CONSERVATION BIOLOGY OF FRESHWATER TURTLES AND TORTOISES

A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group

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Testudo graeca **Linnaeus 1758 (Western Subspecies Clade:**
***Testudo g. graeca, T. g. cyrenaica, T. g. marokkensis, T. g. nabeulensis, T. g. whitei*) –**
Mediterranean Spur-thighed Tortoise, Moorish Tortoise, Libyan Tortoise,
Moroccan Tortoise, Tunisian Tortoise, Souss Valley Tortoise

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Testudo graeca Linnaeus 1758 (Western Subspecies Clade: *Testudo g. graeca, T. g. cyrenaica, T. g. marokkensis, T. g. nabeulensis, T. g. whitei*) – Mediterranean Spur-thighed Tortoise, Moorish Tortoise, Libyan Tortoise, Moroccan Tortoise, Tunisian Tortoise, Souss Valley Tortoise

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Summary. – The western subspecies clade of the Mediterranean Spur-thighed Tortoise, *Testudo graeca* (Family Testudinidae) is comprised of small to medium-sized subspecies (maximum straight carapace lengths [SCL] <25 cm) native to northern Africa and southwestern Europe. In North Africa, *Testudo graeca* occurs in Mediterranean climates from humid to arid. In the Iberian Peninsula, it is restricted to subhumid, semi-arid, and arid regions. In North Africa, it reaches an altitude of 2090 m in the Haut Atlas (Morocco); in the Iberian Peninsula, it occurs at low elevations below 500 m. *Testudo graeca* is characterized by the presence of two spurs on the thighs, which are present in all subspecies except in 23% of specimens of *T. graeca graeca*. Adult females are on average larger (mean SCL = 15.5 cm, males mean SCL = 13.5 cm) and heavier than males (females mean body mass = 689 g, males mean body mass = 442 g). Females have proportionately shorter tails than males. Females produce 1–4 clutches of 1–8 eggs annually between April and July. The annual survival rate of adults is very high; it is estimated at over 90% in southern Spain. Population stability depends mainly on adult survival. The species is still relatively common and widespread in much of North Africa. However, European populations are endangered and in steep decline. In North Africa, the main threats to *T. graeca* are illegal collection for domestic and some international trade, degradation of habitats by overgrazing, and urbanization. In Europe, populations are threatened by habitat loss and fragmentation of populations. In Northern Africa and southwestern Europe, there is a strong tradition of collecting individuals to be kept in gardens. In Mallorca and southeastern Spain, several captive breeding projects are being carried out to reintroduce specimens in regions where the species has been extirpated.

Distribution. – Algeria, Libya, Morocco, Spain, and Tunisia. Introduced since historic times in the Balearic islands of Spain and western Sardinia, Italy.

Synonymy. – *Testudo graeca* Linnaeus 1758, *Testudo graeca graeca, Peltastes graecus, Testudo pusilla* Linnaeus 1758, *Chersine pusilla, Testudo mauritanica* Duméril and Bibron 1835, *Testudo graeca mauritanica, Chersus mauritanicus, Peltastes mauritanicus, Testudo ibera mauritanica, Testudo flavominimaralis* Highfield and Martin 1989, *Testudo graeca flavominimaralis, Furculachelys nabeulensis* Highfield 1990, *Testudo nabeulensis, Testudo graeca soussensis* Pieh 2001, *Testudo soussensis, Testudo (Testudo) graeca soussensis, Testudo graeca lamberti* Pieh and Perälä 2004.

Subspecies. – Based on molecular analyses, five subspecies are currently recognized in the western clade of the Mediterranean Spur-thighed Tortoise: *T. graeca graeca* (southwestern Morocco, previously referred to as *T. graeca soussensis*), *T. graeca cyrenaica* (northeastern Libya), *T. graeca marokkensis* (northern and central Atlantic plain of Morocco), *T. graeca nabeulensis* (Tunisia, extreme northeastern Algeria, northwestern Libya, introduced in Sardinia) and *T. graeca whitei* (northeastern Morocco, western Algeria, peninsular Spain, introduced in Mallorca and Formentera, previously referred to as *T. graeca graeca*).

Status. – IUCN 2021 Red List: Vulnerable (VU A1cd, assessed 1996); Regional (Europe): Vulnerable (VU A2bcde+4bcde, assessed 2009); CITES: Appendix II; EU: Annex A (regulation of trade of fauna and flora); Bern Convention: Annex II.

Figure 1. *Testudo graeca graeca* from Essaouira, southwestern Morocco. Photo by Daniel Escoriza.

Taxonomy. — *Testudo graeca* is a polytypic species, with 10 subspecies currently recognized (Fritz et al. 2009; TTWG 2021). The species spans a broad geographical range, encompassing the southern Mediterranean, eastern Balkans, and the Middle East, ranging from Morocco to Iran. The Caucasus is possibly the region of origin of the species, as indicated by genetic and fossil evidence (Fritz et al. 2007). Up to 20 subspecies have been described in studies based on external morphology (Fritz et al. 2007; TTWG 2021), but molecular analyses have revealed incongruence between the number of mitochondrial DNA clades and those defined morphologically (Fritz et al. 2007). The western clade of *T. graeca* constitutes a monophyletic group, being sister to the subspecies *T. graeca armeniaca*, belonging to the eastern Caucasian clade (Fritz et al. 2009; Graciá et al. 2017). The western subspecies clade, which occurs in northern Africa, the Iberian Peninsula, Mallorca, and Sardinia, is genetically supported (*T. graeca graeca* sensu van der Kuyl et al. 2005) and comprises five subclades (subspecies): *T. graeca cyrenaica* Pieh and Perälä 2002, *T. graeca graeca* Linnaeus 1758, *T. graeca marokkensis* Pieh and Perälä 2004, *T. graeca nabeulensis* Highfield 1990, and *T. graeca whitei* Bennett *in* White 1836 (TTWG 2021). Previous morphological studies considered two additional Moroccan subspecies as part of the western clade: *T. graeca soussensis* Pieh 2001 and *T. graeca lamberti* Pieh and Perälä 2004. Following Fritz et al. (2009) and TTWG (2021), *T. g. soussensis* is considered a synonym of *T. g. graeca* and *T. g. lamberti* a synonym of *T. g. marokkensis*. *Testudo flavominimaralis* was described by Highfield and Martin (1989b) for bright-yellow small-sized specimens from Tunisia, which Highfield (1990) later placed in a new genus *Furculachelys*, also including other Tunisian forms. It is considered a synonym of *T. g. nabeulensis*, as it is not supported by genetic analyses (see van der Kuyl et al. 2002, 2005).

Description. — *Testudo graeca* is a medium-sized tortoise. In lateral profile, the carapace is a convex dome, and from above has an oval (female) or trapezoidal (male) shape. The background color of the carapace is yellowish, pale olive, or brownish to reddish-brown

Figure 2. Adult *Testudo graeca whitei* from *Left*: Doñana National Park, Spain. Photo by Carmen Díaz-Paniagua; *Center*: male from Théniet el Had National Park, Algeria. Photo by Daniel Escoriza; *Right*: female from Moulouya basin, northeastern Morocco. Photo by Daniel Escoriza.

Figure 3. *Testudo graeca graeca* from Essaouira, Atlantic Morocco. **A, B**. adult females; **C**. juvenile male. Photos by Daniel Escoriza.

Figure 4. *Testudo graeca whitei* from northwestern Africa. **A**. juvenile female, Moulouya delta, northeastern Morocco; **B**. adult female, Moulouya delta, northeastern Morocco; **C**. adult male, Théniet el Had, northern Algeria. Photos by Daniel Escoriza.

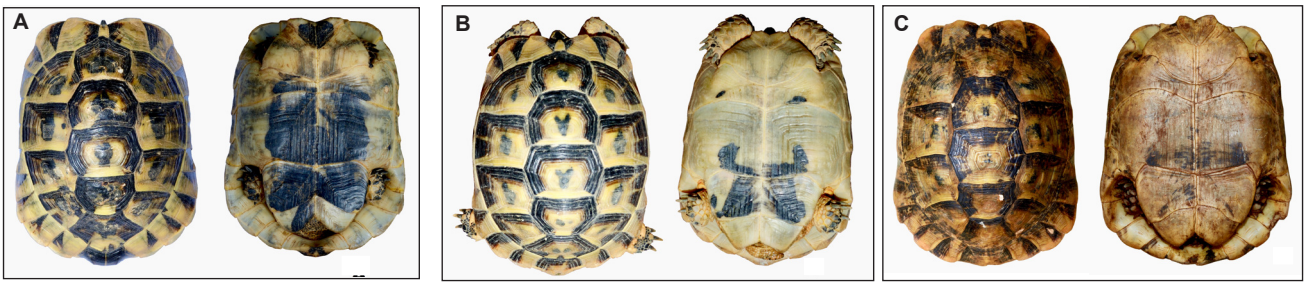

Figure 5. *Testudo graeca* from northwestern Africa. **A**. juvenile male *Testudo graeca nabeulensis*, Khroumirie, northwestern Tunisia; **B**. juvenile female *Testudo graeca nabeulensis*, Mehdia, Tunisia; **C**. adult female *T. graeca marokkensis*, Taza, Middle Atlas, Morocco. Photos by Daniel Escoriza.

with some black spots arranged asymmetrically, often with a central spot on the vertebral and costal scutes. The carapace is composed of 5 vertebral, 8 costal, and 22 marginal scutes (11 on each side), plus one nuchal and one undivided supracaudal scute (which helps to distinguish *T. graeca* from *Testudo hermanni*, which has a divided supracaudal). The color of the carapace ranges from very light to yellowish-brown to darker brown, but maintains a contrasting pattern of a central dark spot and black edges on the scutes. The presence of a spur in the mid-hind part of the thigh is characteristic of the species, although it is sometimes absent (Pieh and Perälä 2004). Juveniles usually show a similar pattern, with each scute bordered with dark lines and a central spot, except for *T. g. marokkensis* and *T. g. graeca*, which typically lack the central dark spot. The plastron has six pairs of scutes, of which the abdominals are the largest, with yellowish or light background coloration. Most of these scutes exhibit irregular black spots or radiating blotches.

Figure 6. *Testudo graeca cyrenaica* from Libya. *Left*: Qasr Libya, *Right*: Ras al Hilal. Photos by Christoph Schneider and Willi Schneider (TTWG 2021).

The head is rounded and dark, but with several disconnected yellow postorbital and prefrontal scales. The eyes are small with dark irises and poorly distinguishable pupils. The beak is usually dark in color, tricuspid, and weakly hooked. The neck can be light brown or dark. The limbs have large, juxtaposed, imbricate cuspidal scales in 3–6 longitudinal series; there are 5 claws on the forelimbs and 4 on the hindlimbs. The limbs usually have a light background color, with some darker scales more numerous distally.

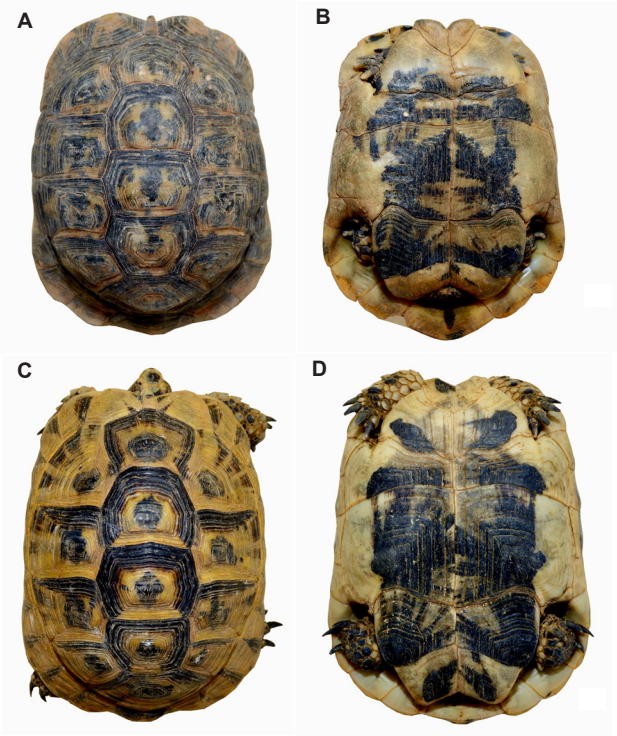

Figure 6. *Testudo graeca nabeulensis* from Mehdia, central coast of Tunisia. **A–B**. male; **C–D**. female. Photos by Daniel Escoriza.

