

Population Dynamics of the European Pond Turtle, *Emys orbicularis* (L., 1758) (Testudinata: Emydidae) from Lake Eğirdir (Isparta, Turkey)

Yusuf Bayrakcı, Dinçer Ayaz, Kerim Çiçek & Süleyman İlhan

Zoology Section, Department of Biology, Faculty of Science, Ege University, 35100 Izmir, Turkey; E-mail: yusuf.bayrakci@ege.edu.tr

Abstract: The Lake Eğirdir is the fourth largest lake in Anatolia, with an area of 468 km². By using a mark-recapture method, the population of *Emys orbicularis* was monitored for three consecutive years (2011–2013) and data regarding their population size, sex ratio and information about habitats used was gathered. During the whole sampling period, 4 juveniles, 105 males and 98 females were captured and marked. According to the POPAN model, the three-year super-population size of Lake Eğirdir was calculated as 460 individuals. Capture rate and survival rate was calculated as 0.17 and 0.61, respectively. Sex ratio was determined nearly equal (males : females = 1.07). The Lake Eğirdir population is the only one showing increasing trend among the Mediterranean populations of *E. orbicularis* in Turkey.

Key words: *Emys orbicularis*, population size, sex ratio, Lake Eğirdir

Introduction

Emys orbicularis (Linnaeus, 1758) (Testudinata: Emydidae) is one of the freshwater turtle species having a wide distribution range (FRITZ & ANDREAS 2000); however, it is rare in many countries (e.g. BONA et al. 2012). Although the declines in populations of *E. orbicularis* are well documented, the reasons of this decline are still debated. The most important reasons can be listed as hunting for food, habitat loss caused by wetland draining for agriculture, water pollution and introduced alien species into their habitats (FICETOLA et al. 2004). Due to habitat destruction, 46–57% of the freshwater turtles are endangered (BÖHM et al. 2013).

In many countries, conservation studies on *E. orbicularis* have been carried out. This species is listed as Near Threatened (NT) in the IUCN Red List of Threatened Species (FRITZ & CHIARI 2013). As part of these studies, in order to determine the status of the species in Turkey, we monitored Mediterranean populations for three years. The current article gives information about the population inhabiting the Lake Eğirdir, which has been the largest permanent station in our project.

Materials and Methods

Lake Eğirdir is located in Isparta Province in the Mediterranean region of Turkey. This lake is the fourth largest lake in Turkey, having a surface area of 468 km². The study area (sampling site, N38°8'19.14" E30°46'0.69", 910 m a.s.l) is nearly 9.5 ha, with depths of 1–4 m (Fig. 1).

In the scope of this study, 12 field surveys were conducted in Lake Eğirdir in 2011–2013. Turtles were captured using fyke nets placed 15–20 m away from the shore and 5–10 m away from each other. Twenty-six pairs of fyke nets were baited and set up at night and were collected early in the morning. Capture effort was the same for every sampling period. The captured turtles were marked individually by notching marginal scutes according to ERNST et al. (1974). Then, the individuals were released where they were captured. Straight carapace length (SCL) and plastron length (PL) of each individual were measured to the nearest 0.1 mm using a calliper. Body mass was recorded to the nearest 0.1 g using digital scales. Sex was determined by carapace concavity and iris coloration.



Fig. 1. Location and the sampling site (in red in the inset) of Lake Eğirdir

Table 1. Annual values of estimated parameters for the population of *Emys orbicularis* from Lake Eğirdir. [(.) constant, (t) time specific]

	2011	2012	2013
N	348	425	607
SE	25	120	24.7
Min	299	190	560
Max	397	660	657
Model	$\phi(t)p(.)\lambda(t) N(.)$	$\phi(.)p(.)\lambda(.) N(.)$	$\phi(t) p(.)\lambda(.) N(.)$
AICc	234.3	171.8	296.6
ϕ	0.55	0.52	0.76
P	0.2	0.15	0.15
Model	$\phi(t) p(.)$	$\phi(.) p(.)$	$\phi(t) p(.)$
AICc	134.72	100.5	162.9

