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SOUSS VALLEY TORTOISE (*TESTUDO GRAECA SOUSSENSIS*) BIOLOGY IN THE ARID STEPPES OF CENTRAL JBILET, WEST CENTRAL OF MOROCCO

Review

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ABSTRACT

The Souss Valley tortoise, Testudo graeca soussensis, is endemic to the semi-arid and arid low quality habitats of west central Morocco. Populations of this area are among the best investigated populations in western Mediterranean. The conservation of a long-term of these declining populations is a particular management concern for this endemic and endangered subspecies. Here we present a data review on biological and ecological aspects of this subspecies dealing with morphology, geographical distribution, habitat use, food habits, activity cycle, growth and sexual maturity, sexual dimorphism, breeding ecology and demographics.

KEY WORDS: *Testudo graeca soussensis, arid environments, west-central Morocco, biology, ecology, life history, threatened subspecies.*

Morocco has an island-type geographical location in North-West Africa. It is isolated by the Mediterranean Sea from the north, the Atlantic Ocean from the west, the Moulouya Valley from the northeast and the Sahara from the south and south-east. In addition, various geographical units appear within the country, notably the Atlas chain which constitutes the most important biogeographically barrier between the Sahara and the Mediterranean zones.

From a biological point of view, Morocco, and because of its location in the Mediterranean basin, one of the world's 25 hotspots of biodiversity, is hosted the second largest concentration of terrestrial biodiversity and the largest assemblage of marine organisms in the entire Mediterranean basin (National Biodiversity Report, 2002). Morocco has a species richness of more than 31,000 species of which about 11% are endemic to the country. Among Vertebrates, Morocco's herpetological biodiversity is the richest and most diversified in the entire western Mediterranean with no less than 111 species (including 11 amphibians and 100 reptiles), including 23 species (3 amphibians and 20 reptiles), or about 21% are endemic to the country. Of these species, 12 are considered the most endangered and 18 others are rare. The loss of herpetological biodiversity in Morocco has been attributed to three main causes: the

destruction of habitats (intensive agriculture, urbanization, pollution), the development of road traffic (particularly in the Saharan region) and the illegal collection for the animal trade companionship, folklore exhibition and traditional medicine. Among the most remarkable species, the Moorish turtle, *Testudo graeca*, the only terrestrial chelonian in the country, is very threatened in Morocco.

In Morocco, *T. graeca* is represented by three distinct subspecies *T. g. soussensis*, *T. g. marokkensis* and *T. g. graeca*; the first two being endemic to the country and the last is distributed between eastern of Morocco, northern of Algeria and southern of Spain (Fritz *et al.*, 2009). *Testudo g. soussensis* occupies the most northern and most western areas of the species' range between the Middle Atlantic, the Souss Valley, the Haouz plain with incursions in the Western High Atlas and the pre-Saharan zones in the surroundings of Ouarzazate. Unlike *T. g. marokkensis*, from northwestern Morocco, almost untested, several aspects of taxonomy, ecology and life history were studied especially in *T. g. graeca* in southern Spain (Andreu *et al*, 2004) and more recently in *T. g. subsides* mainly in arid and semi-arid environments in western central of Morocco (Slimani *et al*, 2002; Znari *et al*, 2005; El Mouden *et al*, 2006).