Males of the western subspecies clade of *T. graeca* are smaller than females (mean male straightline carapace length [SCL] = 13.5 cm, maximum male SCL = 19.3 cm; mean female SCL = 15.5 cm, maximum female SCL = 24.8 cm). In the central Jbilets of Morocco, mean body mass of males is 436 g and of females 628 g (Díaz-Paniagua and Andreu 2015). Males have proportionately longer and wider tails, and usually a shorter but more concave plastron with a more convex and incurved supracaudal plate (Lambert 1982). In some subspecies, the rear marginal scutes of the males flare, forming a fan or skirt. A detailed general description of the species was also provided by Loveridge and Williams (1957).

There is wide geographical variation in morphological traits across the species' range, which has been used to describe different subspecies. Individuals of *T. g. graeca* (Souss Valley Tortoise) differ from *T. g. whitei* (Moorish Tortoise) in their greater SCL; males of *T. g. graeca* average 14.1 cm SCL (maximum = 16.2 cm) and females average 17.3 cm SCL (maximum = 19.8 cm) (Pieh 2001; Pieh and Perälä 2004). The carapace has striped black markings over yellowish to brown background coloration (Pieh 2001) and 23% of the specimens lack spurs on the thighs (Pieh and Perälä 2004).

In *T. g. whitei* (Moorish Tortoise), males average 11.3 cm SCL (maximum = 14.8 cm), and females 13.4 cm (maximum = 17.0 cm) (Díaz-Paniagua and Andreu 2015). In Doñana National Park, Spain, the mean body mass of males is 558 g and 886 g in females; in Murcia, Spain, the mean body mass of males is 331 g and 574 g in females (Díaz-Paniagua and Andreu 2015). These tortoises have a variable coloration with the background color ranging from yellowish to pale olive greenish-brown, with black spots in the center and black lines along the border of the carapace scutes.

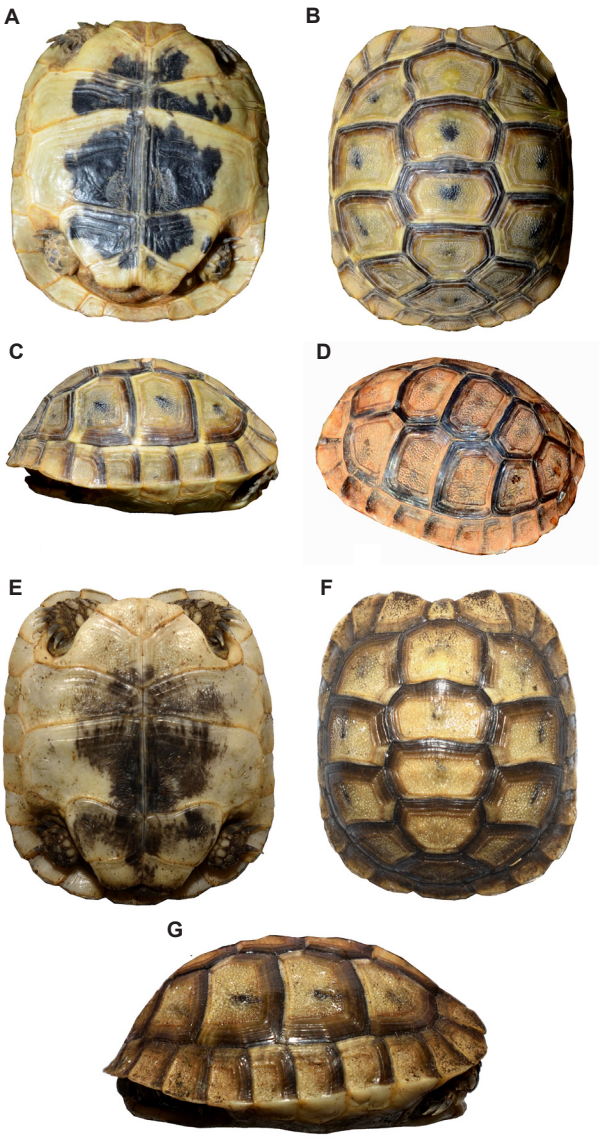

Figure 7. Hatchlings of *Testudo graeca* from northwestern Africa. **A, B, C**. *Testudo graeca whitei*, Chlef, northern Algeria; **D**. *Testudo graeca graeca*, Tiznit, southern Morocco; **E, F, G**. *Testudo graeca marokkensis*, Tingitana Peninsula, northern Morocco. Photos by Daniel Escoriza.

Individuals of *T. g. cyrenaica* (Libyan Tortoise) may reach larger sizes, with average SCL in males of 14.95 cm (maximum = 19.3 cm) and females of 17.25 cm (maximum = 20.5 cm) (Pieh and Perälä 2002). Shells are characterized by having a yellowish background coloration with mottled dark pigmentation, extreme dorsal flaring of the rear marginals, and a narrow and low anterior carapace opening. Solid dark spots are extended along the central sutures of the plastron plates. The forelimbs are very slender and are

Figure 8. Adult female *Testudo graeca whitei*, Beni Snassen mountains, Morocco. Photo by Daniel Escoriza.

mustard yellow, with few scattered black scales, and the head is dark and yellowish.

Testudo g. marokkensis (Moroccan Tortoise) is also characterized by a larger size than *T. g. whitei*, SCL of males averaging 13.85 cm (maximum = 18.8 cm) and of females 17.82 cm (maximum = 20.38 cm) (Pieh and Perälä 2004). The carapace has an oval shape, less domed than that of *T. g. whitei*, and trapezoidal in dorsal view in males. Males usually have flaring rear marginals. The scutes of the carapace have a light background coloration with striped lines appearing as a starry black pattern.

Testudo g. nabeulensis (Tunisian Tortoise, Nabeul Tortoise) was previously considered the smallest of the African subspecies of *T. graeca*. The adult size is usually below 18.0 cm (males average = 13.0 cm; females average = 12.1 cm; Pieh and Perälä 2002). In northeastern Algeria, SCL in males averages 13.8 cm (maximum length 15.5 cm) and females 15.1 cm (maximum = 20.5 cm) (Rouag et al. 2007). In southern Tunisia (Sfax) SCL in males averages 11.1 cm (maximum length 12.0 cm) and females 12.1 cm (maximum length 13.9 cm) (Ben Hassine, unpubl. data). This subspecies reaches larger sizes on La Galite island, northwestern Tunisia: up to 24.8 cm SCL in females and 17.3 cm in males (Ben Hassine, unpubl. data). In Sardinia, the subspecies does not usually exceed 13–15 cm SCL, with maximum SCL of 16 cm for males and 18 cm for females. The largest individuals are found in the small island of Isola di Mal di Ventre (Di Nicola and Mezzadri 2018). In northeast Algeria (El Kala) the mean body mass of males was 610 g and of females 894 g (Rouag et al. 2007). In southern Tunisia (Sfax) the body mass of males (n = 12) was 280 g (maximum 380 g) and of females (n = 6) 387 g (maximum 500 g) (Ben Hassine, unpubl. data).

The background carapacial color is usually light brown, milk-coffee, yellow-mustard, or bright yellow ("*flavominimaralis*" type), with some specimens having a highly contrasting large black central dot on each carapace scute (except marginals), which may be also edged in black. The background color of the plastron is pale yellow with black spots that usually form two almost continuous bands, parallel to the longitudinal axis of the plastron. They can also have a bright yellow spot on the top of the head between the eyes (Highfield and Martin 1989b).

Distribution. — In northern Africa *T. graeca* is distributed almost continuously from southern Morocco to northwestern Libya, with isolated populations in the Cyrenaica (northeastern Libya).

In Morocco it occurs from the Anti-Atlas (Tiznit-Sidi Ifni) to the Tingitana Peninsula, occupying most of the Atlantic plain (Bons and Geniez 1996). Along the Mediterranean coast, it extends from the eastern Rif to the Algerian border and southwards through the Mouloya Valley (Schleich et al. 1996). The Moulouya valley constitutes the separation between *T. g. whitei* and the Atlantic subspecies *T. g. marokkensis*, while the separation between *T. g. marokkensis* and *T. g. graeca* appears north of the Haut Atlas, approximately along the line Essaouira-Marrakech, including the Central Jbilets (Fritz et al. 2009; Graciá et al. 2017).

In Algeria, *T. graeca* occupies the north of the country, from the Presaharan Atlas, Haut Plateaux to the Mediterranean coast, being absent in the Sahara Desert (Doumergue 1901; Le Berre 1989; Schleich et al. 1996). In Algeria, *T. g. whitei* is the most widespread subspecies, but *T. g. nabeulensis* has been found in the extreme northeast, around Annaba (Fritz et al. 2009).

In Tunisia, only the subspecies *T. g. nabeulensis* occurs, being present in most of the country. This species barely penetrates the arid southern inland, extending as far as Gafsa and the oases around Tozeur (Ridha Ouni, pers. comm.). The species is also present on La Galite island. In Libya, *T. graeca* is found in two different areas separated by the Gulf of Sidra (Bauer et al. 2017). The northwestern population is confined to the Tripoli region and belongs to the subspecies *T. g. nabeulensis*, reaching the Nalut district in the southwest (Ibrahim and Ineich 2005). In the Cyrenaica Peninsula, *T. g. cyrenaica* is confined to a narrow coastal strip between Benghazi and Tobruk (Bauer et al. 2017).

In Western Europe, *T. graeca* appears in isolated groups of populations in the southern Iberian Peninsula, and the islands of Mallorca, Formentera, and Sardinia (Carpaneto 2006; Díaz-Paniagua and Andreu 2014). Recent records in Málaga, Algeciras, Cádiz (southern Spain), Girona (northern Spain), Segovia (central Spain), Tenerife (Canary Islands), Gibraltar, southern France, Malta, and Sicily represent isolated introduced specimens or populations (Savona-Ventura 1985; Turrisi and Vaccaro 1998; Balmori 2000; Pascal et al. 2003; Mateo et al. 2011; Báez et al. 2012; Poch et al. 2020). Some observations also exist further north,

