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Mauremys leprosa (Schoepff in Schweigger 1812) –

Mediterranean Pond Turtle, Spanish Terrapin, Mediterranean Stripe-necked Terrapin

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SUMMARY. – The Mediterranean Pond Turtle, *Mauremys leprosa* (Family Geoemydidae) is a small to medium-sized freshwater turtle (carapace length up to ca. 210 mm in males, 240 mm in females), widely distributed in North Africa and across the Strait of Gibraltar to the Iberian Peninsula and southern France. Our current understanding of the species' evolutionary history involves complex patterns of population origination, dispersion, extinction, evolution into two major lineages (each with three sublineages), and human-assisted transport. Populations in North Africa are often isolated from one another by intervening arid terrain, and a complex pattern of local variation in shell markings has occurred. *Mauremys leprosa* tolerates salt water, and has a high tolerance for polluted freshwater habitats, reduced water levels, and elevated ambient temperatures; carnivorous by preference, it will also feed freely upon vegetation and has been reported ingesting nitrogenous animal and human waste. Nesting occurs once annually in most populations, with mean clutch size ranging from 3.8 to 9.6 eggs, depending on the population, with the incubation period also variable, from 55–108 days in Europe to 25–30 days in Africa, the shorter period there perhaps as a response to irregular and brief pluvial periods under very arid conditions.

DISTRIBUTION. – Algeria, France, Libya, Mauritania, Morocco, Niger, Portugal, Spain, Tunisia. Occurs widely across northwestern Africa and the Iberian Peninsula into southern France; scattered populations across the Saharan region may represent prehistoric introductions.

SYNONYMY. – *Emys leprosa* Schoepff in Schweigger 1812, *Clemmys* (*Clemmys*) *leprosa*, *Clemmys leprosa*, *Emys caspica leprosa*, *Clemmys caspica leprosa*, *Mauremys caspica leprosa*, *Mauremys leprosa*, *Mauremys leprosa leprosa*, *Emys lutescens* Schweigger 1812, *Clemmys* (*Clemmys*) *lutescens*, *Clemmys lutescens*, *Emys marmorea* Spix 1824, *Clemmys marmorea*, *Clemmys sigriz* Michahelles 1829, *Terrapene sigriz*, *Emys sigriz*, *Clemmys caspica sigriz*, *Emys vulgaris* Gray 1830, *Emys sigritzii* Michahelles in Gray 1831 (*nomen novum*), *Emys laticeps* Gray 1854, *Clemmys laticeps*, *Eryma laticeps*, *Emys fuliginosus* Gray 1860, *Emys fuliginosa*, *Clemmys fuliginosa*, *Mauremys fuliginosa*, *Mauremys laniaria* Gray 1869a, *Emys flavipes* Gray 1869b, *Emys fraseri* Gray 1869b (*partim, nomen dubium*), *Mauremys leprosa atlantica* Schleich 1996, *Mauremys leprosa erhardi* Schleich 1996, *Mauremys leprosa marokkensis* Schleich 1996, *Mauremys leprosa wernerkaestlei* Schleich 1996.

SUBSPECIES. – Two are currently recognized: 1) *Mauremys leprosa leprosa* (Mediterranean Pond Turtle) (distribution: from northwestern Morocco through the Iberian Peninsula to southern France); 2) *Mauremys leprosa saharica* (Saharan Pond Turtle) (distribution: from southern and eastern Morocco through Algeria to northwest Libya, with scattered populations in the Saharan region) (synonymy: *Mauremys leprosa saharica* Schleich 1996, *Mauremys leprosa zizi* Schleich 1996, *Mauremys leprosa vanmeerhaeghei* Bour and Maran 1999).

STATUS. – IUCN 2017 Red List: Global: Least Concern [Not Listed] (LC, assessed 1996); Regional: Europe: Vulnerable (VU A2ac+3c, assessed 2004); TFTSG Draft Red List: Vulnerable (VU, assessed 2011); CITES: Not Listed; European Commission for the Environment, Birds and Habitats Directive: Annexes II and IV; Berne Convention on the Conservation of European Wildlife and Natural Habitats: Annex II.