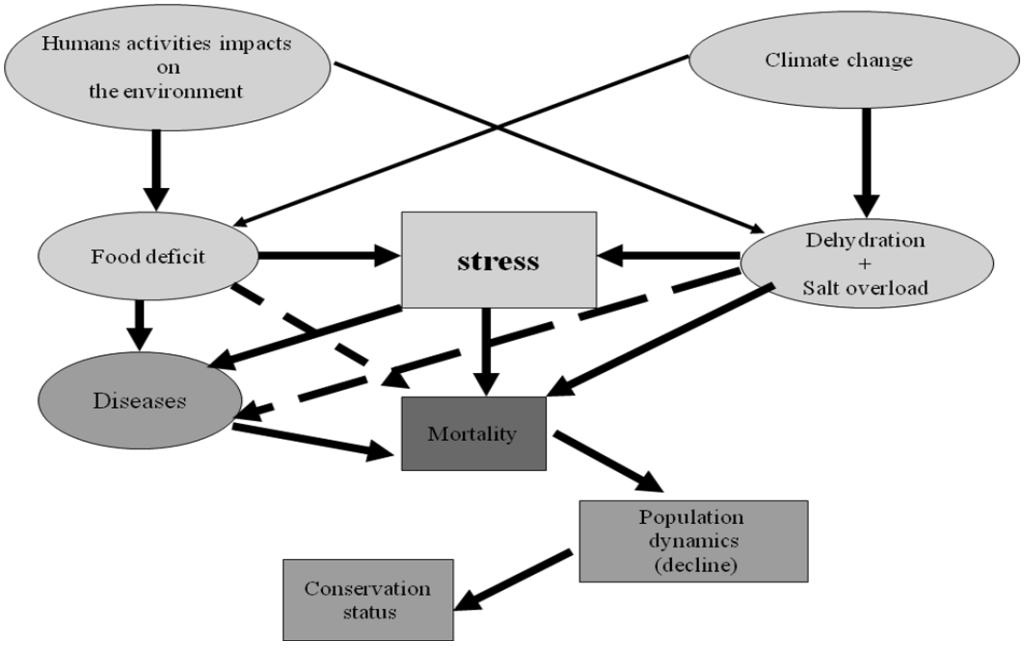

FIG. 1. Relationship between changes in the environment (man-made changes and natural changes), physiological processes (eg under-nutrition and dehydration), consequences for individuals (eg stress and / or disease) and the resulting demographic phenomena (eg, Mortality) and the demographic consequences of the population (eg, changes in population dynamics) and the conservation status of the species. (modified from Tracy *et al*, 2004).

Like other subspecies, populations of *T. g. soussensis* are also threatened by the destruction and loss of their habitat following urbanization and intensification of agricultural activities, overgrazing and also collections for the supply of the illegal turtle trade as pets. In addition, prolonged and repeated periods of drought accentuate the decline of the populations through a reduction of the vegetal cover and thus of the trophic resources as well as the increase of the dehydration risks. Thus, conservation measures are needed to protect the last populations of this subspecies throughout the western center of Morocco, particularly in the arid plain of Haouz which is currently experiencing an unprecedented development linked to the expansion of Marrakech city.

1. Morphological characteristics

Testudo g. soussensis is a subspecies of *T. graeca L.*, 1758. It has an high phenotypic plasticity in both the size and the carapace shape (Carretero *et al*, 2005; Znari *et al*, 2005). It is usually smaller in size than *T. g. graeca* reaching a record in eastern Morocco with a maximum carapace length of 248.3 mm for females and 200.3 mm for males (Bertolero *et al*, 2005); the maximum size in *T. graeca* under species being observed in the Admine forest population with maximum carapace lengths of 226.3 mm and 184 mm, respectively for females and males and respective weights of approximately 2 and 1.2 kg (Znari *et al*, 2005).

Other distinctive morphological features are a third vertebral plate with a smaller relative length compared to that of the carapace and a ratio of inter-pectoral suture length to inter-femoral suture greater than 2/3 (Pieh, 2004). The absence of femoral tubercles (spurs) and of a split supracaudal are not true distinguishing features of this subspecies, as they occur in only 23% and 8% of the tortoises examined exclusively in the population of Admine (Souss Valley). The populations of the northern coastal area of Essaouira show a much more pronounced melanism and the lighter forms meet in continental areas. In addition, central Jbilet tortoises in arid environments are relatively smaller in size and have a softer carapace, probably in relation to harder ground (Carretero *et al*, 2005). However, it should be noted that there is no genetic differentiation between the populations of the Souss valley, the central Jbilet and the Essaouira region, suggesting the belonging to the same genetic stock (Harris *et al*, 2003).

Testudo g. soussensis has a greater or lesser degree of sexual dimorphism in favor of larger females than males, and sexual dimorphism of form (Carretero *et al*, 2005; Ben kaddour *et al*, 2005), but without geographical variations on the scale of western central Morocco (Carretero *et al*, 2005).