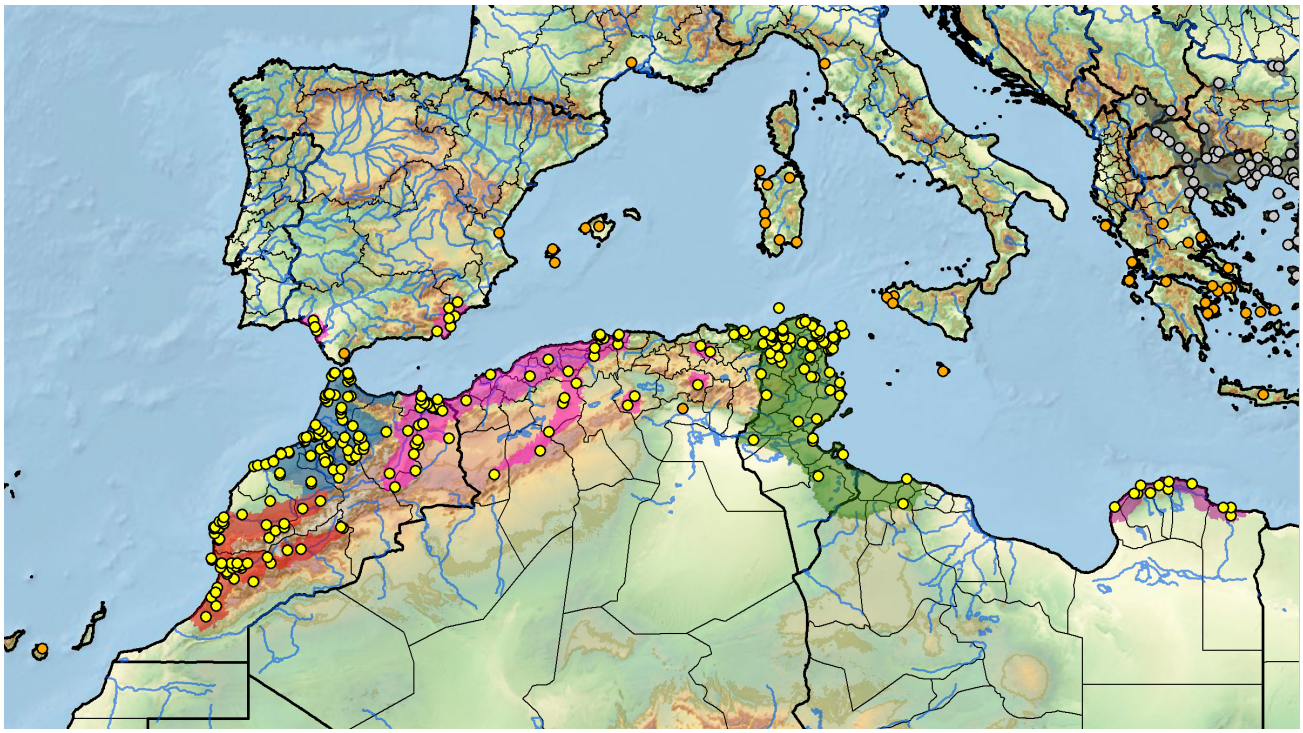

Figure 9. Distribution of the western subspecies clade of *Testudo graeca* in southwestern Europe (Spain) and northwestern Africa (Algeria, Libya, Morocco, Tunisia). Yellow dots = museum and literature occurrence records of native populations based on Iverson (1992), other more recent literature sources (see TTWG 2017, 2021), and authors' data; orange dots = introduced or historically relict populations or individual trade specimens; gray dots and gray shading = western extent of the eastern subspecies clade of *T. graeca* (= *T. g. ibera*); colored shading = presumed historic indigenous ranges of: 1) *T. g. graeca* (formerly referred to *T. g. soussensis*) = red; 2) *T. g. cyrenaica* = purple; 3) *T. g. marokkensis* = blue; 4) *T. g. nabeulensis* = green; and 5) *T. g. whitei* (formerly referred to *T. g. graeca*) = pink. Distribution based on GIS-defined level 12 HUCs (hydrologic unit compartments) constructed around verified localities and then adding HUCs that connect known point localities in the same watershed or physiographic region, and similar habitats and elevations as verified HUCs (Buhlmann et al. 2009; TTWG 2017, 2021), and adjusted based on data from authors' and other sources.

in northern Europe (e.g., in Dublin, Ireland, in 1906), but these are non-native released specimens (Frazer 1964). The population in Algeciras (southwestern Spain), introduced in 1987 from Morocco, may have been viable at least until 1990, but it is currently extirpated (Mateo 1997). In southern Spain, reproductive populations of this species occur in Doñana National Park (Huelva), the southeast (Murcia and Almeria), and perhaps in Málaga (Sánchez et al. 1986; Graciá and Giménez 2015).

It was previously thought that the nominotypical form *T. g. graeca* occurred in the Iberian Peninsula (Álvarez et al. 2000), but Schweiger and Gemel (2020) corrected the confusing history regarding the type locality of *T. g. graeca*, documenting it as Agadir in southwestern Morocco, thereby rendering *T. g. whitei* the apparently most correct name for the subspecies on the Iberian Peninsula and northeastern Morocco and western Algeria (TTWG 2021).

The population of the Iberian southeast is autochthonous, although its origin is relatively recent (20,000–30,000 ybp) being genetically close to the populations of the Algerian northwest (Graciá et al. 2013). In the Iberian southeast, it extends between the south of Murcia and the northeast of Almeria, between the Sierra de Carrascoy, Vélez-Rubio, and Sorbas, occupying a region of 2700 km^2 (Andreu 2002). There are also reintroduced and possibly established populations in the south of Alicante province (Pérez-García et al. 2014). This species was historically present in the south of Alicante and was extirpated from there around 1980 (Monzó-Giménez 2002).

Testudo g. whitei has been known in Doñana since 1765–1774 (Granados 1987; Andreu et al. 2000), and its distribution was more widespread historically, reaching the villages of Almonte and El Rocío (Machado 1859), and perhaps further west (López-Jurado et al. 1979). In the middle of the 20th century, several hundred specimens corresponding to the subspecies *T. g. marokkensis* were introduced from Morocco (Valverde 1967). Specimens of this subspecies are still present in the National Park (Graciá et al. 2017). In Doñana *T. graeca* occupies an area of 70 km^2; both *T. g. marokkensis* and *T. g. whitei* are mixed in this population, although the latter subspecies is more prevalent (87% of specimens; Graciá and Giménez 2015). *Testudo g. whitei* also occurs in the Balearic Islands where they are thought to be allochthonous (Fritz et al. 2009).

In Mallorca, it has been cited since at least 1876 (Barceló 1876) and until 1975 its range extended through the southwestern quadrant, between the villages of Palma, Cala Figuera, Puigpunyent, Andratx, and Santa Ponça (López-

Jurado et al. 1979). Currently, it is confined to a very small region around the town of Calvià (40 km^2), although some isolated specimens have been found in other areas on the island, possibly not representing established populations (Mayol 2003; Pinya 2011). On the island of Formentera, *T. graeca* has been cited since 1918 (Maluquer 1918) but was extirpated from the wild in 1970–1980, although numerous individuals of this population have survived in captivity. In Ibiza, it may still be present in the region of Santa Eulalia where it was thought to have been extirpated at the end of the 19th century (Boscà 1883), but a few isolated individuals have been found more recently (Palerm 1997).

In Italy, introduced *T. graeca* is found on the western coast of Sardinia (Oristano, Portixeddu) and in the Isola di Mal di Ventre (Bassu et al. 2008); there are also isolated records in other parts of the island: Cagliari, Isola Asinara, Gallura, and around Villasimius (Di Nicola and Mezzadri 2018). All Sardinian populations belong to the subspecies *T. g. nabeulensis* and could have been introduced in prehistoric or early historical times, perhaps by the Phoenicians (Vamberger et al. 2011). In the Italian Peninsula, there are numerous isolated records of *T. graeca*, particularly in coastal Tuscany (Parco San Rossore, Pisa; Ballasina 1995), Lazio and Calabria (Bruno 1986; Carpaneto 2006).

In Sicily, some records date from the 19th century, but they could correspond to *T. hermanni*, given that these species were not differentiated until 1925 (Turrisi and Vaccaro 1998). However, the presence of allochthonous individuals of *Testudo* in some port cities of southern Sicily, imported from northern Africa by fishermen, was already noted by Doderlein (1881). Bruno (1986) considered that the presence of *T. graeca* in Sicily originated much earlier and believed the species was introduced by Arabs or even the Phoenicians. This author also considered that *T. graeca* is naturalized in at least seven localities along the southern Sicilian coast, between Syracuse and Trapani, where it is mainly restricted to coastal dunes (Bruno 1986). A specimen from southern Sicily (Marsala) was genotyped by Fritz et al. (2009), and was found to group with the Tunisian subspecies *T. g. nabeulensis*. *Testudo graeca* was recorded on Lampedusa at the end of the 19th century but it does not occur on this island at present (Massa and Falcone 2007).

The species was also recorded on Malta, but all specimens found were in captivity, and this island possibly does not support naturalized populations (Savona-Ventura 1985; Borg and Schembri 1991). However, the species was present historically (about 6000 ybp) on Malta and Gozo, and its remains have appeared in several Neolithic excavations (Savona-Ventura 1984).

In France there are numerous observations of this species in the Mediterranean region of the country (mainly around Montpellier, Nimes, Frejus and Perpignan) and further north (Bordeaux, Lyon and Rouen-Le Havre), although most of these observations correspond to isolated introduced individuals (Dupré et al. 2003; Geniez and Cheylan 2012). Between 1970 and 1975, several adult individuals of *T. graeca* were located around the train station of Le Vigan (Gard) and local people suggested the possibility that a wild population could exist in the area (Geniez and Cheylan 2012). However there is no evidence of any naturalized reproductive populations in southern France, although they breed frequently in private gardens (Astre 1948; Dupré et al. 2003).

Habitat and Ecology. — The western subspecies of *Testudo graeca* inhabit mainly humid to semiarid Mediterranean climates types *Csa* and *Bsh-Bsk* in the Köppen classification (Peel et al. 2007). In the coastal regions of southern Tunisia, they also occur in the subtropical desert climate belt (*Bwh*). Average annual temperatures range between 19.3ºC (Sidi Ifni; southern Morocco) and 17ºC (Calvià; southern Mallorca) and annual rainfall between 177 mm (Gabès; southern Tunisia) and 910 mm (El Kala; northeastern Algeria).

In northern Africa, *T. graeca* occurs in a wide range of habitats from mesophilic oak forests (mainly composed of *Quercus suber*), thermophilic shrub formations, dunes, steppes and agricultural fields, both in plains and in mountainous regions. In northern Algeria, *T. g. whitei* occurs in mixed oromediterranean forests of *Cedrus atlantica* and *Quercus ilex*. In southern Tunisia, *T. g. nabeulensis* occurs in the maritime oases of Gabès and the *Acacia* subtropical savannah in Bouhedma National Park (Ben Hassine, unpubl. data).

In Morocco, *T. g. marokkensis* reaches a maximum altitude of 2090 m asl in the Haut Atlas (Anadón et al. 2012), but below the altitudinal limits reported for some Asian subspecies of *T. graeca* (e.g., 2200 m asl; Crucitti and Emiliani 2013). In Algeria, *T. g. whitei* reaches 1450 m asl in Théniet el Had and in northwest Tunisia, *T. g. nabeulensis* reaches an altitude of at least 900 m in Khroumirie (Jendouba). In the Iberian Peninsula, *T. g. whitei* is restricted to lowland and mid-elevation areas, from sea level to 500 m.

In the southeastern Iberian Peninsula, *T. g. whitei* is confined to semi-arid areas with annual precipitation of about 260–290 mm, mainly in hill regions with abundant grass and shrubby vegetation and scattered forests of *Pinus halepensis* (Giménez et al. 2004; Anadón et al. 2007). In Doñana, *T. g. whitei* occupies dune systems and herbaceous meadows with ferns and Mediterranean shrubs, near marshes (Andreu et al. 2000).

In southwestern Mallorca, *T. g. whitei* inhabits open pine forests (*Pinus halepensis*) and thermal shrubs (Balearic '*garriga*') interspersed with small patches of traditional crops of almond trees *Prunus dulcis* (Escoriza, unpubl. data).

Figure 10. Habitats of *Testudo graeca*. **A**. Moulouya delta dune scrubland, Morocco (*T. graeca whitei*); **B**. Beni Snassen mountains semi-arid scrubland, Morocco (*T. graeca whitei*); **C**. Middle Atlas mountains semi-arid scrubland, Morocco (*T. graeca marokkensis*); **D**. Atlantic subhumid cork oak forest, Morocco (*T. graeca marokkensis*); **E**. Anti-Atlas subtropical arid scrubland, Morocco (*T. graeca graeca*); **F**. Khroumirie subhumid scrubland, Tunisia (*T. graeca nabeulensis*); **G**. semi-arid scrubland, southern Spain (*T. graeca whitei*); **H**. Tell Atlas oromediterranean forest, Algeria (*T. graeca whitei*). Photos by Daniel Escoriza.

Figure 11. Habitat of *Testudo graeca whitei*, Doñana National Park, Spain. Photo by Carmen Díaz-Paniagua.

In Sardinia, *T. g. nabeulensis* is found mainly in coastal localities, below 250 m asl, occupying dune systems covered with psammophilic vegetation interspersed with dense shrub formations of mastics, European fan palms, rosemaries, junipers, and rock-roses (Di Nicola and Mezzadri 2018).

Daily Activity. — *Testudo graeca* is exclusively diurnal. In the Maâmora forest of northern Morocco and in central coastal Tunisia, active individuals can be observed during the midday hours from February on, but by June activity is considerably reduced, although some individuals can be observed in the early morning hours and at the end of the afternoon (Ben Hassine, unpubl. data). In southern Morocco at the end of spring, tortoises dedicate an important part of their daily activity to thermoregulation, moving between places exposed to the sun and in the shade (62.9% of daily activity; Meek and Jayes 1982). The time the tortoise spends in the shade is slightly longer than the time it remains exposed to the sun (35.3% vs. 27.6%). Movement displacements constitute 26.4% and foraging behavior 12.3% of the daily activity (Meek and Jayes 1982). Basking occurs mainly between 1000–1400 hrs, while remaining in the shade dominates the afternoon (1600–1800 hrs), before retiring to nightspots (Meek and Jayes 1982). The average active body temperature is 29.8ºC (range = 22–35ºC; Meek and Jayes 1982).