Taxonomy. – The species was originally described as *Emys leprosa* in an unpublished manuscript by Schoepff. Schweigger (1812), who discovered the manuscript in the

Muséum national d'Histoire naturelle, Paris, cited Schoepff as the name's author. In 1862, Strauch assigned the species to the genus *Clemmys*. Between 1824 and 1869, several other



Figure 1. Juvenile *Mauremys leprosa leprosa*, Flix, Catalonia, Spain. Photo by Albert Bertolero.

species names for various populations of this turtle were proposed by Spix (1824), Michahelles (1829), and Gray (1830, 1831, 1854, 1860, 1869a,b), but all were subsequently found to be synonymous with *leprosa* (see also Wermuth and Mertens 1961). Duméril and Bibron (1835) also described *Emys sigriz* as “new”, but that name is also a synonym of *leprosa* and properly attributed to Michahelles (1829). Loveridge and Williams (1957) provided an extensive synonymy and treated *leprosa* as a subspecies of *Clemmys caspica*, but presented no discussion for this assignment. McDowell (1964), in his revision of the turtle families Emydidae and Bataguridae (= Geoemydidae), assigned European members of the genus *Clemmys* to the genus *Mauremys*, a name first used for the synonymous *Mauremys laniaria* Gray (1869a). Busack and Ernst (1980) considered the analysis of 17 protein systems provided by Merkle (1975), coupled with their detailed morphological analysis, as support for the decision to assign full species status to *Mauremys leprosa*.

Busack and Ernst (1980) reported ontogenetic variation in plastral pattern and coloration among subadult specimens from various North African populations. Using

similar characteristics, Schleich (1996) later partitioned Moroccan populations into seven subspecies (*M. l. leprosa*, *M. l. atlantica*, *M. l. erhardi*, *M. l. wernerkaestlei*, *M. l. marokkensis*, *M. l. saharica*, and *M. l. zizi*) and Bour and Maran (1999) followed with the description of an additional subspecies (*M. l. vanmeerhaeghei*) based mostly upon eye color.

Fritz et al. (2006), following a comprehensive range-wide molecular analysis, recognized only *Mauremys l. leprosa* (France, Spain, Portugal, and northern Morocco) and *M. l. saharica* (southern Morocco, Algeria, Tunisia, and northwestern Libya), with the Atlas Mountains as the barrier between the subspecies (Fritz et al. 2005). This classification has been accepted by the Turtle Taxonomy Working Group (TTWG 2014, 2017).

Utilizing data from mitochondrial cytochrome *b*, its control region, and a nuclear intron (R35), Veríssimo et al. (2016) identified two major lineages (A and B) (corresponding to the two recognized subspecies), each with three sublineages, within an analysis of 566 samples from throughout the taxon’s range. Sublineage A1 is distributed in



Figure 2. Adult male (left) and female (right) *Mauremys leprosa leprosa*, Flix, Catalonia, Spain. Photo by Albert Bertolero.



Figure 3. *Mauremys leprosa saharica*, Bou-Jerif, Morocco. Photo by Andreas Nöllert.

southwestern Morocco north of the High Atlas Mountains; A2 is distributed across central-north Morocco, but also south of the High Atlas Mountains; and A3 is widely distributed throughout the Iberian Peninsula (with haplotypes A3-9 and A3-15 occurring on each side of the Strait of Gibraltar) to southern France, and in the Middle Atlas and Rif Mountains. Sublineages B1, B2, and B3 are confined to North Africa; B1 and B2 are admixed, with B1 distributed mostly between the High Atlas and Anti Atlas, but also found north of the High Atlas Mountains, in Morocco, and B2 distributed south of the High Atlas Mountains. B3 is found on the southeastern slope of the High Atlas Mountains, and from the Rif and Middle Atlas Mountains of Morocco east to Tunisia (Veríssimo et al. 2016). Turtles in southern France representing sublineage A1 and lineage B are believed to be associated with human-mediated translocation (Palacios et al. 2015; Veríssimo et al. 2016).

Veríssimo et al. (2016) identified Morocco during the Early Pleistocene as the source for each lineage, with the western Rif Mountains serving as the geographic origin of lineage A (1.7–0.4 MYBP) (= *M. l. leprosa*), and the Atlas and Middle Atlas Mountains as origins of lineage B (1.5–0.3 MYBP) (= *M. l. saharica*). Changes in climate between glacial and interglacial periods are considered to have facilitated northward expansion in each lineage, with lineage A colonizing the Iberian Peninsula while lineage B expanded to the Rif Mountains during the Middle Pleistocene. Lineage A then continued its expansion across Iberia during the Late Pleistocene or Holocene while lineage B proceeded eastward, eventually including the northeastern portion of its current distribution in Africa.