2. Geographical distribution

Testudo g. soussensis occurs in the Souss valley (where it was firstly described) to the entrance of the urban area of Agadir, on the narrow coastal strip up to a few tens of kilometers south of Essaouira , then widening into a triangle Essaouira-

Marrakech-Safi then in the High Atlas for an altitude of about 2000 m and the region of Ouarzazate on the northern margin of the Sahara. It is almost completely absent in the extremely arid climate zone of Chichaoua, forming a "hole" in the range (Fritz *et al*, 2009).

FIG. 1. Different characteristics of *Testudo graeca soussensis*.

3. Habitat

Testudo g. soussensis occupies lower quality habitats than other subspecies. Indeed, it is found throughout its range, mainly in the most arid environments with very large seasonal thermal differences (Anadon *et al*, 2012). In the Souss valley and the coastal strip between Essaouira and Agadir, southwest Morocco, *T. g. soussensis* takes refuge in Argan forest *(Argania spinosa*) and especially in their undergrowth. It is also present along the middle Atlantic coast between Essaouira and Safi in steppe and dune environments. On the other hand, in the arid plains of Haouz and Jbilet, tortoises take refuge under the bushes of jujube, *Zizyphus lotus* (Lagarde *et al*, 2012). Finally, it can be found in the mountains in the High Atlas and more rarely in the pre-Saharan zone in the region of Ouarzazate.

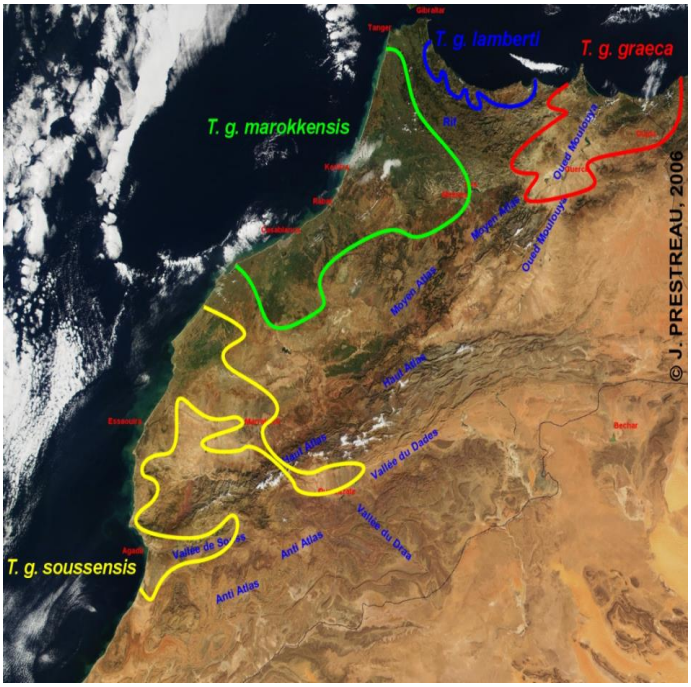

FIG. 2. Distribution map of *Testudo graeca* in Morocco *(T. g. lamberti* and *T. g. marokkensis* were recently grouped into a single subspecies: *T. g. marokkensis* by Fritz *et al*, 2009, after Prestreau, 2008).
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4. Food habits

In the Jbilet Mts, *T. g. soussensis* fed only on a small proportion of the available plant species during the spring season, but at the same time did not discriminate against species that would be toxic to mammals (El mouden *et al*, 2006). The diet composition, obtained by fecal analysis and compared to plant assemblages seems rather a specialist herbivore. The five main plant species found in fecal samples (*Leontodon saxatilis* (Asteraceae); *Malva parvilora* (Malvaceae); *Astragalus cruciatus*, *Medicago hispida* and *Lotus arenarius* (Fabaceae)) represent 70% of the identified material and were highly preferred whereas several other plant species, common in the field (e.g., *Eryngium ilicifolium* (Ombellifereae); *Emex spinosus* (Polygonaceae); *Spergula laccida* Caryophyllaceae) were actively avoided. Fabaceae made up 27% of the diet and may be important forbs in the diet of terrestrial tortoise owing to their high nutritional value. The diet composition of *T. g. soussensis* suggests that diet overlap may occur between domestic ungulates and tortoises in overgrazed landscape and could generate a competition context. However, *T. g. soussensis* seems to focus its

foraging effort mostly under the spiny of jujube shrubs where the impact of overgrazing is strongly attenuated (El Mouden *et al,* 2006; Znari & Hichami, 2018).