In southern Spain, activity is unimodal after hibernation, being more intense between 1000–1230 hrs. It becomes progressively bimodal (morning-afternoon, avoiding the central day hours) until the summer. During the summer, the low number of active individuals reduce their movements to the first hours of the morning (0700–1200 hrs) (Andreu 1987; Pérez et al. 2002). In October the activity becomes more intense at noon (Andreu 1987).

Studies conducted with captive animals indicate that activity starts when air temperatures reach 18ºC and animals move to shady places above 28ºC (Lambert 1981). Tortoises are completely inactive at 13ºC (Cloudsley-Thompson 1974). Tortoises avoid overheating by evaporative cooling, with salivation starting at 39.5ºC and the critical maximum temperature is about 40.5ºC (Cloudsley-Thompson 1974).

Annual Activity. — Air temperature deeply impacts the activity of these tortoises. Adults of *T. g. graeca* are active in winter in Morocco (Pieh 2000), as are also *T. g. cyrenaica* adults in Libya, showing a short or no hibernation period (Schleich 1989). Juveniles and adults of *T. g. nabeulensis* in Tunisia also winter discontinuously and bask in the midday hours during days with relatively low air temperatures (maximum of 14–16ºC), although without feeding (Ben Hassine, unpubl. data). These animals rest in winter partially or totally buried or hidden within dense vegetation (Ben Hassine, unpubl. data).

In Doñana, Spain, adults are active on days when maximum temperatures reach or exceed 19ºC (Díaz-Paniagua et al. 1995). The activity pattern shows two peaks of intensity, in spring and autumn, one period of very low activity (from November to March) and another of very low or no activity in summer (from July to September). Females show a longer period of winter rest than in summer, while in males it is the opposite. Winter rest in juveniles is discontinuous and they can be active on the warmest days of winter in Spain (Díaz-Paniagua et al. 1995).

Home Range. — In west-central Morocco, home range for *T. g. marokkensis* was estimated as 0.17 ha in males and 0.24 ha in females (Slimani et al. 2006). In Doñana, Spain, the home range of *T. g. whitei* ranges between 3.37 ha (males) and 2.55 ha (females), although females sometimes leave their home range to nest (Andreu 1987). During a single day, individuals cover an average distance of 50 m, but during the mating season, males may cover a maximum distance of 1019 m while searching for females (Díaz-Paniagua et al. 1995). The home range of hatchlings and juveniles is about 13.7 m^2 (Keller et al. 1997). In Murcia, Spain, home range averaged 2.56 ha for males and 1.15 ha for females (Giménez et al. 2004).

Reproduction. — In southern Morocco, nesting for *T. g. graeca* extends from late May to early July, clutch size

Figure 12. A pair of *Testudo graeca nabeulensis* from Mahdia, coast of central Tunisia. The male (in the background) is courting the female, walking around her and trying to bite her forelimbs. Photo by Daniel Escoriza.

averages 3.44 (1–5) eggs, which are round and 30 (28–31) mm in diameter and weigh 19.3 (16.8–23.6) g (Hichami et al. 2016). Hatchlings of *T. g. graeca* from the Souss Valley in Morocco average 3.57 cm SCL and 12.8 g in body mass (Hichami et al. 2016).

In Tunisia, the mating season for *T. g. nabeulensis* starts in February (Bouhedma National Park, southern Tunisia) and extends to the end of May to mid-June (Khroumirie, northern Tunisia), and in central coastal Tunisia there is a second mating season during September and October (Ben Hassine, unpubl. data). In *T. g. nabeulensis* a 15 cm SCL female laid 3 eggs in early June that hatched the last week of August, at an average air temperature of 31ºC (Ben Hassine, unpubl. data).

In Doñana, Spain, the main mating season for *T. g. whitei* takes place from the end of winter to the end of spring, although there is a second less important period in October (Andreu et al. 2000). Males actively seek females at the end of hibernation. Several males sometimes compete with each other after encountering a female. When a male encounters a female, he usually strikes her shell several times with his shell and pursues her, trying to mount her carapace, alternating pursuing, bumping her carapace, and attempting to mount (Astre 1948; Andreu et al. 2000). When the female stops walking, he mounts her and copulates in a standing vertical position (Andreu et al. 2000; Díaz-Paniagua and Andreu 2015).

In Spain, eggs are laid between April and June, exceptionally in July (Díaz-Paniagua et al. 1996). Clutches are composed of 1–8 eggs (mean = 3.5) laid between 1–4 times per yr (mean = 2.47) (Díaz-Paniagua et al. 1996). Eggs are hard-shelled and have average diameters of 33.9 x 28 mm and an average weight of 14.4 g. They hatch after 82–140 days of natural incubation (mean = 94.9 days), in late summer (Díaz-Paniagua et al. 1996). Hatchlings of *T. g. whitei* in Doñana average 3.48 cm in SCL and weigh 10.8 g on average (Díaz-Paniagua et al. 1997).

Growth patterns have been studied by Braza et al. (1981), Lambert (1982), and Blasco et al. (1987), showing that there are differences between the sexes. The relative growth of the head is isometric in males (with respect to SCL), but not in females (Braza et al. 1981). The relationship between SCL and body mass (BM) is strongly allometric (SCL = 16.63 $BM^{0–34}$; Lambert 1982; Blasco et al. 1987). Growth slows when animals reach an SCL of between 13–14 cm (11 yr in males and 10 yr in females; Moreno 1987).

Population Structure and Survivorship. — In central Morocco, most (74%) *T. g. graeca* were larger than 10 cm SCL and older than 7 yrs, with a sex ratio of 1.2:1 (Kaddour et al. 2006). In northeastern Algeria, the sex ratio for *T. g. nabeulensis* is approximately 1.06:1, being slightly higher for males (Rouag et al. 2007). Sexual maturity is reached after 7 yrs in males and 9 yrs in females. The average age of animals in this population was 13.8 yrs, with a maximum of 24 yrs (Rouag et al. 2007). Juveniles (SCL <9 cm) constituted 6.2% of the population. Mortality was estimated at 3.92% annually and was mainly associated with bush fires (Rouag et al. 2007). The mean age at maturity was estimated as 5.8 to 7.6 yrs in males and 7.7 to 10.5 yrs in females (Znari et al. 2005). In Doñana, Spain, sexual maturity for *T. g. whitei* is reached at 6.9 yrs in males and 8.5 yrs in females (Díaz-Paniagua et al. 2001).

Survival rates are much higher in adults than in hatchlings and juveniles and population stability depends mainly on low adult mortality (Díaz-Paniagua et al 2001). In Doñana, the survival of offspring is 39% from hatching to the first spring (Keller et al. 1998). The annual survival rate of juveniles from hatching to 6 yrs is 1.3–9.7% in Doñana (Díaz-Paniagua et al. 2001) and 0.91% in Murcia (Ballestar et al. 2004). As in other chelonians (Escoriza et al. 2020), the adult annual survival rate is very high: it is estimated at 90.5–94.4% in males and 92.0–94.1% in females from Doñana (Díaz-Paniagua et al. 2001), and 99.8% in males and 100% in females from Murcia (Ballestar et al. 2004). In Doñana, both males and females exceed 20 yrs of age (Braza et al. 1981).

Diet. — *Testudo graeca* is generally herbivorous. In the Central Jbilets (Marrakech, Morocco) a total of 34 species of plants were documented in the feces of *T. g. graeca*, but the tortoise fed mainly on five species of plants of the genera *Astragalus*, *Leontodon*, *Lotus*, *Malva,* and *Medicago*; diet selection did not depend on plant availability (El Mouden et al. 2006). In southern Morocco (Agadir), on the periphery of cultivated areas, *T. g. graeca* also fed on cultivated or naturalized plants, such as *Opuntia maxima* (Bailey and Highfield 1996). In northeastern Algeria, 40 species of plants were found to compose the diet of *T. g. nabeulensis*; 70% of plant samples belonged to the families

Fabaceae (legumes), Asteraceae (composites), Primulaceae (primroses), and Caryophyllaceae (carnations) (Rouag et al. 2008). As in Morocco, plants included in the diet were not dependent on their abundance. Tortoises forage on toxic plant species, which are usually avoided by ruminant mammals (Rouag et al. 2008). In the Algerian population, no intersexual differences were detected in the diet. Juveniles feed on similar types of plants as adults but also consume invertebrates more frequently (Rouag et al. 2008).

In Doñana, Spain, 81 species of plants were documented in the diet of *T. g. whitei*, which encompassed 26 families — mainly Poaceae (grasses), Fabaceae (legumes), Asteraceae (composites), and Juncaceae (rushes); animal matter such as insects, scat, and carrion was also consumed (Andreu 1987). Tortoises in Doñana consume the seeds of 34 plant species and promote the germination of at least four: seeds of several plants were given to tortoises, and four of them were able to germinate and two of them (*Lavandula stoechas* and *Hypochaeris glabra*) even increased their germination rate after digestion, revealing that *T. graeca* acts as a dispersing agent for several plant species (Cobo and Andreu 1988). In Murcia and Mallorca, *T. graeca* also feeds on fruits of naturalized and native plants such as *Ceratonia*, *Chamaerops* and *Opuntia*, *Pistacia lentiscus* (leaves), and *Cistus albidus* (flowers) (López-Jurado et al. 1979).

Predation. — In southern Morocco, the Great Grey Shrike *Lanius excubitor* is an important predator of juveniles of *T. g. graeca* (below 3.5 cm SCL) (Barje et al. 2005). In southern Spain (*T. g. whitei*), most of the depredated specimens are also juveniles, usually <4 yrs old (Ballestar et al. 2006). In Murcia, tortoise remains were detected in the droppings of three species of carnivorous mammals: Genet (*Genetta genetta*), Badger (*Meles meles*), and Eurasian Red Fox (*Vulpes vulpes*) (Ballestar et al. 2006, 2007a), and in nest remnants of Golden Eagles (*Aquila chrysaetos*) (Delibes et al. 1975; Martinez-Pastor, Giménez, Graciá, and Rodríguez-Caro, unpubl. data). In Doñana, predation has been observed by the Egyptian Mongoose *Herpestes ichneumon* (Palomares and Delibes 1991). Remains of hatchlings and adult specimens have also occasionally been found in the nests of the Black Kite (*Milvus migrans*) and the Spanish Imperial Eagle (*Aquila adalberti*) (Díaz-Paniagua and Andreu 2015). In Mallorca, there are no specific data on predation, but Aguilar (1990) considered rats, mustelids, crows, kites, and seagulls as potential predators.

Parasites and Ectobionts. — Tortoises are frequently parasitized by ticks (Ixodidae), which are located mainly on the hind limbs (Brianti et al. 2010). Tick infestation is very common on wild specimens of *T. graeca* from northern Africa, notably Morocco, Algeria, and Tunisia (Segura et al. 2019; Najjar et al. 2020), and has also been reported in the southeastern Iberian Peninsula, but not in Doñana (Díaz-Paniagua and Andreu 2015). In the Maâmora forest of northwestern Morocco, 92.5% of the tortoises were parasitized by ticks in spring, with an infestation intensity and an abundance of 6.7 and 6.2 ticks per tortoise, with 95.6% of the ticks being *Hyalomma aegyptium*, present on 100% of the parasitized tortoises). This species of tick has also been found in captive animals from Malta (Sultana Loporto et al. 2018). Other species of ticks found in the Maâmora population were *H. marginatum*, *H. excavatum,* and *H. scupense*. Ticks were more abundant on males than on females or juveniles (Segura et al. 2019). In populations of *T. graeca* from Tunisia, the prevalence of *H. aegyptium* was 91.2% during spring (Najjar et al. 2020). According to these authors, differences in the intensity of tick infestation were observed based on the size of the tortoises and the vegetation cover; the overall infestation abundance was 8.5 ticks per tortoise. Gharbi et al. (2015) also found a positive correlation between tortoise size (SCL and mass) and tick infestation. The overall infestation intensity in Tunisia is similar to that reported from Algeria (1.7–9.4 ticks/tortoise; Tiar et al. 2016).