Any discussion of intercontinental expansion and dispersion of *M. leprosa* requires consideration of the Strait of Gibraltar (Busack 1977, 1986). Electrophoretic examination of 37 loci within 30 protein systems (non-specific esterases, enzymes, and plasma proteins) from Spanish (Facinas, Benalup de Sidonia, and Río Hozgarganta [Cádiz Province]) and Moroccan (Ksar es-Seghir, Asilah, and Chefchaouen [Tanger-Tétouan-Al Hoceima Region])



Figure 4. *Mauremys leprosa saharica*, Tlemcen National Park, Ras Oued El Garsa, M'sila, Algeria. Photo by Khaled Merabet.

specimens determined locus polymorphism as 10.8% in each assemblage, with mean heterozygosity per locus as 0.04 in the southern Spanish assemblage and 0.14 in the northern Moroccan assemblage. Unbiased genetic distances (\hat{D} ; Nei 1978) both within, and between continental assemblages were essentially zero, and between-continent migration rates



Figure 5. Hatchling *Mauremys leprosa leprosa* at Center de Recuperació d'Amfibis i Rèptils de Catalunya, Spain. Photo by Joaquim Soler Massana.



Figure 6. Adult female *Mauremys leprosa leprosa*, Flix, Catalonia, Spain; as females age their head coloration becomes uniform. Photo by Albert Bertolero.

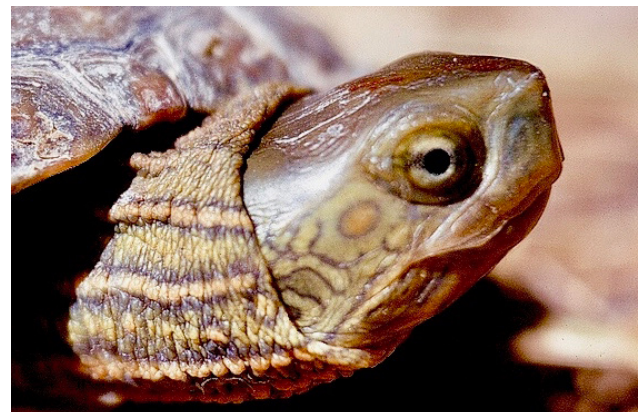


Figure 7. Juvenile *Mauremys leprosa leprosa*, southeast of El Ksiba, Beni Mellal, Morocco. Photo by Stephen D. Busack.