As the sampling period covered three years, it was assumed that the population was open (i.e. individuals enter into the population by birth and immigration and leave the population by death and emigration). With the data set formed from the captured and recaptured individuals, POPAN (SCHWARZ & ARNASON 1996) and MARK (LEBRETON et al. 1992, COOCH & WHITE 2016) programs were used for generating models. Akaike's information criteria (AICc) were used for selecting the most suitable model. With the suitable model, the capture rate (p), survival rate (ϕ), annual change rate (λ), annual population size (N) and the super-population size (\bar{N}) were estimated. The approximate population density (d) was calculated with the formula $d = N/a$ by dividing the mean population size (N) by the sampling area

(a, ha). All statistical analyses were performed using SPSS, Version 10.0.

Results and Discussion

During the study, 207 (105 males, 98 females, and 4 juveniles) individuals of European Pond Turtle were marked and 48 of them were recaptured. The average straight carapace length (mm) was 92.25 ± 4.73 (79–100) for juveniles, 133.51 ± 1.12 (120–147) for males and 150.1 ± 1.75 (124–166) for females. The average plastron length (mm) was 83 ± 4.85 (69–90) in juveniles, 118.8 ± 1.21 (105–139) in males and 143.26 ± 1.78 (115–158) in females. The average body mass (g) was 144.9 ± 22.8 (87–190) for juveniles, 379.7 ± 10.93

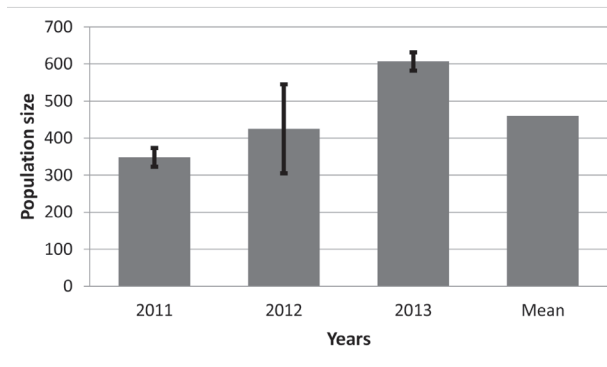


Fig. 2. Trend of population size of *Emys orbicularis* from Lake Eğirdir in 2011–2013

(232–503) for males and 596.7 ± 20.36 (320–810) for females.

The body size of *E. orbicularis* varies depending on latitude and environmental factors (FRITZ 2001, 2003) and southern populations tend to be smaller (FRITZ 1998, KELLER et al. 1998). Anatolian populations of *E. orbicularis* exhibit diverse morphological differentiation within Turkey (FRITZ et al. 1998). AYAZ et al. (2008a) have reported that, despite variations by region, SCL ranges from 89 to 169 mm in males ($n = 396$) and from 90 to 183 mm in females ($n = 354$).

The sex ratio observed by this study (males : females = 1.07) was generally balanced. The values were calculated as 0.45 for 2011, 1.35 for 2012 and 1.36 for 2013. Balanced (TAŞKAVAK & AYAZ 2006), male-biased (AUER & TAŞKAVAK 2004, MOSIMANN & CADI 2004, AYAZ et al. 2007, 2008b) and female-biased (GIRONDOT & PIEAU 1993, MAZZOTTI 1995, MASCORT 1998, SERVAN 1998, SNIESHKUS 1998) sex ratios were observed in different European Pond Turtle populations.

According to the POPAN model, average super-population size was calculated as 460 (range 348–607) (Fig. 2). The survival rate ranged was 0.52–0.76 during the three years (mean 0.61). Capture probability ranged from 0.15 to 0.20 during the three years (mean 0.17). The population density in the lake was 48 individuals/ha but this value was calculated just for the sampling site in order to compare with other studies. Annual values of estimated parameters were summarized in Table 1.