Tortoise intestinal tracts are frequently parasitized. The analysis of the intestinal contents of 17 tortoises from Morocco and the Iberian Peninsula produced 13 nematode species, with an average of 8.59 species of nematodes and 35,370 individual parasites per tortoise (Roca 1999). In a single specimen of *T. g. nabeulensis* from Tunisia, a high prevalence of species of the genera *Tachygonetria* and *Mehdiella* was also reported (Adamson and Petter 1983). In southern Spain (*T. g. whitei*), the most prevalent genera of nematodes are *Tachygonetria* and *Mehdiella* (Roca 1999). In Murcia, the specific composition of intestinal parasites is different between wild and captive specimens, e.g., *Tachygonetria longicollis*, *T. pusilla*, *T. conica*, *T. robusta,* and *Mehdiella stylosa* are more frequent in wild specimens (Chávarri et al. 2012). In the Sardinian populations of *T. graeca*, there is a very high level of nematode (Pharyngodonidae) infestation which appears in animals older than one year (Traversa et al. 2005).

Population Status. — In northern Africa, *T. graeca* is still common in most of its range, although data on specific abundance are only available for two sites (Central Jbilets, Morocco and El Kala, Algeria; Kaddour et al. 2006; Rouag et al. 2007; Hichami and Znari 2021). The species is likely in decline in very degraded habitats, such as those under intensive agriculture and/or cattle grazing and peri-urban areas. In the arid, overgrazed steppes of northern Marrakech (*T. g. graeca*), a density of 6 individuals/ha has been estimated (Kaddour et al. 2006), although there is a marked decline in this population and in 2012 status surveys showed lower densities, around 3 individuals/ha (Hichami and Znari 2021). In northeastern Algeria (*T. g. nabeulensis*), in a forest and shrub habitat near the

Figure 13. Burned adult specimen of *T. graeca marokkensis* found dead after a forest fire in the protected area of Parc Bouhachem, northern Morocco. Photo by Daniel Escoriza.

coast with relatively humid conditions, the density was estimated at 3.73 individuals/ha (Rouag et al. 2007). The high frequency of forest fires potentially threatens this population (Rouag et al. 2007). In the Iberian Peninsula, most of the populations are considered vulnerable because they occur in small, fragmented regions or have low densities (Andreu 2002; Pinya 2011). In Doñana, Spain, the density is 4.2 individuals/ha (Andreu et al. 2000). In the Iberian southeast, densities range between 0.36–16.24 individuals/ha (Ballestar et al. 2007b). In Mallorca, the species is considered in steep decline, with densities ranging from 0.1–2.7 individuals/ha (Pinya and Cuadrado 2008; Pinya 2011). In Sardinia, *T. g. nabeulensis* has a very dense population, estimated at 51.83 individuals/ha, the highest for this species in Europe (Biaggini et al. 2018). In the Isola di Mal di Ventre, near the coast of Sardinia, the density is also high, estimated between 10–22 individuals/ha (Biaggini et al. 2018).

Threats to Survival. — Populations of *T. graeca* are mainly threatened by habitat degradation and collection for the pet trade, which is still a frequent practice in northern Africa. In this region overgrazing reduces the quality of habitats, affecting local tortoise populations by two different mechanisms: direct competition for similar food resources and the reduction of plant cover, which exposes juveniles to avian predators, overheating, and dehydration (Barje et al. 2005; Lagarde et al. 2012). During the 20th century, tortoises were a common pet sold in Britain and other European countries (e.g., Belgium, France, Germany, Italy, Netherlands, Switzerland), and more than 300,000 individuals were exported annually from northern Africa in the 1950s and 1960s, most of them coming from Morocco (Lambert 1979; Türkozan et al. 2008). Since 1978, when the CITES convention was ratified in Morocco, tortoise trade has been banned there (Highfield 1990). However, tortoises are still sold in Morocco in local markets, although the trade has shifted from the large export trade in the 20th century to a largely domestic trade, commonly involving hundreds of tortoises in shops, mainly individuals from 2 to 8 yrs old (Znary et al. 2005; Nijman and Bergin 2017). In Morocco, it is common custom to keep tortoises in gardens (55% of 480 people surveyed, with an average of two turtles per person) and 42% come from juvenile animals caught in the wild (Segura et al. 2020). Tortoises are not only sold as pets but also the shells of adults are used to make artisanal guitars (called *Gimbri Kora*), which are frequently offered to tourists. On some busy roads, such as around Khenitra, road-killed specimens can be found during the spring.

In Tunisia, even though *T. g. nabeulensis* is a protected species according to national law, it is commonly sold as a pet in most regions of the country. It is frequently sold in the weekly markets of coastal cities (Jost 2011), including tourist regions where the species does not occur naturally (such as Djerba island). Tortoises are also kept in gardens, as they are traditionally considered as a symbol of fertility and also as guardians of the house from bad spirits (Ben Hassine, unpubl. data). In the capital city, Tunis, hatchlings are sold in markets (born in captivity, according to the merchants), along with *Mauremys leprosa*. Adult specimens of *T. graeca* captured in the wild are still exported to Europe illegally, from Morocco, Algeria, and Tunisia (van Uhm 2016).

In Spain, populations of *T. g. whitei* are mainly threatened by fires and habitat fragmentation (Sanz-Aguilar et al. 2011; Rodríguez-Caro et al. 2013). Fragmentation is caused by development and urbanization, including road infrastructure and agricultural expansion, particularly of greenhouse complexes (Martinez-Fernandez and Esteve 2005; Pérez et al. 2012). In southeastern Spain, there is a tradition of keeping tortoises in house gardens, and specimens are still captured for this reason; it is estimated that the captive population could exceed 10,000 specimens (Pérez et al. 2004). In Doñana, the population is completely confined in a protected area and has remained stable since its monitoring began during the 1980s (Andreu 1987; Andreu et al. 2000).

In southwestern Mallorca, the *T. g. whitei* population is split into four areas by roads, which hampers population interchanges (Pinya and Cuadrado 2008). On Mallorca, less than 1% of wild animals are affected by chronic rhinitis, so this disease possibly has a low impact on the survival of wild populations (Pons and Aguilar 1992). The collection of specimens to keep as pets is still common in Mallorca, but not for commercial purposes. Until the mid-20th century, specimens of *T. graeca* and *T. hermanni* were occasionally collected by shepherds to obtain oil or for human food (Aguilar 1990).

In Sardinia, the species occupies a small area of the central-western coast, but populations are relatively abundant (Corti et al. 2007). It has been suggested that these Sardinian populations should be eradicated because they are not native and can compete with *T. hermanni* (Carpaneto 2006). The introduction of *T. graeca* to various Mediterranean islands is ancient, and the species should be preserved as part of the local cultural heritage (Vamberger et al. 2011).

Conservation Measures Taken. — *Testudo graeca* has been assessed as globally Vulnerable on the IUCN Red List (TFTSG 1996), but this status needs updating. In Europe it has also been regionally assessed by the IUCN as Vulnerable (van Dijk et al. 2004; Cox and Temple 2009). The situation of all the western Mediterranean populations of *T. graeca* has more recently been evaluated as "unfavorable," with the exception only of Sardinia (European Environmental Agency 2019).

Morocco has legally prohibited large-scale trade in turtles, only allowing intermittent exports to zoos or individuals belonging to private collections (involving approximately a dozen turtles per year; Nijman and Bergin 2017). Since 2011, *T. graeca* is also protected by the Law Trade 277 29-05, limiting the capture of wild specimens and trade in species listed on CITES Appendix II.

In Algeria, the capture and trade of this species has been illegal since 1983 (Décret No. 83-509). In Tunisia, the capture, destruction, retention, and sale of *T. graeca* has been illegal since 2005 (Loi 2005-13), following international conventions ratified by Tunisia.

In Spain, *T. g. whitei* has been legally protected since 1980, and since 2015 the private possession of this species is punishable by imprisonment. It has been listed in Spain's National Catalog of Threatened Species (Catálogo Nacional de Especies Amenazadas) since 1989, where it is assessed as Interés Especial (Special Interest) (Decreto 439/1990). Regionally in Spain, it is classified as Vulnerable in the Catálogo Balear de Especies Amenazadas (Decreto 75/2005 and 139/2011), as a protected species in Andalusia (Decreto 4/86), and as Vulnerable in the Catálogo de Especies Amenazadas de la Región de Murcia (Decreto 7/95).

In the Iberian southeast, land has been purchased to build micro-reserves (50 ha) where captive specimens are reintroduced to regions from where the species had recently been extirpated. However, the reintroduction of captive animals has been discouraged, due to the potential for genetic contamination and transmission of parasites and diseases (Martínez-Silvestre et al. 2001).

In Mallorca the situation is critical and the priority should be to restore connectivity between populations (Pinya 2011). There is a program to strengthen wild populations through the regular contribution of captive-born specimens obtained at the facilities of the Centro de Recuperación de Fauna Silvestre de Mallorca.

Conservation Measures Proposed. — In northern Africa, numerous healthy populations of *T. graeca* persist: the priority should be to establish a series of reserves that preserve quality habitats and stable populations of these tortoises, but also that include most of the species' genetic diversity. Some potentially appropriate candidate sites could be: 1) the woodland of forêt de la Maâmora (Morocco); 2) the shrubland around Beni Slimane (Morocco); 3) the juniper forests around Essaouira (Morocco); 4) the Argan forest around Tiznit (Morocco); and 5) the shrubland in Cap Bon (Tunisia). Fortunately, some of the areas that harbor populations of *T. graeca* are already legally protected.

In Morocco, populations of this species are present in several national parks and some small protected reserves, which include all the subspecies present in this country: *T. g. graeca* (Parc National [PN] de Souss-Massa), *T. g. marokkensis* (PN Tazekka, PN d'Ifrane, PN de Khénifra, PN Talassemtane-Bouhachem), and *T. g. whitei* (Parc des Beni Snassen, Embouchure de la Moulouya Ramsar Site).

In Algeria, *T. g. whitei* is present in PN Tlemcen, PN Theniet El-Had, PN de Chréa, and PN de Taza and *T. g. nabeulensis* in PN El Kala. In Tunisia, *T. g. nabeulensis* is present in PN Bouhedma, PN Boukornine, PN Chambi, PN d'El Feija, PN de l'Ichkeul, PN Jebel Chitana-Cap Négro, PN Jebel Serj, PN Jebel Zaghouan, and PN Oued Zen. In Libya, populations of *T. g. cyrenaica* occur in the PN El Kouf and *T. g. nabeulensis* in PN Algharabolli.

In these protected areas, cattle overgrazing, sheep herding, illegal collection of tortoises, and forest fires need to be controlled. Recently it has been proposed to start captive breeding programs for some unique and particularly threatened populations in southern Morocco, such as *T. g. graeca* in the Central Jbilets, Marrakech (Hichami and Znari 2021). The status of the populations in the Cyrenaica of northeastern Libya is unknown, but it would be advisable to create a natural reserve to include populations of this endemic subspecies. In recent years, numerous specimens of *T. g. cyrenaica* have been offered in the pet trade, indicating that there is ongoing harvesting of wild populations.

In Spain, *T. g. whitei* is included within the PN Doñana, created in 1969. This population is stable, but lacks any possibility for expansion beyond the protected area, due to the intense developmental transformation of the surrounding lands (Palomo et al. 2014). In southeastern Spain, several populations of *T. g. whitei* are protected by small LIG reserves (Lugares de Interés Comunitario — Sites of Community Interest): Sierra de las Moreras, Calnegre, Sierra del Gigante, Sierra de la Tercia, Cabo Cope, Lomas del Buitre y Luchena River, Sierra de Almenara, Cabezo de Jara y Rambla de Nogalte, Sierra de En medio, Sierra de

la Torrecilla, Sierra de Alto Almagro, and Sierra Cabrera-Bédar. The main problems faced by the populations present in these microreserves are genetic isolation and occasional bush fires (Anadón et al. 2006; Sanz-Aguilar et al. 2011).

In Sardinia, the population of Isola Mal di Ventre is included within the Protected Marine Area Penisola del Sinis-Isola Mal di Ventre created in 1997 and the populations of Sinis within the Parco Regionali del Sinis-Montiferru.

The proposed measures for the conservation of this species in Europe involve: 1) determine accurately the species' specific occurrence and monitor the long term stability of populations; 2) encourage captive breeding programs under strict veterinary control to provide stock to repopulate those regions where the species has recently been extirpated (this could be particularly useful in the Balearic Islands where all populations of this species are either critically endangered or already extirpated [Formentera]); 3) initiate awareness programs to limit the collection of specimens by the local human population; 4) institute measures to improve habitat quality, including enhancement of population connectivity (e.g., building green corridors or removing or otherwise bypassing artificial barriers such as golf courses and roads); and 5) suppress illegal trade and gain greater regulatory control of legal commerce.