The spring specific richness of plants in the Jbilet habitat was reduced during drier years (2011 and 2012) compared to that reported in a previous above normal rainfall year (Hichami, 2017) (44 and 27 *vs* 88 plant species). The dry plant biomass density differed greatly between under and out of the Jujube. The mean plant species richness and the total dry biomass density were higher in under than in out Jujube. Tortoises tended to consume only about 5–6 and almost the same species, out of all the available annual forbs and grasses. The total number of plant species that were counted as being within the top 5 for all tortoises included more than 8–10 species. Many other species, abundant in the habitat, were rather avoided. It was suggested that the few herbaceous plants that represented ~90% of tortoise diet, might be important in sustaining tortoise populations during droughts.

These results underline the tortoises' vulnerability to global change on the availability of their preferred food plants (Hichami, 2017). The diet composition showed significant differences among seasons, either qualitatively or quantitatively (Hichami *et al,* 2016). The spring diet was more diverse with 16 plant species consumed against only 5 and 7 species in summer and autumn-winter respectively, with 5 shared species (*Cynodon dactylon*, *Salvia aegyptiaca*, *Leontodon saxatilis, Lotus arenarius* and *Medicago hispida*) during the all seasons.

5. Growth and sexual maturity

Both male and female tortoises from the central Jbilet Mountains, grew relatively quickly for 10–12 year, after which their growth rates decreased markedly. Females had greater asymptotic sizes than males, and CL and log mass differed significantly between sexes by age 9 year. The age at sexual maturity, estimated using large carapace growth annuli, varies from 6 to 9 years for males and from 8 to 11 years for females (7 versus 9 years in average) (Znari *et al,* 2005; Hichami, 2017). The males reached their sexual maturity at a lower mean minimal size (90.7 ± 10 mm, range: 91.4–131.4 mm) than females (146.2 ± 16.5, range: 71.8–114.6 mm). More than 60% of males attained the sexual maturity between 6 and 7 years with a carapace length of 100–120 mm, while around 60% of females are mature between 9 and 10 years with a carapace length ranging from 140 to 170 mm. The estimated minimal size at maturity, based on the sexual behaviors observed in the wild (courtship, mating) is 104.8 and 152 mm, respectively for males and females (Znari, 2005).

6. Reproductive ecology

In semi-captive Souss Valley tortoises from central Jbilet Mountains, courtship and mating activities in occurred in early spring, from March to early May, and again in mid-Autumn, for a shorter period from late October to early November (Hichami *et al,* 2016). The egg-laying season occurs in late May to early July in central Jbilet Mts (Hichami *et al,* 2016). Mean clutch size in *T. g. soussensis* varies from 3.44 to 3.80

eggs with a range of 1–7 within a clutch (Barje et al., 2005; Hichami *et al*, 2016). The mean relative egg mass and relative clutch mass are 1.70 ± 0.28% and 4.06 ± 1.32%, respectively. No egg variable was significantly correlated with the female body size (carapace length and body weight) (Hichami *et al*, 2016). Average incubation duration at 31°C in *T. g. soussensis* in Jbilet, was 70 days ranging from 62 to 78 days (Hichami et *al*, 2016). Krüger (2007) found comparable values of 72 and 81 days at 28°C (6 h) to 33°C (18 h) in two artificially incubated clutches from semi-captive females from Southwestern Morocco.

7. Predation and parasitism

The main predators of *T. graeca* are represented by some birds and mammals (Schleich *et al*, 1996; Keller *et al*, 1998) Predation mainly affects young people or laying eggs. Among the main predators of *T. g. soussensis*, the southern shrike, *Lanius meridionalis Temmnick*, 1820 (Aves: Passeriformes: Laniidae), which mainly attacks very young tortoises (LC <40 mm) (Fig.3) whose carapace is still more or less calcified (soft) allowing it to be impaled in the spines of the Argan tree (Barje *et al*, 2005).