Annual survival rate of adult individuals of some freshwater turtles is very high, e. g. 0.96–0.98 for *Emydoidea blandingii* (see CONGDON et al. 1993, 2000) and 0.95 for *Kinosternon flavescens* (see IVERSON 1991). Like many other freshwater turtles, the survival rate of *E. orbicularis* is very high. AYAZ et al. (2007) calculated the survival rate of

the Pazaragaç population as 0.82 ± 0.04 (0.73–0.90). Similarly, AYAZ & ÇIÇEK (2011) have calculated the survival rate of the Lake Sülüklü population as 0.82 ± 0.04 (0.73–0.89). Even though the survival rate of the population in Lake Eğirdir is relatively low (range 0.52–0.76) compared to literature data, the trend of the population size is increasing (2012 – λ : 0.09, 2013 – λ : 0.16) (Fig. 2). It is generally known that mortality rate of freshwater turtles inhabiting at higher latitudes is higher during overwintering (e.g. ULTSCH 1989) than in spring and summer seasons (MITRUS & ZEMANEK 2004). E. g., MITRUS & ZEMANEK (2004) estimated an annual survival rate of *E. orbicularis* ranging between 0.80–1.00 depending on the year in central Poland. Thus, the low annual survival rate and its yearly fluctuation that we observed could be attributed to differences in seasonal activities (e.g., overwintering, nesting) of individuals in Lake Eğirdir. Moreover, the sampling area and its surroundings area provide suitable habitats for feeding, basking and nesting place for *E. orbicularis*. Therefore, the low capture probability (0.17) could be caused by habitat characteristics precluding capture/recapture and by a high proportion of dispersing individuals.

The population densities reported from Turkey range from 22.5 to 242 individuals/ha (AUER & TAŞKAVAK 2004, AYAZ et al. 2007, 2008b, AYAZ & ÇIÇEK 2011, BAYRAKCI & AYAZ 2014, BAYRAKCI et al. 2015). The density of the populations located in Mediterranean coastal region of Turkey is relatively lower than that of Central Anatolian populations. The reason for that is the sympatric population formation of *E. orbicularis* with *Mauremys rivulata* (Valenciennes, 1883) (Testudinata: Geoemydidae), which has wide ecologic tolerance in Mediterranean and Aegean coastal regions (AYAZ & ÇIÇEK 2011). The presence of *M. rivulata* is known from the Lake Eğirdir (AYAZ et al. 2008b); however, during the study they were not observed at the study site. This shows that, relatively, *M. rivulata* is found less frequently in Lake Eğirdir than in coastal regions and it is not considered as limiting factor for the abundance of *E. orbicularis* in Lake Eğirdir.

At present, Lake Eğirdir is surrounded by orchards and vineyards, continuing a historic trend of intense agriculture in the region. Such agricultural activities negatively affect the lake. The fertilizers and pesticides are polluting the lake with irrigation runoff, and this issue is the most important among other issues that threatens the lake (WWF 2013). Other Mediterranean populations suffer from habitat loss and degradation because of intense tourism activities (AYAZ et al. 2013);

this threat, however, does not apply to the Lake Eğirdir population.

Numerous terrestrial predators such as *Lutra lutra* (Carnivora: Mustelidae), *Vulpes vulpes* (Carnivora: Canidae), *Meles meles* (Carnivora: Mustelidae), *Martes foina* (Carnivora: Mustelidae), *Martes martes* (Carnivora: Mustelidae) and *Procyon lotor* (Carnivora: Procyonidae) occasionally hunt European Pond Turtles, mainly their eggs (FRITZ 2001, 2003, LANSZKI et al. 2006). *Lutra lutra*, *V. vulpes*, *M. meles* were recorded as predators for the eggs of *E. orbicularis* (AYAZ et al. 2017) and *Rattus rattus* (Rodentia: Muridae) is a potential candidate that can be added to the list because a few individuals were found in fyke nets during field studies. We observed significant damage from predators such as destroyed nesting sites in the study period. This situation affects survival rate of juveniles and will have impact on future population trends.