The sale of turtles and tortoises is a widespread practice in Western Europe and practically impossible to eradicate. Until the 1980s, a significant part (between 2.8–4.3% in 1982–1983; Lawrence 1987) of the animals that were offered for sale died before being sold, but now the situation is much more regulated. There are many legal turtle markets in Germany and Italy where a huge diversity of reptiles are offered, including most European species (Auliya et al. 2016). This trade is legal and regulated under permits for registered specimens originating from captive breeding (i.e., non-detrimental to wild populations). Agents in these pet markets should strictly control for hybrid specimens and those not microchipped, of unknown origin, prosecuting the small component of (illegal) trade in wild-collected, smuggled and otherwise illegally acquired specimens, and also when specimens are sold in poor conditions.

Captive Husbandry. — The maintenance of reproductive groups of this species is easy in dry Mediterranean climates (Lambert 1984), but in temperate climates, the species is sensitive to wet winters and frequently dies from immunosuppression and associated respiratory diseases (Lawrence and Needham 1985). North African subspecies, and particularly *T. g. nabeulensis* and *T. g. cyrenaica*, are more sensitive to cold and humid conditions than the eastern clade subspecies *T. g. ibera*. In addition, outdoor reproduction is not feasible in northern Europe because the hours of insolation are insufficient for the incubation of the eggs and the survival of hatchlings (Lambert 1983). However, even thermophilic subspecies such as *T. g. graeca* can be easily bred in greenhouses (Krüger 2007).

Captive breeding for small-scale reintroductions is currently carried out in Murcia (Proyecto Testudo, Asociación de Naturalistas del Sureste) and Mallorca (COFIB, Centro de Recuperación de Fauna Autóctona). In Mallorca, captive breeding is also supported by authorized private keepers, and 211 captive-bred specimens were reintroduced in the 2019 campaign.

Current Research. — Current work focuses on improving knowledge about the distribution and status of populations in Europe (Pinya 2011; Díaz-Paniagua and Andreu 2015). In northern Africa, a greater understanding of the phenology, demography, and ecology of local populations is necessary and should be undertaken.

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Literature Cited

Adamson, M.L. and Petter, A.J. 1983. Haplodiploidy in pharyngodonid (Oxyuroidea: Nematoda) parasites of *Testudo graeca*. Annales de Parasitologie Humaine et Comparée 58:267–273.

Aguilar, J.S. 1990. La protecció de les tortugues terrestres i marines a les Balears. Palma de Mallorca: Docs. Tècnics de Conservació, 6. Govern Balear, 50 pp.

Alvarez, Y., Mateo, J.A., Díaz-Paniagua, C., Andreu, A.C., Díez, A., and Bautista, J.M. 2000. Mitochondrial DNA haplotyping of *Testudo graeca* on both continental sides of the Straits of Gibraltar. Journal of Heredity 91:39–41.

Anadón, J.D., Giménez, A., Pérez, I., Martínez, M., and Esteve, M.A. 2005. The role of relief in local abundance patterns of the spur–thighed tortoise *Testudo graeca graeca* in south-east Spain. Herpetological Journal 15:285–290.

Anadón, J.D., Giménez, A., Martínez, M., Martínez, J., Pérez, I., and Esteve, M.A. 2006. Factors determining the distribution of the spur-thighed tortoise *Testudo graeca* in south-east Spain: a hierarchical approach. Ecography 29:339–346.

Anadón, J.D., Giménez, A., Martínez, M., Esteve, M.A., and Palazón, J.A. 2007. Assessing changes in habitat quality due to land use changes in *Testudo graeca* using hierarchical predictive habitat models. Diversity and Distributions 13:324–331.

Anadón, J.D., Giménez, A., Graciá, E., Pérez, I., Marcos Ferrández, M., Fahd, S., El Mouden, E.H., Kalboussi, M., Jdeidi, T., Larbes, S., Rouag, R., Slimani, T., Znari, M., and Fritz, U. 2012. Distribution of *Testudo graeca* in the western Mediterranean according to climatic factors. Amphibia-Reptilia 33:285–296.

Andreu, A.C. 1987. Ecología y dinámica poblacional de la tortuga mora, *Testudo graeca*, en Doñana. Doctoral Thesis, Universidad de Sevilla.

Andreu, A.C. 2002. *Testudo graeca*. In: Pleguezuelos, J.M., Márquez, R., and Lizana, M. (Eds.). Atlas y Libro Rojo de los Anfibios y Reptiles de España. Madrid: Dirección General de la Conservación de la Naturaleza – Asociación Herpetológica Española, pp. 147–150.

Andreu, A.C., Díaz-Paniagua, C., and Keller, C. 2000. La Tortuga Mora en Doñana. Asociación Herpetológica Española–Monografías de Herpetología 5:1–70.

Astre, G. 1948. Reproduction de la Tortue mauresque à Toulouse. Bulletin de la Société d'Histoire Naturelle de Toulouse 83:60–64.

Auliya, M., Altherr, S., Ariano-Sanchez, D., Baard, E.H., Brown, C., Brown, R.M., Cantu, J.C., Gentile, G., Gildenhuys, P., Henningheim, E., and Hintzmann, J. 2016. Trade in live reptiles, its impact on wild populations, and the role of the European market. Biological Conservation 204:103–119.

Báez, J.C., Estrada, A., Torreblanca, D., and Real, R. 2012. Predicting the distribution of cryptic species: the case of the Spur–thighed Tortoise in Andalusia (southern Iberian Peninsula). Biodiversity and Conservation 21:65–78.

Bailey, J.R. and Highfield, A.C. 1996. Observations on ecological changes threatening a population of *Testudo graeca graeca* in the Souss Valley, southern Morrocco. Chelonian Conservation and Biology 2:36–42.

Ballasina, D. 1995. Distribuzione e Situazione delle Tartarughe Terrestri in Italia. Bologna: Edagricole.

Ballestar, R., Anadón, J.D., Giménez, A., López, G., and Pérez, I. 2004. Variaciones locales en parámetros poblacionales de tortuga mora (*Testudo graeca graeca*) en el sureste ibérico. VIII Congreso Luso-Español de Herpetología, Málaga, Libro de Resúmenes, p. 64.

Ballestar, R., Anadón, J.D., Sánchez, J.A., Botella, F., and Giménez, A. 2006. Predation of the Spur–Thighed Tortoise *Testudo graeca graeca* by mammalian carnivorous fauna in southeastern Spain. Chelonii 4:220–230.

Ballestar, R., Anadón, J.D., Giménez, A., Abad, V., Larrosa, M., and Pardo, B. 2007a. Depredación de tortuga por mamíferos carnívoros en tres poblaciones de distinta densidad de tortuga mora (*Testudo graeca graeca*) en el Sureste ibérico. In: Gosá, A., Egaña-Callejo, A., and Rubio, X. (Eds.). Herpetologia Iberiarraren Egoera = Estado Actual de la Herpetología Ibérica: Lehen Herpetologia Kongressua Euskal Herrian, IX Congresso Luso-Espanhol, XIII Congreso Español de Herpetología Munibe, Suplemento 25, pp. 210–215.

Ballestar, R., Giménez, A., and Anadón, J.D. 2007b. Patrones de abundancia a escala local de la tortuga mora (*Testudo graeca graeca*) en el Sureste Ibérico. In: Gosá, A., Egaña-Callejo, A., and Rubio, X. (Eds.). Herpetologia Iberiarraren Egoera = Estado Actual de la Herpetología Ibérica: Lehen Herpetologia Kongressua Euskal Herrian, IX Congresso Luso-Espanhol, XIII Congreso Español de Herpetología Munibe, Suplemento 25, pp. 216–223.

Balmori, A. 2000. *Testudo graeca* (Tortuga Mora) observación en el norte de Segovia. Boletín de la Asociación Española de Herpetología 11:65.

Barceló, F. 1876. Nuevos apuntes para la fauna balear. Catálogo de los reptiles observados en las Islas Baleares. Museo Balear 18:201–210.

Barje, F., Slimani, T., El Mouden, E.H., Lagarde, F., Bonnet, X., and Ben Kaddour, K. 2005. Shrewd shrikes and spiny shrubs: a calamity for hatchling Moorish tortoises (*Testudo graeca graeca*). Amphibia-Reptilia 26:113–115.

Bassu, L., Nulchis, V., Satta, M.G., Fresi, C., and Corti, C. 2008. Atlas of amphibians and reptiles of Sardinia – state of the art and general considerations. In: Corti, C., et al. (Eds.). Herpetologia Sardiniae. Latina: Belvedere, pp. 52–58.

Bauer, A.M., DeBoer, J.C., and Taylor, D.J. 2017. Atlas of the Reptiles of Libya. Proceedings of the California Academy of Sciences 64:155–318.

Biaggini, M., Romano, A., Di Tizio, L., and Corti, C. 2018. Density and sex-ratio of wild populations of three *Testudo* species in Italy. Herpetozoa 30:203–208.

Blasco, M., Crespillo, E., and Sánchez J.M. 1987. The growth dynamics of *Testudo graeca* L. (Reptilia: Testudinidae) and other data on its populations in the Iberian Peninsula. Israel Journal of Zoology 34:139–147.

Bons, J. and Geniez, P. 1996. Amphibiens et reptiles du Maroc (Sahara occidental compris): Atlas biogéographique. Barcelona: AHE, 319 pp.

Borg, M.J. and Schembri, P.J. 1991. A short note on the herpetofauna of Gozo. British Herpetological Society Bulletin 38:8–9.

Boscà, J. 1883. Exploración herpetológica de la isla de Ibiza. Anales de la Sociedad Española de Historia Natural 12:241–250.

Bruno, S. 1986. Guida a Tartarughe e Sauri d'Italia. Firenze: Giunti Martello, 256 pp.

Buhlmann, K.A., Akre, T.S.B., Iverson, J.B., Karapatakis, D., Mittermeier, R.A., Georges, A., Rhodin, A.G.J., van Dijk, P.P., and Gibbons, J.W. 2009. A global analysis of tortoise and freshwater turtle distributions with identification of priority conservation areas. Chelonian Conservation and Biology 8:116–149.

Carpaneto, G.M. 2006. *Testudo graeca* Linnaeus, 1758. In: Corti, C., Capula, M., Luiselli, L., Razzetti, E., and Sindaco, R. (Eds.). Fauna d'Italia. Reptilia. Bologna: Calderini de Il Sole, pp. 180–187.

Chávarri, M., Berriatua, E., Giménez, A., Graciá, E., Martínez-Carrasco, C., Ortiz, J.M., and de Ybánez, R.R. 2012. Differences in helminth infections between captive and wild spur-thighed tortoises *Testudo graeca* in southern Spain: a potential risk of reintroductions of this species. Veterinary Parasitology 187:491–497.

Cloudsley-Thompson, J.L. 1974. Physiological thermoregulation in the spurred tortoise (*Testudo graeca* L.). Journal of Natural History 8:577–587.

Cobo, M. and Andreu, A.C. 1988. Seed consumption and dispersal by the spur-thighed tortoise *Testudo graeca*. Oikos 51:267–273.

Corti, C., Bassu, L., Nulchis, V., Paliaga, B., Satta, M.G., and Zuffi, M.A.L. 2007. Morphology and preliminary data on the ecology of *Testudo graeca graeca* of Mal di Ventre Island (W Sardinia, Italy). In: Bologna, M.A., Capula, M., Carpaneto, G.M., Luiselli, L., Marangoni, C., and Venchi, A. (Eds.). Atti del 6 Congresso Nazionale della Societas Herpetologica Italica. Latina: Societas Herpetologica Italica/Edizioni Belvedere, pp. 123–126.

Cox, N.A. and Temple, H.J. 2009. European Red List of Reptiles. Luxembourg: Office for Official Publications of the European Communities.

Crucitti, P. and Emiliani, F. 2012. Morphological variability of the Spurthighed Tortoise, *Testudo graeca*, in the Nemrut Volcano (Eastern Turkey) (Testudines: Testudinidae). Zoology in the Middle East 56:19–26.

Delibes, M., Calderón, J., and Hiraldo, F. 1975. Selección de presa y alimentación en España del águila real *Aquila chrysaetos*. Ardeola 21:285–303.

