A Review of the European Pond Turtle, *Emys orbicularis* (Testudines: Emydidae), as a Subject for Integrative Population Studies

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Abstract: The Proceedings of the EMYS Symposium, held at Dresden in 1996, were published in 1998 as the 10th issue of *Mertensiella*. This volume, consisting of 28 articles and seven notes all devoted to the systematics, ecology, physiology, and conservation of the European pond turtle (*Emys orbicularis*) populations, is reviewed in the light of its significance as a first step toward the international exchange of information/experiences for the comprehensive understanding of this widely distributed, but locally differentiated and threatened species. All the articles and notes, though arranged in a rather curious way, contribute much to our knowledges of this systematically interesting and conservationally important turtle, which, until recently, had been poorly studied from the viewpoint of population biology. Reading of this book, one can realize the importance of integrative approaches for the designation of effective conservation measures, especially for a wide-ranging polymorphic organism like this species. This volume is thus recommended for the bookshelves of all students interested in this and relevant fields of biology. Applications of a few other methods/techniques, such as the multivariate analysis of morphological characters and allozyme electrophoresis, are recommended to further improve the evaluation of taxonomic status and conservation priority for local populations of this turtle. Establishment of the criteria and guidelines for international translocation-based conservation procedures seems to be an urgent necessity.

Key words: Review; *Emys orbicularis*; Testudines; Population biology; Conservation

The European pond turtle *Emys orbicularis* is the only native Old World representative of the family Emydidae (as opposed to Bataguridae: Gaffney and Meylan, 1988), occurring from northern Africa and southern Europe (including a few Mediterranean islands) northward to Denmark and Lithuania, and eastward to northern Iran and the Aral Sea region of the former USSR (Iverson, 1992; Podloucky, 1997). Despite the long-standing view of its being a monotypic species with a broad distributional range, recent revisional studies by Uwe Fritz and his colleagues strongly suggested that the species is actually highly polytypic, consisting of some 13, more or less localized subspecies (e.g., Fritz, 1989; Fritz and Obst, 1995; Fritz et al., 1996). Such a progress in the infraspecific taxonomy has lead to the increase of conservational concerns about this turtle in most of its range, where populations belonging to particular localized subspecies are threatened by various human activities.

Under such a situation, “The *Emys Symposium*” was held from 4th to 6th October 1996 at Dresden to promote an exchange of information relevant to various aspects of population biology of *E. orbicularis* among international authorities, and its proceedings were recently published. In this essay, I review these proceedings with appreciation of their being the first step toward the comprehensive understanding of this systematically interesting and conservationally important turtle.

The volume (Uwe Fritz, Ulrich Joger, Richard Podloucky, and Jean Servan [eds.]. 1998. Proceedings of the EMYS Symposium Dresden 96. *Mertensiella*, Number 10. Published by Deutche Gesellschaft fur Herpetologie und Terrarienkunde e. V. [DGHT]. i–vi + 302 pages; available from DGHT Geschäftsstelle, Postfach 1421, D-53351 Rheinbach, Germany; price, 29.80 DM for DGHT members and 59.80 DM for nonmembers; paperback), henceforth abbreviated as PESD, is composed of 35 contributions (28 articles and seven notes) by 54 authors. Of these, ten articles and notes are chiefly or exclusively devoted to systematics, 11 to ecology, and 13 contributions and the remaining one arti-
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cle to issues relevant to conservation and physiology of *E. orbicularis*, respectively. The text of each contribution is written in plain, verbally correct English: this seems to be at least partially attributable to efforts by James R. Buskirk as the Language Editor. A German abstract (Zusammenfassung) is added to each contribution, and an English abstract to each article.

**Summary of the Contents**

**Systematic studies.** Of the ten contributions devoted to systematics, the article by Fritz (p. 1-27) provides an overview on the current taxonomic and geographical delimitations of subspecies and subspecies groups. Four pages of beautiful color photographs provided therein show most, though not all, of the subspecies recognized at present. He also refers to a few additional variant populations or groups of populations most likely representing yet undescribed subspecies. In this article, fossil records of the Eurasian *Emys* are also reviewed, and the historical biogeography of *E. orbicularis* is discussed with the assumption that most, if not all, of those fossils are of direct ancestors of this species. He argued that the current geographical range of *E. orbicularis* reflects influences of both the climatic changes during the latest continental glaciation and recent human activities.