References

- AUER M. & TAŞKAVAK E. 2004. Population structure of syntopic *Emys orbicularis* and *Mauremys rivulata* in western Turkey. *Biologia*, Bratislava 59 (14): 81–84.
- AYAZ D., ÇİÇEK K., BAYRAKCI Y. & TOK C. V. 2017. Reproductive ecology of European Pond Turtle, *Emys orbicularis* (Linnaeus, 1758) (Emydidae), from Mediterranean Turkey. *Acta Zoologica Bulgarica*, Supplement 10: 23-29.
- AYAZ D., FRITZ U., TOK C. V., MERMER A., TOSUNOĞLU M., AFSAR M. & ÇİÇEK K. 2007. Population estimate and body size of European Pond Turtles (*Emys orbicularis*) from Pazarağaç (Afyonkarahisar/Turkey). *Biologia* 62 (2): 225–227.
- AYAZ D., FRITZ U., TOK C. V., MERMER A., TOSUNOĞLU M. & AFSAR M. 2008a. Systematic revisions of freshwater turtles *Emys orbicularis* (Testudinata: Emydidae), *Mauremys caspica* (Testudinata: Geoemydidae) and *Mauremys rivulata* (Testudinata: Geoemydidae). TÜBİTAK Project Final Report, İzmir, 143 p. [in Turkish].
- AYAZ D., FRITZ U., ATATÜR M. K., MERMER A., ÇİÇEK K. & AFSAR M. 2008b. Aspect of population structure of the European Pond Turtle (*Emys orbicularis*) in Lake Yayla, western Anatolia. *Journal of Herpetology* 42 (3): 518–522.
- AYAZ D., ÇİÇEK K., TOK C. V., MUTLU H. S., CUMHURİYET O., BAYRAKCI Y. & KUMAŞ M. 2013. Conservation activities for European Pond Turtles (*Emys orbicularis*) in Turkey. *Herpetology Notes* 6: 143–144.
- AYAZ D. & ÇİÇEK K. 2011. Data on the population structure of the European Pond Turtle, *Emys orbicularis* (Linnaeus, 1758) in Lake Sülüklü (western Anatolia, Turkey) (Testudines: Emydidae). *Herpetozoa* 24 (1/2): 33–41.
- BAYRAKCI Y., AYAZ D. & ÇİÇEK K. 2015. Data on the population of syntopic turtles *Emys orbicularis* (L., 1758) and *Mauremys rivulata* (Valenciennes, 1883) from Great Menderes Delta (western Anatolia, Turkey). *Russian Journal of Herpetology* 22 (2): 79–83.
- BONA M., BUREŠOVÁ B., DANKO S., HAVAŠ P. & NOVOTNÝ M. 2013. Conservation activities for the European Pond Turtle (*Emys orbicularis*) in Slovakia. *Herpetology Notes* 6: 145–146.
- As result of the project we carried out for the determination of the threatened populations of *E. orbicularis* in Mediterranean region, we observed that the Lake Eğirdir population is more stable than other Mediterranean populations. Even more, during the three year study, the population size showed a tendency to increase. Even though a few possibly low impact threats like predation and pollution were observed, with the extensive water volume and suitable terrestrial habitats, Lake Eğirdir is one of the best habitats for *E. orbicularis* in the Turkish Mediterranean region.
- Acknowledgements:** This study is financially supported by TÜBİTAK [Project number: 110T927] and EBİLTEM [2012/BİL/013]. We are indebted to these organizations for financial support. The study protocol was approved with Decision No. 2010/13 by the Laboratory Animals Ethical Committee at Ege University, Turkey.
- BÖHM M., COLLEN B., BAILLIE J. E., BOWLES P., CHANSON J., COX N.,... & RHODIN A. G. 2013. The conservation status of the world's reptiles. *Biological Conservation* 157: 372–385.
- CONGDON J. D., DUNHAM A. E. & VAN LOBEN SELS R. C. 1993. Delayed sexual maturity and demographics of Blanding's Turtles (*Emydoidea blandingii*): implications for conservation and management of longlived organisms. *Conservation Biology* 7: 826–833.
- CONGDON J. D., NAGLE R. D., KINNEY O. M., OSENTOSKI M., AVERY H. W., VAN LOBEN SELS R. C. & TINKLE D. W. 2000. Nesting ecology and embryo mortality: implications for hatchling success and demography of Blanding's turtles (*Emydoidea blandingii*). *Chelonian Conservation and Biology* 3: 569–579.
- COOCH E. & WHITE G. C. 2016. Program Mark, a gentle introduction. 14th edition. 1077 p. Available at <http://www.phidot.org/software/mark/docs/book/> (accessed on 24/02/2016).
- ERNST C. H., HERSHEY M. F. & BARBOUR R. W. 1974. A new coding system for hardshelled turtles. *Transactions of the Kentucky Academy of Science* 35: 27–28.
- FICETOLA G. F., PADOA-SCHIOPPA E., MONTI A., MASSA R., BERNARDI F. D. & BOTTONI L. 2004. The importance of aquatic and terrestrial habitat for the European Pond Turtle (*Emys orbicularis*): implications for conservation planning and management. *Canadian Journal of Zoology* 82 (11): 1704–1712.
- FRITZ U. 2001. *Emys orbicularis* (Linnaeus, 1758) – Europäische Sumpfschildkröte. In: FRITZ U. (Ed.): *Handbuch der Reptilien und Amphibien Europas. Schildkröten I.* Wiesbaden/Wiebelsheim, Germany: AULA-Verlag, pp. 343–515.
- FRITZ U. 2003. Die Europäische Sumpfschildkröte. Supplement der Zeitschrift für Feldherpetologie No. 1. Bielefeld: Laurenti Verlag. 224 p.
- FRITZ U. & ANDREAS B. 2000. Distribution, variety of forms and conservation of the European Pond Turtle. In: *Proceedings of the 2nd International Symposium on *Emys orbicularis*. Chelonii 2: 23–26.*