Di Nicola, M.R. and Mezzadri, S. 2018. Anfibi e Rettili di Sardegna. Milano: Libreria della Natura, 175 pp.

Díaz-Paniagua, C., Keller, C., and Andreu, A.C. 1995. Annual variation of activity and daily distances moved in adult Spur-thighed tortoises, *Testudo graeca*, in southwestern Spain. Herpetologica 51:225–233.

Díaz-Paniagua, C., Keller, C., and Andreu, A.C. 1996. Clutch frequency, egg and clutch characteristics, and nesting activity of spur-thighed tortoises, *Testudo graeca*, in southwestern Spain. Canadian Journal of Zoology 74:560–564.

Díaz-Paniagua, C., Keller, C., and Andreu, A.C. 2001. Long-term demographic fluctuations of the spur-thighed tortoise, *Testudo*

graeca, in SW Spain. Ecography 24:707–721.

Díaz-Paniagua, C. and Andreu, A.C. 2014. *Testudo graeca* Linnaeus, 1758. In: Salvador, A. (Ed.). Reptiles. Fauna Iberica Vol. 10. Madrid: MNCN–CSIC, pp. 205–216.

Díaz-Paniagua, C. and Andreu, A.C. 2015. Tortuga mora – *Testudo graeca*. In: Carrascal, L.M. and Salvador, A. (Eds.). Enciclopedia Virtual de los Vertebrados Españoles. Madrid: Museo Nacional de Ciencias Naturales. http://www.vertebradosibericos.org/.

Doderlein, P. 1881. Rivista della fauna sicula dei vertebrati. Palermo: Tipografia P. Montana, 92 pp.

Doumergue, F. 1901. Essai sur la faune erpétologique de l'Oranie: avec des tableaux analytiques et des notions pour la détermination de tous les reptiles et batraciens du Maroc, de l'Algérie et de la Tunisie. Oran: L. Fouque, 397 pp.

Duméril, A.M.C. and Bibron, G. 1835. Erpétologie Générale ou Histoire Naturelle Complète des Reptiles. Tome Second. Paris: Roret, 680 pp.

Dupré, A., Frétey, T., and Lorvelec, O. 2003. La Tortue mauresque: *Testudo graeca* Linné, 1758. In: Pascal, M., Lorvelec, O., Vigne, J.-D., Keith, P., and Clergeau, P. (Eds.). Évolution Holocène de la Faune de Vertébrés de France: Invasions et Extinctions. Paris: Rapport INRA/CNRS/MNHN, pp. 160–162.

El Mouden, E.H., Slimani, T., Kaddour, K.B., Lagarde, F., Ouhammou, A., and Bonnet, X. 2006. *Testudo graeca graeca* feeding ecology in an arid and overgrazed zone in Morocco. Journal of Arid Environments 64:422–435.

Escoriza, D., Franch, M., Ramos, S., Sunyer-Sala, P., and Boix, D. 2020. Demographics and survivorship in the European Pond Turtle (*Emys orbicularis*): a 31-year study. Herpetological Conservation and Biology 15:41–48.

Frazer, J.F.D. 1964. Introduced species of amphibians and reptiles in mainland Britain. British Journal of Herpetology 3:145.

Fritz, U., Hundsdörfer, A.K., Široký, P., Auer, M., Kami, H., Lehmann, J., Mazanaeva, L.F., Türkozan, O., and Wink, M. 2007. Phenotypic plasticity leads to incongruence between morphology-based taxonomy and genetic differentiation in western Palaearctic tortoises (*Testudo graeca* complex; Testudines, Testudinidae). Amphibia-Reptilia 28:97–121.

Fritz, U., Harris, D.J., Fahd, S., Rouag, R., Graciá Martinez, E., Giménez Casalduero, A., Široký, P., Kalboussi, M., Jdeidi, T.B., and Hundsdorfer, A.K. 2009. Mitochondrial phylogeography of *Testudo graeca* in the Western Mediterranean: old complex divergence in North Africa and recent arrival in Europe. Amphibia-Reptilia 30:63–80.

Geniez, P. and Cheylan, M. 2012. Les Amphibiens et les Reptiles du Languedoc–Roussillon et Régions Limitrophes. Atlas Biogéographique. Mèze: Biotope, 448 pp.

Gharbi, M., Rjeibi, M.R., Rouatbi, M., Mabrouk, M., Mhadhbi, M., Amairia, S., Amdouni, Y., and Boussaadoun, M.A. 2015. Infestation of the spur–thighed tortoise (*Testudo graeca*) by *Hyalomma aegyptium* in Tunisia. Ticks and Tick-Borne Diseases 6:352–355.

Giménez, A., Esteve, M.A., Pérez, I., Anadón, J.D., Martínez, M., Martínez, J., and Palazón, J.A. 2004. La tortuga mora en la Región de Murcia. Conservación de una especie amenazada. Murcia: DM Ed.

Graciá, E. and Giménez, A. 2015. La tortuga mora (*Testudo graeca*) en la península ibérica y en las islas Baleares. Boletín de la Asociación Herpetológica Española 26:28–35.

Graciá, E., Giménez, A., Anadón, J.D., Harris, D.J., Fritz, U., and Botella, F. 2013. The uncertainty of Late Pleistocene range expansions in the western Mediterranean: a case study of the colonization of south-eastern Spain by the spur-thighed tortoise, *Testudo graeca*. Journal of Biogeography 40:323–334.

Graciá, E., Vargas-Ramírez, M., Delfino, M., Anadón, J.D., Giménez, A., Fahd, S., Corti, C., Jdeidi, T.B., and Fritz, U. 2017. Expansion after expansion: dissecting the phylogeography of the widely distributed spur-thighed tortoise, *Testudo graeca* (Testudines: Testudinidae). Biological Journal of the Linnean Society 121:641–654.

Granados, M. 1987. Transformaciones históricas de los ecosistemas del Parque Nacional de Doñana. Doctoral Thesis, Universidad de Sevilla.

Hichami, N. and Znari, M. 2021. A management plan for a declining population of the Souss valley tortoise in an arid steppe-land of west-central Morocco. Basic and Applied Herpetology 5:45–61 .

Hichami, N., Znari, M., Naimi, M., and Namous, S. 2016. Clutch, egg and hatchling characteristics in the Souss Valley tortoises, *Testudo graeca soussensis* Pieh, 2001 (Testudines: Testudinidae) from an arid steppe-land of west-central Morocco. African Journal of Herpetology 65:21–32.

Highfield, A.C. 1990: Tortoises of North Africa: taxonomy, nomenclature, phylogeny, and evolution with notes on field studies in Tunisia. Journal of Chelonian Herpetology 1:1–56.

Highfield, A.C. and Martin, J. 1989a. *Testudo whitei* Bennett 1836. New light on an old carapace–Gilbert White's Selborne tortoise re-discovered. Journal of Chelonian Herpetology 1:13–22.

Highfield, A.C. and Martin, J. 1989b. Description of a miniature tortoise *Testudo flavominimaralis* n. species from North Africa. London: The Tortoise Trust/Tortoise Survival Project.

Ibrahim, A.A. and Ineich, I. 2005. Additional records to the herpetofauna of Nalut Province, Libya. African Herp News 38:2–9.

Iverson, J.B. 1992. A Revised Checklist with Distribution Maps of the Turtles of the World. Richmond, IN: Privately Printed, 363 pp.

Jost, U. 2011. Die Tunesische Landschildkröte, *Testudo graeca nabeulensis*: Beobachtungen in Nordtunesien und Bemerkungen zur Haltung und Nachzucht. Testudo 20:5–41.

Kaddour, K.B., Slimani, T., El Mouden, E.H., Lagarde, F., and Bonnet, X. 2006. Population structure, population density and individual catchability of *Testudo graeca* in the central Jbilets (Morocco). Vie et Milieu 56:49–54.

Keller, C., Díaz-Paniagua, C., and Andreu, A.C. 1997. Post-emergent field activity and growth rates of hatchling spur-thighed tortoises, *Testudo graeca*. Canadian Journal of Zoology 75:1089–1098.

Keller, C., Díaz-Paniagua, C., and Andreu, A.C. 1998. Survival rates and causes of mortality causes of *Testudo graeca* hatchlings in southwestern Spain. Journal of Herpetology 32:238–243.

Krüger, E. 2007. Near-natural incubaton of *Testudo graeca soussensis* Pieh, 2000, eggs. Radiata 16:42–48.

Lagarde, F., Louzizi, T., Slimani, T., El Mouden, H., Kaddour, K.B., Moulherat, S., and Bonnet, X. 2012. Bushes protect tortoises from lethal overheating in arid areas of Morocco. Environmental Conservation 39:172–182.

Lambert, M.R.K. 1979. Tortoise drain in Morocco. Oryx 10:161–166.

Lambert, M.R.K. 1981. Temperature, activity and field sighting in the Mediterranean Spur-thighed or common garden tortoise *Testudo graeca* L. Biological Conservation 21:39–54.

Lambert, M.R.K. 1982. Studies on the growth, structure and abundance of the Mediterranean spur-thighed tortoise, *Testudo graeca* in field populations. Journal of Zoology 196:165–189.

Lambert, M.R.K. 1983. Some factors influencing the Moroccan distribution of the western Mediterranean spur-thighed tortoise,

Testudo graeca graeca L., and those precluding its survival in NW Europe. Zoological Journal of the Linnean Society 79:149–178.

Lambert, M.R.K. 1984. Threats to Mediterranean (West Palaearctic) tortoises and their effects on wild populations: an overview. Amphibia-Reptilia 5:5–15.

Lawrence, K. 1987. Mortality of Mediterranean tortoises (*Testudo graeca* and *Testudo hermanni*) in pet shops prior to sale. British Veterinary Journal 143:567–573.

Lawrence, K. and Needham, J.R. 1985. Rhinitis in long term captive Mediterranean tortoises (*Testudo graeca* and *T. hermanii*). The Veterinary Record 117:662–664.

Le Berre, M. 1989. Faune du Sahara. 1. Poissons, Amphibiens, Reptiles. Paris: Lechevalier-R. Chabaud, 332 pp.

Linnaeus, C. 1758. Systema Naturae, per Regna Tria Naturae, secundum Classes, Ordines, Genera, Species, cum Characteribus, Differentiis, Synonymis, Locis. Tomus I. Editio Decima, Reformata. [10th Ed.]. Holmiae [Stockholm]: Laurentii Salvii, 824 pp.

López-Jurado, L.F., Talavera, P.A., Ibáñez, J.M., MacIvor, J.A., and García, A. 1979. Las tortugas terrestres *Testudo graeca* y *Testudo hermanni* en España. Madrid: Instituto Nacional para la Conservación de la Naturaleza, Naturalia Hispanica 17.

Loveridge, A. and Williams, E.E. 1957. Revision of the African tortoises and turtles of the suborder Cryptodira. Bulletin of the Museum of Comparative Zoology 115:163–557.

Machado, A.A. 1859. Erpetologia hispalense; seu Catalogus Metodicus Reptilium et Amphibiorum in provincia Hispalensi viventium. Memorias de la Real Academia de Ciencias Exactas, Físicas y Naturales de Madrid 2:561–573.

Maluquer, J. 1918. Notas herpetológicas: III. La *Testudo graeca* en Formentera? Boletín de la Real Sociedad Española de Historia Natural 18:402–406.

Martínez-Fernández, J.M.A.E. and Esteve, M.A. 2005. A critical view of the desertification debate in southeastern Spain. Land Degradation & Development 16:529–539.

Martínez-Silvestre, A., Silva, J.L., Andreu, A., Mateo, J.A., and Soler, J. 2001. Cría en cautividad de reptiles amenazados. Ventajas e inconvenientes de los programas de conservación ex situ. Quercus 190:54–60.

Massa, B. and Falcone, S. 2007. Atlante della Biodiversità della Sicilia: Vertebrati Terrestri. Palermo: Arpa Sicilia, 536 pp.

Mateo, J.A. 1997. Las especies introducidas en la península Ibérica, Baleares, Canarias, Madeira y Azores. In: Pleguezuelos, J.M. (Ed.). Distribución y Biogeografia de los Anfibios y Reptiles en España y Portugal. Granada: Universidad de Granada, Monografias Tierras del Sur, pp. 465–475.