Other systematic works include those by Farkas et al. (p. 89-101), Fritz, Baran et al. (p. 103-121), Fritz, Pieh et al. (p. 123-133), Taskavak and Reimann (p. 267-278), and Zuffi and Ballasina (p. 279-286), which concern the taxonomic status, relationships and/or diversity of populations in the Hungarian Lowlands, Turkey, Majorca (a Mediterranean island east of the Iberian Peninsula), Turkey, and Italy, respectively. Of these, Farkas et al. highlight the differentiation of the Hungarian population from the German and Polish populations in size and coloration, which contradicts results of a molecular study, which suggested closer historical relationships of the former two populations. Fritz, Baran et al., on the basis of external characters in a large series of specimens, assign some of the Anatolian populations, formerly considered to represent *E. o. hellenica* or *colchica*, to *E. o. luteofusca*, and others to a new subspecies, *E. o. eiselti*. Taskavak and Reimann also analyse morphometric and color variation in a different series of Anatolian specimens and, while assigning some to *luteofusca*, demonstrate the intermediacy of one isolated population between *luteofusca* and *hellenica*. Fritz, Pieh et al., based on the results of morphological and molecular analyses, consider that the Majorcan population has originated not from the natural dispersals from Iberian Peninsula, but from artificial introductions from the more eastern parts of Europe. Based on the morphometric analysis of several large samples and observations of captive bred individuals, Zuffi and Ballasina recognize the presence of at least four divergent groups of populations within Italy. While referring to these groups as ecotypes, they argue the necessity for re-evaluation of taxonomic significances of color characters.

From a viewpoint of population systematics and historical biogeography, the article by Lenk, Joger et al. (p. 159-175) is of particular interest. They analyse sequence variation of the mitochondrial cytochrome *b* gene among samples of *E. orbicularis* from broad geographical ranges, and discuss the historical implications of the phylogeographical pattern illustrated. A total of 187 specimens examined possess 13 different haplotypes composing six major assemblages, which largely correspond to their geographic arrangements but with a certain degree of mixture especially in the southeastern Balkans. They attempt to explain the recognized phylogeographical patterns chiefly on the ground of extinction of northern and inland populations during the late Pleistocene glaciation, and of post-glacial range extensions from southern refugia along major river systems. The remaining three, all notes, by Ardizzone and Fritz (p. 287-288), Fritz (p. 296), and Triperi and Fritz (p. 299-302) refer to morphological features in samples from Sicily, Catalonia, and southern Italy, respectively.

**Ecological and physiological studies.**—Six contributions chiefly or exclusively focus on the reproductive ecology of populations in Germany (Andreas and Paul, p. 29-32; Schneeweiss, Andreas and Jendretzke, p. 227-234), Poland (Jablonksi and Jablonska, p. 141-146; Mitrus and Zemanek, p. 187-191), the former USSR (Snieshkus, p. 253-258), and France (Gay and Lebraud, p. 297). Of these, Andreas and Paul, while providing some quantitative data for clutches and dimensions of nests in northeastern Germany, report the massive deaths of hatchlings and embryos in the nest during an extremely cold winter. Schneeweiss, Andreas, and Jendretzke describe additional reproductive properties, such as the preferred nesting environments, incubation period, and the nest temperature during the embryonic development for the northeastern German populations of *E.
 orbicularis, and also report the massive deaths of hatchlings during a recent very cold winter. They argue that the breeding success of this turtle is severely influenced by predators, agricultural activities, and fluctuation of climatic factors. Based on ten years of observations of the eastern Poland population, Jablonski and Jablonksa report that egg-laying is most frequent during the first half of June, and that females usually lay eggs in the evening and at same sites for many years. They also claim that examinations of nests by researchers often induce subsequent predation upon eggs, especially by crows and ravens. Mitrus and Zemanek describe a number of breeding properties, such as mating (from late April to early May) and egg-laying seasons (from late May to middle June), and clutch size (10–18, usually 14 or 15), for the central Poland populations. They also reported an occasional death of neonates in the soil (as in the case of northeastern German populations: see above). The note by Gay and Lebraud, despite its brevity, provides an excellent summary of nesting records of E. orbicularis in France. It also lists factors causing threats to the survival of southern French populations, and emphasizes the possible impact by the exotic turtle, Trachemys scripta elegans, which has already established a feral population in this region.

