days as an average between egg laying within one year. Distances were however significantly spread from 12.5 m to 357 m. In spite of this large difference, we know from personal observation that turtles use nearly the same route and nesting location. The discrepancy we found is probably a result of either inappropriate immediate conditions in the nesting area or disturbance by predators (*Vulpes vulpes*, *Meles meles*) and humans.

The nesting period of the Pond Turtle in Slovakia corresponds approximately to the nesting period of these populations in neighbouring countries. However, a strict comparison of the determined fidelity level with that established by other authors is not possible due to the diversity of methods used, the geographical locations and climatic differences. Yet, even under these circumstances, it is worth noting that the fidelity to nesting site of the Pond Turtle has been confirmed in all previous studies. We assume that the loyalty is conditioned by a changelessness of the environment that is almost impossible in nature. Changed conditions, in either the nesting territory or in the path to the nesting area, could

create better places for nesting. These new locations may be used for nesting by turtles, as we observed in 2009. In our work, the distances between individual nests are greater than those reported in previous studies. This is, however, understandable in the context that distances from the water in the studied environments were several times greater than in our study. Additionally, the average time span of 24 days between the double nesting in one year was also established in this work.

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