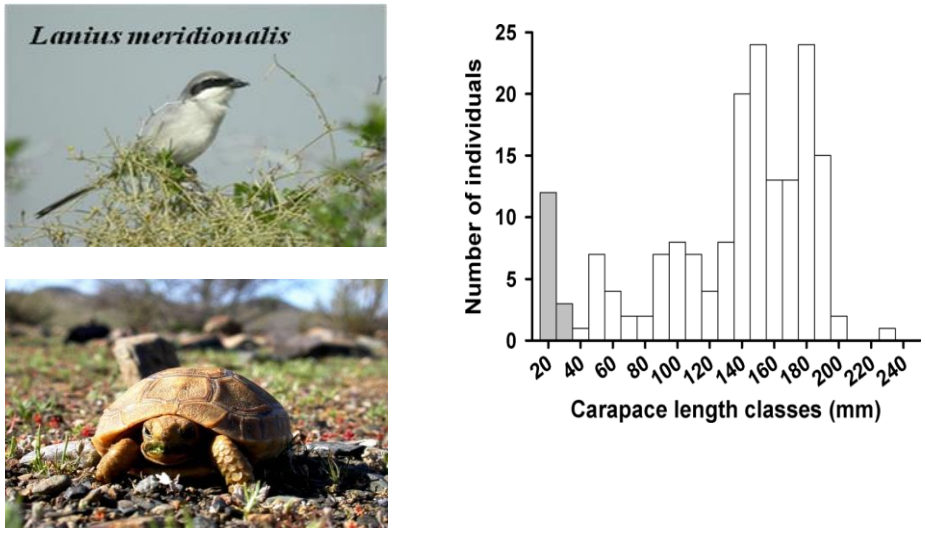

FIG. 3. Distribution of carapace size (LC, in mm) of tortoises observed in the Argan forest south of Essaouira showing, in gray, the size classes prone to predation by the southern shrike (*Lanius meridionalis*) (According to Barje *et al*, 2005).

Most tortoises in central Jbilet are infested, to varying degrees, with ticks (up to 10 ticks on the same tortoise) (Anadon *et al*, 2015). Infective ticks, mainly *Hyalomma aegyptium*, the Ixodidae family, were carriers of various microorganisms

(Kireçci *et al*, 2013). According to these authors, and in addition to various specific infections, ticks can act as mechanical or biological vectors of various bacterial pathogens in tortoises and humans. The most important bacteria are *Salmonella* sp. that present in about 90% of the tortoises in the center of Jbilet Mts (Hidalgo *et al*, 2008).

FIG. 4. *Testudo. g. Soussensis* with ticks

8. Conservation status

Intensive harvesting from the 1950s to the 1970s, and current illegal sales, the succession of years of drought, habitat destruction, threats and others have severely reduced the populations of *Testudo graeca soussensis* populations in western central Morocco (Bayley & Highfield, 1996). In addition, their important introduction in Europe in the 60s and 70s (more than 150,000 per year) quickly made it a "pet" (the garden turtle), which worsened the status of the latter. Although it is still abundant in certain areas of Morocco, the Moorish turtle, and like everywhere else, is a threatened species. *Testudo graeca* is classified in the IUCN red list in the "vulnerable" category, and more specifically VU A1cd, according to an evaluation dating back to 1996 (IUCN, 2016). It is also listed in CITES Appendix II (Washington Convention) and is considered "LA" (marketed as a pet). The conservation status of *T. graeca* and more particularly that of *T. g. underesensis* at the regional scale, should be reconsidered following the years of drought and the impact of various new human activities experienced in the center west of Morocco during the last 10 to 15 years.

CONCLUSIONS

The Souss Valley tortoise, *T. g. soussensis*, is an endemic to west-central Morocco that occur in semi-arid to arid low quality habitats and spend most of their

time under bushes to avoid overheating. the growth rate for these tortoises is slows down for females and males after maturity but high in juveniles. Adult females are larger than males with a relatively delayed sexual maturity.

The over collecting for pet trade and the human disturbance threats are the mainly causes of the decline of these tortoise populations. Moreover, hatchlings are mostly exposed to a high predation pressure due to their soft carapace. Hence the need for rapid intervention to preserve it following ecological strategies such as habitat restoration and captive breeding for population reinforcement. However, conserving and restoring biodiversity requires extensive knowledge and multidisciplinary researches.

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