Keller, Andreu, and Ramo (p. 147–158) present results of their progressive study on the size and age structures of an E. orbicularis population in southwestern Spain. Their study indicates that the growth annuli observed on plastral scutes are not always formed annually, and that the age determined by counting these lines may thus suffer underestimation. Maximum female and male longevities, confirmed by the more reliable mark and recapture method, are 29 and 28 years, respectively.

Based on telemetry data, Paul and Andreas (p. 193–197), while presenting home ranges of E. orbicularis in Germany, report that females showed a rather long migration for nesting. Schneeweiss and Steinhauer (p. 235–243) also report a long distance (up to 1650 m) migration by a female for oviposition near the field of the former study. Interestingly, they also report that the turtles recaptured with an interval of 24 years migrated to, and oviposited in, the same areas. It is argued that the loss of small permanent forest ponds and reforestation have recently been causing deficiencies of favorable habitats for hatchlings and suitable nesting sites for adult females, respectively. On the basis of ten years of mark-recapture study, Servan (p. 245–252) estimates sizes and structures of populations that collectively compose a metapopulation in France. While further assuming that environmental heterogeneity influences the life history of turtles, he suspects that the significant differences in carapace length between populations may reflect variability in the growth rate induced by a few environmental constraints such as food availability and the type of microclimate. Szczersbak (p. 259–266) summarizes the body size (i.e., carapace length) variation, habitat properties, abundance, reproduction, diet, and other aspects of natural history in the Ukraine populations of E. orbicularis.

As the only contribution on the physiological aspect of E. orbicularis, Pieau (p. 199–207) reports results of field experiments conducted in France, which showed that gender of a hatchling depends on the proportions of its development exposed to masculizing and feminizing temperatures during the thermosensitive period. He also confirmed that estrogens play a major role in gonadal differentiation. Based on these results, he suspects the presence of thermosensitive regulation for aromatase (an enzyme that promotes conversion of androgens to estrogens) gene in gonads of the turtle.