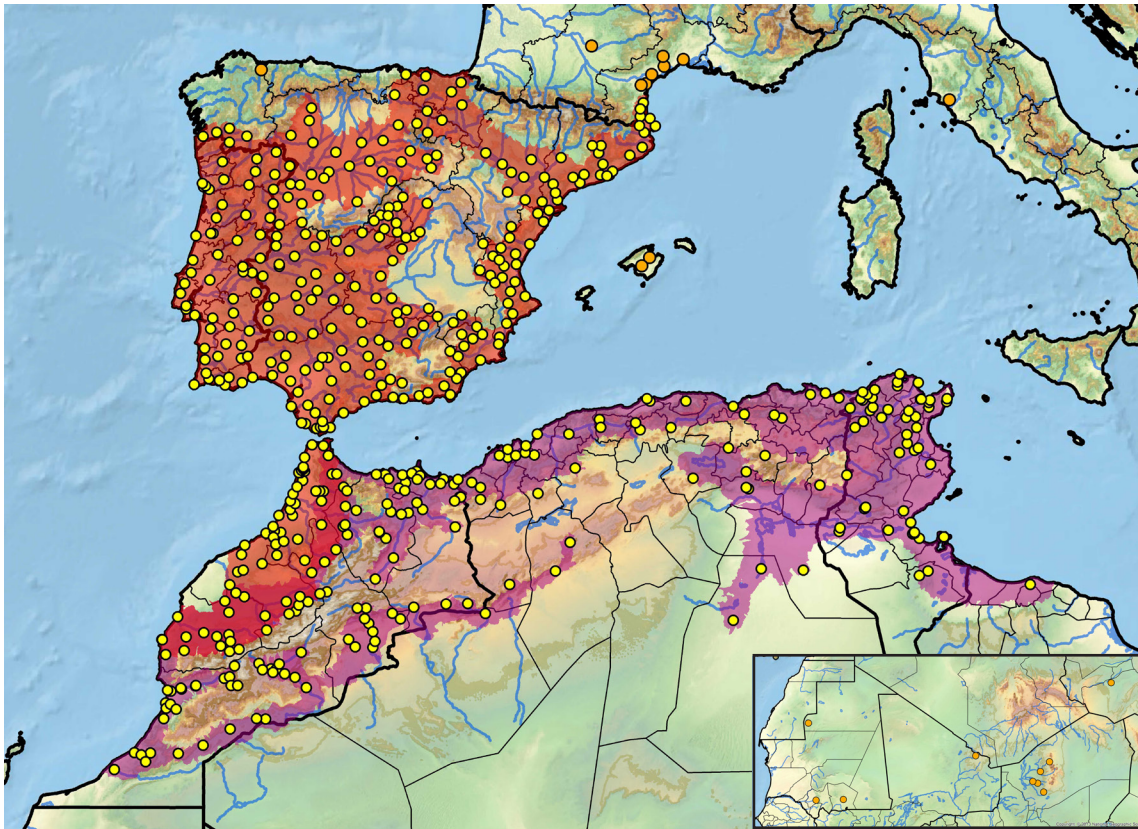


Figure 8. Historic distribution of *Mauremys leprosa* in southwestern Europe and northwestern Africa; inset shows Saharan region. Yellow dots = museum and literature occurrence records of native populations based on Iverson (1992) and other sources (Malkmus 1990; Fahd and Pleguezuelos 1996; da Silva 2002; Araújo and Segurado 2008; Hernández Socias 2009; Iñobe 2009; Martín i Pérez 2011; Buenetxea et al. 2011; Trape et al. 2012; Alarcos et al. 2013; Salvador and Pleguezuelos 2013; Díaz-Paniagua and Andreu 2014; Panzeri et al. 2014; Franch et al. 2015; Palacios et al. 2015; Sacco 2015; Mediani et al. 2015; Héritier et al. 2017); orange dots = introduced or historically relict populations; red shading = projected historic distribution of *M. l. leprosa*; purple shading = *M. l. saharica*; overlap (dark red shading) = intergrades. Distribution based on GIS-defined level 10 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 2014, 2017), and adjusted based on data from authors and other sources.

exceeded mutation rates (Busack 1985, 1986). Feldman and Parham (2004) found no intraspecific haplotype diversity between samples (likely including lineages A3-9 and A3-15 as noted by Veríssimo et al. 2016) from each side of the Strait of Gibraltar. Lack of genetic differentiation on both sides, and low genetic diversity in Iberian populations provide strong support for the hypothesis that the Strait of Gibraltar is permeable to intercontinental gene flow and dispersal; trans-Mediterranean gene flow has also been reported for *Mauremys rivulata* (Vamberger et al. 2014) and this mode of dispersion is considered likely for *M. leprosa* as well.

Etymology and Vernacular Names. — When a mud-encrusted individual *M. leprosa* emerges to bask, the horny shields of the carapace tend to become brittle and flake off. The specific epithet “*leprosa*” supposedly referred to the leprous appearance resulting from attacks by freshwater algae flourishing in the Malpighian layer and underlying bone, which may become gangrenous – see Gadow (1901) or Loveridge and Williams (1957). The holotype does not demonstrate this appearance, however, and Bour and Maran (1999) cited Schweigger’s (1812) description of

scutes covered with wart-like tubercles as the source of the epithet.

Recorded vernacular names for *M. leprosa* include *galápagoleproso* (Spanish), *cágado-mediterrânico* (Portuguese), *tortuga d’aigua* and *tortuga de rierol* (Catalan), *emyde lepreuse* (French), and *fakrun al-má* (Arabic [Morocco]).

Description. — Busack and Ernst (1980) discussed variation within and among populations from Europe and North Africa. The following general description is based upon data provided by Boulenger (1889), Busack and Ernst (1980), Hellmich (1956), Loveridge and Williams (1957), and Schreiber (1912). Wermuth and Mertens (1961) reproduced a black and white illustration of *M. leprosa* originally published by Gray (1860). Loveridge and Williams (1957) illustrated the skull. Sowerby and Lear (1872) provided excellent drawings of both adult and juvenile specimens. Bour and Maran (1999) provided photographs of the holotype (MNHN Paris 1934), and a detailed description of the synonymy.