- FRITZ U. & CHIARI Y. 2013. Conservation actions for European Pond Turtles—a summary of current efforts in distinct European countries. *Herpetology Notes* 6: 105.
- GIRONDOT M. & PIEAU C. 1993. Effects of sexual differences of age at maturity and survival on population sex ratio. *Evolutionary Ecology* 7 (6): 645–650.
- IVERSON J. B. 1991. Life history and demography of the Yellow Mud Turtle, *Kinosternon flavescens*. *Herpetologica* 47: 373–395.
- LANSZKI J., MOLNÁR M. & MOLNÁR T. 2006. Factors affecting the predation of Otter (*Lutra lutra*) on European Pond Turtle (*Emys orbicularis*). *Journal of Zoology* 270: 219–226.
- LEBRETON J.-D., BURNHAM K. P., CLOBERT J. & ANDERSON D. R. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. *Ecological Monographs* 62 (1): 67–118.
- MASCORT R. 1998. Distribution and status of the European Pond Turtle, *Emys orbicularis*, in Catalonia. *Mertensiella* 10: 177–186.
- MAZZOTTI S. 1995. Population structure of *Emys orbicularis* in the Bardello (Po Delta, Northern Italy). *Amphibia-Reptilia* 16: 75–85.
- MITRUS S. & ZEMANEK M. 2004. Body size and survivorship of the European Pond Turtle *Emys orbicularis* in central Poland. *Biologia, Bratislava* 59 (14): 103–107.
- MOSIMANN D. & CADI A. 2004. On the occurrence and viability of the European Pond turtle (*Emys orbicularis*) in Moulin-de-Vert (Geneva, Switzerland): 50 years after first introduction. *Biologia, Bratislava* 59 (14): 109–112.
- SERVAN J. 1998. Ecological study of *Emys orbicularis* in Brenne (central France). *Mertensiella* 10: 245–252.
- SCHWARZ C. J. & ARNASON A. N. 1996. A general methodology for the analysis of capture-recapture experiments in open populations. *Biometrics* 52: 860–873.
- SNIESHKUS E. 1998. Some observations on secondary sexual characteristics, sex ratio, and reproductive aspects of European Pond Turtles, *Emys orbicularis* (Linnaeus, 1758), in the former USSR. *Mertensiella* 10: 253–258.
- TAŞKAVAK E. & AYAZ D. 2006. Some investigations on the taxonomic status of *Emys orbicularis* (Linnaeus, 1758) from Aegean and Central Anatolian regions of Turkey. *Pakistan Journal of Biological Sciences* 9 (4): 574–581.
- WWF (World Wide Fund For Nature) 2013. Report of the study of modelling pollution resources and pollution status in Lake Eğirdir. 35 p. [In Turkish]. Available at http://awsassets.wwftr.panda.org/downloads/eirdir_golu_kirlilik_modellemesi.pdf (accessed on 24/02/2016).

Accepted: 17.11.2016