Directly conservation-oriented studies.—Eight articles and one note chiefly focus on the current distribution and/or status of E. orbicularis populations in Russia (Bozhansky and Orlova, p. 41–46), France (Cheylan, p. 47–65; Cheylan and Poitevin, p. 67–82; Devaux and Bley, p. 83–88), Germany (Hanka and Joger, p. 135–140; Podloucky, p. 209–217; Schneeweiss, p. 219–226; Budde, p. 289–291), and Spain (Mascort, p. 177–186). Of these, Bozhansky and Orlova review the recent distribution of this turtle in western Russia, and point out the possible negative impact on the turtle populations from the construction of irrigation and drainage canals, and propose conservation measures to be taken. Cheylan reviews the prehistoric and recent distributional dynamics of E. orbicularis in southern France on the basis of copious data from osteological remains in post-glacial archaeological sites, writings on this turtle from the 19th and 20th century, and actual field surveys. He argues that this species, having enjoyed a much wider distribution in the prehistoric era, has been reduced through direct human exploitation as food during 11,000–5,500 yrs BP, and more recently destruction and pollution of habitats. Now, most populations but two seem to be in more or less relict states and close to extinction. Cheylan and Poitevin, based on
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the analysis of population dynamics of the turtle in southeastern France after forest fires, report a mortality rate in the fires of approximately 60%, over-mortality of young individuals during and immediately after the fire, and subsequent rejuvenation of populations. They also mention the impact of fire upon the turtle's habitats through an almost total destruction of riparian vegetation, rapid filling of the watercourse under the effect of erosion, and an accentuation of the torrential flow and a reduction in the run-off time. On the other hand, Devaux and Bley report the recent endangered status of the southcentral population of E. orbicularis in France. These authors suspect that the proximity of a rubbish dump and sewage deposit, seasonal variations in the stream flow, and the entry of chemicals from neighboring vineyards may have been unfavorably influencing this population. Hanka and Joger, on the basis of genetic and morphological examinations of several turtles from a nature reserve in western Germany, emphasize the extreme scarcity, or nonexistence, of individuals representing a pure native population: those specimens may have been derived from hybridizations between native individuals of nominotypical subspecies and representatives of E. o. hellenica transported from southern Europe. Such a view is strengthened by Podloucky and Schneeweiss, who, on the basis of extensive literature and field surveys, and morphological examinations of available specimens, demonstrated an extreme predominance of escaped and released turtles (mostly from southern Europe) in western Germany. Podloucky also points out the risk in the project to augment native populations by introducing exotic individuals. On the other hand, Schneeweiss reviews other artificial factors causing the decline of native populations, such as overexploitation for food (up to the 19th century), and destruction of most freshwater habitats and nesting sites. With respect to populations in southwestern Germany, Budde provides results of field surveys that are also strongly suggestive of extreme scarcity of "pure native" individuals. Mascort, on the other hand, reports the results of surveys in northeastern Spain, which demonstrate drastic declines of almost all populations in this region, most likely due to the abrupt reduction of available habitats through freshwater pollution and coastal development. He argues for the necessity of carrying out some conservation practices, such as preservation of the sites that still maintain viable populations, restoration of areas where the species was common in the past, and removal of pollutants from the water in the habitats of this turtle. Arvy and Servan (p. 33–40) report the range of the exotic slider turtle, Trachemys scripta, in France, and compare ecological features between this species and E. orbicularis on the basis of published data. They predict that T. scripta is (or will be shortly) a formidable competitor of E. orbicularis in natural habitats, in which the two species show a large niche overlap. They also suspect that the aclimatization in feral populations of T. scripta to natural environments is already beginning in France. Ferri, Cerbo, and Pellegrini (p. 95–101), on the other hand, introduce the "Serranella Emys project", which started in 1995 for the purpose of conserving severely endangered populations of E. orbicularis in central Italy. This project involves several actions, such as censuses and assessments of natural population, their direct protection by habitat preservations, and collection of individuals of badly endangered populations, their captive breeding, and repatriation. Of the remainder, Delavaud, Seguin, and Veyss- set (p. 292–295) briefly review the history of conservation activities for the E. orbicularis population in the coastal marsh area of Charente Maritime, France, and Miquet (p. 298) summarizes a currently on-going project for the recovery of a once eradicated E. orbicularis population in eastern France by introducing individuals from neighboring regions.

EVALUATION AND CRITICISMS

As summarized above, all papers in PESD should be of great use not only to those interested in the systematics, ecology, and conservation biology of E. orbicularis, but also to students and officers dealing with other taxonomically diverged and/or conservationally concerned species as well. Those reading through this book, while benefiting from the large amount of useful information given therein, should realize the importance of integrative international approaches in developing effective conservation measures for such a wide-ranging, much differentiated organism as E. orbicularis. I was also much impressed to see the active exchanges of relevant information among the authors, which is expressed by frequent mutual citations among the contributions within this book. This is a very important issue for proceedings of symposia on particular topics like PESD, but always requires editors to invest a huge amount of time and effort. Indeed, the editors of this volume have
done a splendid job in this regard. As such, this volume can be recommended for the bookshelves of all students interested in this and relevant fields of biology.

I now turn to a few problematic points in PESD, and also to problems relevant to those raised therein. The worst aspect of this book lies in the arrangement of articles and notes. Contributions on similar topics are often distantly located within PESD. Locations of papers by Fritz, Baran et al. (p. 103–121) and Taskavak and Reimann (p. 267–278), both concerning the taxonomic status of Turkish populations of *E. orbicularis*, and those by Andreas and Paul (p. 29–32) and Schneeweiss, Andreas, and Jendretzke (p. 227–234), both on the reproductive aspect of populations in northeastern Germany, are among examples of such a shortcoming. More careful arrangement of contributions would have saved serious readers the labor of turning over pages so extensively.