Epidermal scute nomenclature follows Zangerl (1969) in the following synopsis. The carapace is depressed, anterior

and posterior margins are neither expanded nor serrated; a vertebral keel, distinct in young specimens, is generally absent in adults. The nuchal region is not emarginated and the posterior edge of the cervical scute is wider than the anterior portion. There are five (rarely six) vertebrae, wider than long, and generally wider than the pleurals in young individuals, but variable in adults. Four paired pleurals with generally interrupted and indistinct keels are present, along with 12 paired marginals.

Carapace color in adults is generally tan to olive. Large, black-bordered, yellow to orange blotches adorn each scute in some populations, and a series of longitudinal bars forming a broken mid-dorsal stripe is usually present. In young individuals the carapace is pale to dark olive-brown and the center of each pleural may be adorned with black-bordered yellowish spots, or with orange-yellow or red longitudinal streaks. Vertebrae in younger individuals may have narrow or broad median streaks of orange-yellow or red, and marginals are frequently edged with yellow, but these may be uniform in color, or each may be marbled with yellow. When any pattern is present, each epidermal scute is often edged with narrow black lines.

Plastron ground color is yellowish-brown. An elongate egg-shaped black patch is visible on either side of the seam between the pectoral and abdominal scutes in some individuals. Plastron and inferior marginals are more or less uniform in color in most adults, without definite pattern. Some adults, however, may have scattered and irregularly shaped dark brown blotches, nearly continuous, or with soft faded margins, throughout, and the plastron is sometimes heavily pigmented. A narrow yellow midseam stripe is sometimes present. Specimens with plastron length less than 110 mm often have dark blotches surrounded by narrow yellow borders in the center of the plastron. Truncate and not notched anteriorly, the plastron is broadly or deeply notched posteriorly; its gulars are paired, the pectorals are wide, and there is one pair of moderately-sized axillary scutes. The single inguinal on each side, also of moderate size, is not in contact with the femoral, and the anals are pointed. The plastron is slightly concave in males, and flat or convex in females. In males the plastral formula is abdominal >> femoral > pectoral >> gular > anal > humeral, for females it is abdominal >> pectoral > femoral >> gular > anal > humeral.

The head is short and broad, becoming massive with age. Jaw margins are never denticulated; mandible width at the symphysis is nearly equal to the horizontal diameter of the orbit. The head is olive to olive-gray in color (see Hinckley et al. [2015] for description of an aberrant facial pattern), and also has an ocellus of yellow or orange located between the tympanum and orbit and sometimes connected to the tympanic ring. Four or five yellow (orange) longitudinal stripes extend anteriorly from the neck, passing above the tympanum to the orbit, and there is a yellow line extending

to the corner of the mouth and continuing along the border of the maxilla to its medial tip. Limbs are olive, with yellow or orange stripes and markings become subdued with age. Variation in limb stripe color is related to body size and immune response in females, and in females limb stripe color is brighter, with more orange and less UV saturated coloration, than in males (Ibáñez et al. 2013a).

Measurements (mm) for the largest male examined by Busack (KU 47509, Sulayman, Tunisia [36.70000°N, 10.48333°E]) are as follows (sample means and numbers of specimens examined [Busack and Ernst 1980] in parentheses): straight midline carapace length (CL) 174.5 (105.1, 44), carapace width (CW) 117.3 (73.8, 44), carapace height (CH) 61.9 (37.3, 44), marginal width (MW) 13.9 (13.1, 44), bridge width (BW) 51.1 (32.0, 44), midline plastron length (PL) 151.6 (92.0, 44), and head width (HW) 27.1 (18.2, 43). For the largest female (USNM 196486, Ouarzazate, Morocco [~30.93376°N, 6.92642°W]), CL 220.0 (139.1, 38), CW 150.2 (101.2, 38), CH 82.8 (52.9, 38), MW 12.6 (11.8, 38), BW 77.7 (46.8, 37), HW 31.0 (24.3, 34), and PL 215.0 (128.7, 38).

In Spain, CL ranges, on average, between 99–167 mm in males and 114–182 mm in females; in Portugal males average 141 and females 162 mm; in Morocco turtles are generally smaller, between 82–134 in males and 97–196 mm in females (Meek 1987; da Silva 1995; Muñoz and Nicolau 2006; Alarcos Izquierdo et al. 2009; Benejam and Saura-Mas 2009; Lovich et al. 2010; Naimi 2015). The largest known female (CL 239.5 mm) was observed in the Llobregat Delta, Spain (Franch Quintana et al. 2007), and the largest male (CL 210.0 mm) in Huelva, Spain (Pérez-Santigosa 2007).

