Is the European "pond" turtle *Emys orbicularis* strictly aquatic and carnivorous?

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In their recent, straightforward overview of the evolution of Emydid Turtles, Stephens and Wiens (2003) treat *Emys orbicularis* (Linnaeus, 1758) as a strictly "aquatic" and "carnivorous" turtle. This interpretation directly draws from the current point of view about the ecology of *E. orbicularis*. Interestingly, *E. orbicularis* is the only species within the subfamily Emydinae considered to be both strictly aquatic and carnivorous. As a consequence, within emydid turtles, two simultaneous changes in diet and habitat have been invoked in the evolution of *E. orbicularis*: the recent ancestors of *E. orbicularis* were likely omnivore and semi-terrestrial (habitat and dietary generalist), thus it has been hypothesized that *E. orbicularis* evolved a more specialised ecology, becoming strictly carnivorous and aquatic, and thus a habitat and dietary specialist (Stephens and Wiens, 2003). It is worth noting that, following this reconstruction, *E. orbicularis* is the only taxon (out of 64 analysed by Stephens and Wiens) in which a simultaneous change in habitat and diet seems to have occurred.

However, evidences from recent studies suggest that *E. orbicularis* is not strictly carnivorous or aquatic: these findings suggest that the "simultaneous changes" hypothesis could be caused by a bias in the existing literature about *E. orbicularis*. A reanalysis of available data about the ecology of *E. orbicularis* can also have an important influence on the management of this threatened species.

Is *E. orbicularis* strictly carnivore?

Only a few studies analysed the diet of *E. orbicularis*. This species is classically considered a carnivore (Bannikov, 1951; Lanza, 1983; Ernst and Barbour, 1989). Instead, several studies found vegetable remains in their faeces. However, it has been disputed whether vegetable remains should be considered as eaten "by mistake" (e.g., Lebboroni and Chelazzi, 1992; Kotenko, 2000). In their recent paper, Ottonello et al. (2005) found plant remains in 89% of faeces of adult *E. orbicularis*. This amount of plant items can hardly be considered to be eaten by mistake: plants are among the most common food items, furthermore adults feed more frequently on plants than juveniles, and the amount of ingested plants increases during the post breeding period (Ottonello et al., 2005). These results are consistent with those found in other Mediterranean populations (Lebboroni and Chelazzi, 1992, 1998), and suggest that *E. orbicularis* is not entirely carnivorous. *Emys orbicularis* seems to shift from a carnivore to a more herbivorous diet as it grows, similarly to other omnivore emydid turtles (e.g., *Trachemys scripta*: Hart 1983), and it could prefer less energetic food, such as plants, during the post breeding season, when the energetic requirements are less intense. It should also be noted that a mixed diet, including both plant and

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animal matter, can increase the efficiency of the digestive process (Bjorndal, 1991).

Is *E. orbicularis* a strictly aquatic species?

Terrestrial environment is important for all freshwater turtles, as they lay eggs on land. However, species using the upland environment only for nesting are usually considered strictly aquatic, while those using upland habitat also for other activities are considered semi-aquatic (or terrestrial). In which category should *E. orbicularis* be classified? Usually, *E. orbicularis* is considered to be an aquatic species (e.g., Ernst and Barbour, 1989), since some of their most conspicuous behaviours (such as basking or mating) occur in or very close to the water (e.g., Di Trani and Zuffi, 1997; Rovero et al., 1999). However, following a quantitative approach, *E. orbicularis* is among Emydid turtles the one that can move furthest from wetlands. Semlitsh and Bodie (2003) review the data about the use of terrestrial habitat in 28 species of freshwater turtles, mainly from North America. They reported no cases of distances exceeding ∼1600 m from wetlands. For the close relatives of *E. orbicularis* (*Emydoidea blandingii* and *Clemmis* spp.), usually considered semi-aquatic species, the overland movements span up to 1620 m (Joyal et al., 2001). However, Jablonski and Jablonska (1998) report that *E. orbicularis* can move up to 4 km far from their wetland for nesting, and reports of terrestrial migrations exceeding 1 km are not uncommon (Lebboroni and Chelazzi, 1998; Schneeweiss and Steinhauer, 1998).

Maybe more importantly than any record of exceptional terrestrial movements, *E. orbicularis* uses upland environment for activities other than nesting migration. Terrestrial activity is frequently performed also by males (Nalleau, 1992); for example the upland environment is used for aestivation, hibernation and for travelling (Naulleau, 1992; Fritz and Gunther, 1996; Utzeri and Serra, 2001). Moreover, the abundance of terrestrial insects in the diet of *E. orbicularis* found by Ottonello et al. (2005) suggests that upland environment can be important also for feeding, since *E. orbicularis* can feed also in an upland environment (Lanza, 1983). The importance of the upland environment for this species can be detected also at a landscape scale. *Emys orbicularis* is more frequent and lives at higher densities in wetlands surrounded by a large proportion of natural, wooded, landscape (Ficetola et al., 2004). The composition of terrestrial environment could affect the presence and abundance of populations of *E. orbicularis* also at distances greater than 1500 m, and can explain most of the variation in their abundance (Ficetola et al., 2004).

Finally, it is possible that the importance of terrestrial behaviour is variable among populations. For example, terrestrial activity could be more important for populations that live in wetlands suffering seasonal draughts (e.g., Utzeri and Serra, 2001).

Conclusion

Altogether, these studies suggest that *E. orbicularis* is not more strictly carnivorous or aquatic than closely related species: plants are important food items for adults, and the upland environment is very important for this species. At least two main implications can be drawn from this analysis.

First, it is not necessary to hypothesize two recent, simultaneous changes in the evolution of ecology of *E. orbicularis*. This observation makes more clear cut the hypotheses about the evolution of ecological traits in Emydid turtles (Stephens and Wiens, 2003): it is consistent with the observation that habitat changes occur prior to dietary changes, that habitat and diet do not change on the same branch, and that changes in ecology are very rare in the evolution of Emydid turtles, both in Emydinae and in Deirochelynae (Stephens and Wiens, 2003).

Second, plans for the conservation of habitat of *E. orbicularis* usually focus on the management of wetlands or of wetland systems (e.g.,

Lebboroni and Chelazzi, 1998; Lacomba and Sancho, 2000). However, as it has been previously recommended (Semlitsch and Bodie, 2003; Ficetola et al., 2004), the conservation of this threatened species can not overlook the importance of upland environment, and wide buffer zones are vital for their survival. Joyal et al. (2001) suggested similar management indications for two species closely related with *E. orbicularis*, *Clemmys guttata* and *Emydoidea blandingii*. Quantitative radiotracking studies analysing a large number of individuals (e.g., Joyal et al., 2001; Schabetsberger et al., 2004) are required to evaluate the optimal structure of buffer zones for the long term survival of *E. orbicularis* populations.

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