Currently prevailing infraspecific classification of *E. orbicularis* has been established only during the last decade, almost entirely through the efforts of Uwe Fritz and his co-workers (e.g., Fritz and Obst, 1995; Fritz et al., 1996; and papers cited by Fritz in PESD). They seem to have made admirable efforts to access most, if not all, of the currently available materials from various localities fairly representing the wide distributional range of the species. They then delimited subspecies by an *a priori* use of color characters and a few measurements, mostly converted into ratios through the division by standard length. Naturally, such an approach is also followed by several other contributors of PESD. This procedure, however, suffers in two ways. First of all, statistical treatments of ratios, such as calculations of means and standard deviations (as are practiced by several authors in PESD), are beyond logical justifications (see Atchley and Anderson [1978] and Atchley et al. [1976] for detailed discussion on the problematic attributes of ratios, which constrain their use in systematics). For the removal of size factor from morphometric characters in univariate between-sample comparisons, analysis of covariance (ANCOVA: e.g., Sokal and Rohlf, 1981) should be employed (but also see the following criticism). Secondly, several recent studies demonstrated that the subdivision of a highly variable taxon by univariate analysis for a limited number of characters easily fails to elucidate actual biological or historical entities (e.g., Willig et al., 1986; Thorpe, 1987; Wüster et al., 1992). Furthermore, according to Zuffi and Ballasina in PESD, coloration may easily vary through highly localized selection and/or in the form of purely physiological responses to particular environmental factors in this species. Thus, I would like to recommend that taxonomists re-analyse the morphological data of local samples by multivariate methods for further revision of subspecific classifications of this turtle. Ratios and coloration, when convenient, may be used to diagnose subspecies elucidated as a result of such analyses in an *a posteriori* fashion (see Yasukawa and Ota [1999] and Yasukawa et al. [1996] for examples of such procedure).

In PESD, several authors use information from sequence variation in mitochondrial DNA to elucidate intraspecific phylogeography (e.g., Lenk et al.), or to infer origins and subspecific allocations of individual specimens in question (e.g., Hanka and Joger). This method, developed to trace the maternal genealogy of individuals, is surely very useful for such purposes (Avisé et al., 1987). However, it would be even much more effective if used in combination with nucleic genetic markers, such as sequence of some parts of nucleic DNA and compositions of allozyme alleles: the present species is likely to have frequently been involved in genealogical reticulations (i.e., hybridization and introgression between individuals from more or less diverged populations) through natural or artificial dispersals, and combined use of markers from mitochondrial and nucleic genomes is most effective in elucidating such events (Arnold, 1992). Analysis of the nucleic genome is also very useful to diagnose within-population genetic diversity, which is considered as an indicator of the population viability (Haig, 1998). Allozyme electrophoresis is one of the simplest, but effective methods to address these issues (Arnold, 1992; Buth, 1984; Murphy et al., 1996). Nevertheless, it has not yet been applied to studies of *E. orbicularis* (and seldom even to studies of other chelonians: see Buth and Rainboth [1999] for review). I would like to recommend that the researchers working on the population systematics, biogeography, and conservation of this species attempt this method, along with recently developed techniques for blood sampling without causing serious damages to live turtles (see Kuchling [1998] for review).

Several contributions in PESD refer to translocations of *E. orbicularis* individuals in the form of augmentations (sensu Reinert, 1991) to endangered populations (e.g., Ferri et al.) and reintroductions to areas where original populations have already disappeared (e.g., Miquet).
However, translocation and release of nonnative individuals, even though they "look" quite similar to native individuals, should be avoided, because such a manipulation is accompanied by considerable risk of reduction of between-population genetic diversity and population decline through deleterious genetic effects of mixing divergent gene pools (e.g., Templeton et al., 1986; Burke, 1991; Reinert, 1991), as well as of the formation of a false biogeographical pattern which would be badly confusing to future researchers (e.g., Sato and Ota, 1999). Moreover, the success ratio of translocation, irrespective of repatriation or introduction, may not be so high (Dodd and Seigel, 1991; but see Burke [1991] for different view). To avoid unorganized imprudent collecting and release of turtles under the excuse of conservation, establishment of international criteria and guidelines for the translocation-based conservation procedure seems to be of urgent necessity. Recent announcement of the Second International Symposium on *Emys orbicularis* by Veyset and Livoreil (1999) lead me to expect that opportunities for the international exchange of information and experiences on this turtle will be continuously provided at certain intervals. I sincerely hope for improvement in the above and other points through the discussion of authorities toward the better understanding and successful conservation of this species.

**Acknowledgments.**—I thank A. Kupfer for the provision of this interesting volume for review, and M. Toda and Y. Yasukawa for constructive discussion.

**Literature Cited**


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