Mateo, J.A., Ayres, C., and López-Jurado, L.F. 2011. Los anfibios y reptiles naturalizados en España: historia y evolución de una problemática creciente. Boletín de la Asociación Herpetológica Española 22:2–43.

Mayol, J. 2003. Rèptils i Amfibis de les Balears. Palma de Mallorca: Moll, 256 pp.

Meek, R. and Jayes, A.S. 1982. Body temperatures and activity patterns of *Testudo graeca* in North West Africa. British Journal of Herpetology 6:194–197.

Monzó-Giménez, J.C. 2002. Anfibios y Reptiles del Entorno de Pinoso (Alicante). Pinoso: Ayuntamiento de Pinoso, 151 pp.

Moreno, S. 1987. Crecimiento de *Testudo graeca*. Amphibia-Reptilia 8:179–181.

Najjar, C., Kaabi, B., Younsi, H., Petretto, M., Riordan, P., and Zhioua, E. 2020. Ticks parasitizing the spur-thighed tortoise (*Testudo graeca*) population of Tunisia. Journal of Wildlife Diseases 56:815–822.

Nijman, V. and Bergin, D. 2017. Trade in spur-thighed tortoise *Testudo graeca* in Morocco: volumes, value and variation between markets. Amphibia-Reptilia 38:275–287.

Palerm, J.C. 1997. Atles dels amfibis i rèptils de l'illa d'Eivissa (Illes Pitiüses). Bolletí de la Societat d'Història Natural de les Balears 40:17–25.

Palomares, F. and Delibes, M. 1991. Alimentación del meloncillo *Herpestes ichneumon* y de la gineta *Genetta genetta* en la Reserva Biológica de Doñana, S.O. de la Península Ibérica. Doñana, Acta Vertebrata 18:5–20.

Palomo, I., Martín-López, B., Zorrilla-Miras, P., Del Amo, D.G., and Montes, C. 2014. Deliberative mapping of ecosystem services within and around Doñana National Park (SW Spain) in relation to land use change. Regional Environmental Change 14:237–251.

Parham, J.F., Macey, J.R., Papenfuss, T.J., Feldman, C.R., Türkozan, O., Polymeni, R., and Boore, J. 2006. The phylogeny of Mediterranean tortoises and their close relatives based on complete mitochondrial genome sequences from museum specimens. Molecular Phylogenetics and Evolution 38:50–64.

Pascal, M., Lorvelec, O., Vigne J.D., Keith, P., and Clergeau, P. 2003. Évolution holocène de la faune de Vertébrés de France: invasions et disparitions. Paris: Institut National de la Recherche Agronomique, Centre National de la Recherche Scientifique, Muséum National d'Histoire Naturelle, 381 pp.

Peel, M.C., Finlayson, B.L., and McMahon, T.A. 2007. Updated world map of the Köppen-Geiger climate classification. Hydrology and Earth System Sciences 11:1633–1644.

Pérez, I., Giménez, A., Anadón, J.D., Martínez, M., and Esteve, M.A. 2002. Patrones de actividad estacional y diaria de la tortuga mora (*Testudo graeca* L. 1758 ssp. *graeca*) en el sureste de la Península Ibérica. Anales de Biología 24:65–75.

Pérez, I., Giménez, A., Sánchez-Zapata, J.A., Anadón, J.D., Martínez, M., and Esteve, M.A. 2004. Non–commercial collection of spur-thighed tortoises (*Testudo graeca graeca*): a cultural problem in southeast Spain. Biological Conservation 118:175–181.

Pérez, I., Tenza, A., Anadón, J.D., Martínez-Fernández, J., Pedreño, A., and Giménez, A. 2012. Exurban sprawl increases the extinction probability of a threatened tortoise due to pet collections. Ecological Modelling 245:19–30.

Pérez-García, J.M., Botella, F., and Sánchez-Zapata, J.A. 2014. Fauna vertebrada de Sierra Escalona y la Dehesa de Campoamor. In: Historia Natural de Sierra Escalona y Dehesa de Campoamor Orihuela: Ayuntamiento de Orihuela, p. 176.

Pieh, A. 2001. *Testudo graeca soussensis,* eine neue Unterart der Maurischen Landschildkröte aus dem Sousstal (Südwest–Marokko). Salamandra 36:209–222.

Pieh, A. and Perälä, J. 2002. Variabilität von *Testudo graeca* Linnaeus, 1758 im östlichen Nordafrika mit Beschreibung eines neuen Taxons von der Cyrenaika (Nordostlibyen). Herpetozoa 15:3–28.

Pieh, A. and Perälä, J. 2004. Variabilität der Maurischen Landschildkröten (*Testudo graeca* Linnaeus, 1758 – Komplex) im zentralen und nordwestlichen Marokko mit Beschreibung zweier neuer Taxa. Herpetozoa 17:19–47.

Pinya, S. 2011. Situación actual de la Tortuga Mora (*Testudo graeca* L.) en Mallorca. Inèdit. Palma: Conselleria de Medi Ambient-Centre d'Estudi i Conservació Herpetològic, 12 pp.

Pinya, S. and Cuadrado, E. 2008. Situació actual de la tortuga mora (*Testudo graeca*) a l'illa de Mallorca. In: Pons, G.X. (Ed.). V Jornades de Medi Ambient de les Illes Balears. Palma de Mallorca: Ponències i Resums. Societat d'Història Natural de les Balears, pp. 122–123.

Poch, S., Sunyer, P., Pascual, G., Boix, D., Campos, M., Cruset, E., Quer-Feo, C., Fuentes, M.A., Molina, A., Porcar, A., Pérez-Novo, I., Pou-Rovira, Q., Ramos, S., and Escoriza, D. 2020. Alien chelonians in north-eastern Spain: new distributional data. The Herpetological Bulletin 151:1–5.

Pons, S. and Aguilar, J.S. 1992. Incidencia de la enfermedad respiratoria de las tortugas de tierra en poblaciones silvestres de la tortuga mora en Mallorca. Revista de Concer 3:8–10.

Roca, V. 1999. Relación entre las faunas endoparásitas de reptiles y sus tipos de alimentación. Revista Española de Herpetología 13:101–121.

Rodríguez-Caro, R.C., Graciá, E., Anadón, J.D., and Giménez, A. 2013. Maintained effects of fire on individual growth and survival rates in a spur-thighed tortoise population. European Journal of Wildlife Research 59:911–913.

Rouag, R., Benyacoub, S., Luiselli, L. , El Mouden, E.H., Tiar, G., and Ferrah, C. 2007. Population structure and demography of an Algerian population of the Moorish tortoise, *Testudo graeca*. Animal Biology 57:267–279.

Rouag, R., Ferrah, C., Luiselli, L., Tiar, G., Benyacoub, S., Ziane, N., and El Mouden, E.H. 2008. Food choice of an Algerian population of the spur-thighed tortoise, *Testudo graeca*. African Journal of Herpetology 57:103–113.

Sánchez, J.M., Crespillo, E., and Romero, J. 1986. La tortuga mora de la península Ibérica. Vida Silvestre 59:170–187.

Sanz-Aguilar, A., Anadón, J.D., Giménez, A., Ballestar, R., Graciá, E., and Oro, D. 2011. Coexisting with fire: the case of the terrestrial tortoise *Testudo graeca* in Mediterranean shrublands. Biological Conservation 144:1040–1049.

Savona-Ventura, C. 1984. The fossil herpetofauna of the Maltese Islands: a review. Il Naturalista Siciliano 8:93–106.

Savona-Ventura, C. 1985. The herpetofauna of the Maltese islands. Civilization 25:693–695.

Schleich, H.H. 1989. Merkmalsausbildungen an Landschildkröten in Nordost-Libyen. Herpetozoa l:97–108.

Schleich, H.H., Kästle, W., and Kabisch, K. 1996. Amphibians and Reptiles of North Africa. Koenigstein: Koeltz, 630 pp.

Schweiger, M. and Gemel, R. 2020. Where do you come from, stranger? A scientific-historical digression with discussion on nomenclature and taxonomy of *Testudo graeca* Linnaeus, 1758. Herpetozoa 33:31–38.

Segura, A., Rodríguez, O., Ruiz-Fons, F., and Acebedo, P. 2019. Tick parasitism in the Mediterranean spur-thighed tortoise in the Maamora forest, Morocco. Diseases 10:286–289.

Segura, A., Delibes-Mateos, M., and Acevedo, P. 2020. Implications for conservation of collection of Mediterranean spur-thighed tortoise as pets in Morocco: residents' perceptions, habits, and knowledge. Animals 10:265.

Slimani, T., El Mouden, E.H., Ben Kaddour, K., Lagarde, F., and Bonnet, X. 2006. Ecological characteristics and habitat status of the spur-thighed *Testudo graeca graeca* in an arid area of Morocco: implications for conservation. Chelonii 4:83–86.

Sultana Loporto, L., Morganti, G., Moretta, I., and Schembri, P.J. 2018. A first record of the tortoise tick, *Hyalomma aegyptium* (Linnaeus 1758) on Malta. International Journal of Acarology 44:49–51.

TFTSG [Tortoise and Freshwater Turtle Specialist Group]. 1996. *Testudo graeca*. The IUCN Red List of Threatened Species 1996: e.T21646A9305693.

Tiar, G., Tiar-Saadi, M., Benyacoub, S., Rouag, R., and Široký, P. 2016. The dependence of *Hyalomma aegyptium* on its tortoise host *Testudo graeca* in Algeria. Medical and Veterinary Entomology 30:351–359.

Traversa, D., Capelli, G., Iorio, R., Bouamer, S., Cameli, A., and Giangaspero, A. 2005. Epidemiology and biology of nematodofauna affecting *Testudo hermanni*, *Testudo graeca* and *Testudo marginata* in Italy. Parasitology Research 98:14.

TTWG [Turtle Taxonomy Working Group: Rhodin, A.G.J., Iverson, J.B., Bour, R., Fritz, U., Georges, A., Shaffer, H.B., and van Dijk, P.P.]. 2017. Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status (8th Ed.). Chelonian Research Monographs 7:1–292.

TTWG [Turtle Taxonomy Working Group: Rhodin, A.G.J., Iverson, J.B., Bour, R., Fritz, U., Georges, A., Shaffer, H.B., and van Dijk, P.P.]. 2021. Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status (9th Ed.). Chelonian Research Monographs 8:1–472.

Türkozan, O., Özdemir, A., and Kiremit, F. 2008. International *Testudo* trade. Chelonian Conservation and Biology 7:269–274.

Turrisi, G.F. and Vacaro, A. 1998. Contributo alla conoscenza degli Anfibi e dei Rettili di Sicilia. Bullettino delle Sedute della Accademia Gioenia di Scienze Naturali in Catania 30:5–88.

Valverde, J.A. 1967. Estructura de una comunidad de vertebrados terrestres. Madrid: CSIC, Monografías de la Ciencia Moderna No. 76.

Vamberger, M., Corti, C., Stuckas, H., and Fritz, U. 2011. Is the imperilled spur-thighed tortoise (*Testudo graeca*) native in Sardinia? Implications from population genetics and for conservation. Amphibia-Reptilia 32:9–25.

van der Kuyl, A.C., Ballasina, D.L.P., Dekker, J.T., Maas, H., Willemsen, R.E., and Goudsmit, J. 2002. Phylogenetic relationships among the species of the genus *Testudo* (Testudines: Testudinidae) inferred from mitochondrial 12S rRNA gene sequences. Molecular Phylogenetics and Evolution 22:174–183.

van der Kuyl, A.C., Ballasina, D.L.P., and Zorgdrager, F. 2005. Mitochondrial haplotype diversity in the tortoise species *Testudo graeca* from North Africa and the Middle East. BMC Evolutionary Biology 5:29.

van Dijk, P.P., Corti, C., Mellado, V.P., and Cheylan, M. 2004. *Testudo graeca* (Europe regional). The IUCN Red List of Threatened Species 2004: e.T21646A9305080.

van Uhm, D. 2016. Illegal wildlife trade to the EU and harms to the world. In: Spapens, T., White, R., and Huisman, W. (Eds.). Environmental Crime in Transnational Context. Routledge: Taylor & Francis, pp. 59–82.

Znari, M., Germano, D.J., and Macé, J.C. 2005. Growth and population structure of the Moorish Tortoise (*Testudo graeca graeca*) in Westcentral Morocco: possible effects of over-collecting for the tourist trade. Journal of Arid Environments 62:55–74.

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