Distribution. — Southwestern France, Spain, Portugal, Morocco, Algeria, Tunisia, and western Libya harbor populations of *M. leprosa*, and there are isolated populations in Mauritania and Niger. Joger and Lambert (1996) report that, although historical records exist, the species has not been recorded from Mali since the second half of the 20th century. Isolated records not recently confirmed for Senegal, Gambia, and Benin may be errors in locality attribution or species misidentification. Bour and Maran (1999) considered the River Gambia, the type locality from which *M. Castang* reported *Emys laticeps* (Gray 1854) to be in error, and Loveridge and Williams (1957) rejected Porto-Novo (Benin), the locality recorded by M. Waterlot for MNHNP 1917.21-22 on authority of Paul Chabanaud who reported the specimens had been destroyed and that nothing concerning the collector's itinerary could be found.

In northwestern Africa *Mauremys* occurs where other aquatic turtles are absent; it demonstrates a tendency to concentrate where freshwater is limited, and a tolerance for truly unsavory conditions. Rozet (1833) reported astonishing abundance in Algeria, where scarcely a pool, stream, or river lacked terrapins, and Stemmler-Morath (1952)



Figure 9. Habitats of *Mauremys leprosa*. *Top Left:* Ahouinez Khenifra, Meknès-Tafilalet, Morocco; photo by Stephen D. Busack. *Top Right:* Oued Assaka, Guelmin, Morocco; photo by Juan M. Pleguezuelos. *Middle Left:* l'Algars, Tarragona-Teruel, Spain; photo by Albert Bertolero. *Middle Right:* Cerro del Trigo, Córdoba, Spain; photo by Ricardo Reques. *Bottom Left:* Aïn Draham, Jendouba, Tunisia; photo by Mohsen Kalboussi. *Bottom Right:* near Tabarka, Jendouba, Tunisia; photo by Philip de Pous.

reported *Mauremys* abundant in most bodies of water, including swift streams of the High Atlas, excluding only the most temporary desert streams. In Mauritania, populations remain between Assaba (Kiffa) and Hodh El Gharbi (Ayoûn el Atrouïs) regions but are considered extinct in Fdérick (Tiris Zemmour region). Isolated populations may be found in *gueltas* (rock pools) at Timia, Taraouadji and Tamgak, the valley of Telloua, and in the pond of Tafadek in Niger (Trape et al. 2012). Within Morocco, north of the Atlas Mountains, *M. l. leprosa* is found at localities north and south of Rabat; north-northeast of Taza, Oued Serou,

Oued Oum Er-Rbia; south of Khenifra; south of Marrakech, and west to Agadir. South of the Atlas Mountains, *M. l. saharica* is found at Oued Ziz, Er Rachidia, Erfound, Rissani, Sidi El Mehdaoui (see Maran 2010), Out Draa, and *oueds* (wadis) near Goulimine.

On the Iberian Peninsula, *Mauremys* is widely distributed in central and southern Portugal and central and southwestern Spain, along the Ebro River and Mediterranean coast (da Silva 2002; Díaz-Paniagua and Andreu 2014; Franch et al. 2015; Rodríguez-Rodríguez et al. 2015), but present only in scattered localities in Galicia, Asturias, Cantabria,

Euskadi, Navarra, and Castilla y León in northern Spain (da Silva 2002; Díaz-Paniagua and Andreu 2014). It is found discontinuously in northwestern Portugal, but substantial populations occur in an area parallel to the Spanish border, 30–60 km wide, with an exception for the Serra da Estrela and Serra da Malcata, extending southwest of Bragança along the Rio Douro (east of Régua), Rio Côa, Rio Tua, and Rio Sabor north of the Rio Tejo. The species is also quite common within a 30–60 km wide corridor parallel to the coast south from Nazaré and the Rio Tejo to the mouth of the Rio Zézere, with tributaries of the Rio Guadiana and environs of the Serra de São Mamede serving as distribution nuclei (Malkmus 2004; Araujo and Segurado 2008).

The species is localized in southwestern France, with small populations in the Rivers Basse, Baillaury and the stream Tech (Département des Pyrénées-Orientales), and the River Agly (Département de l'Aude) (Franck 1998; Palacios et al. 2015); individuals observed in other French localities are considered introductions (Palacios et al. 2015). Introduced individuals have been reported in the Balearic Islands where it has been seen on Mallorca in S'Albufera Natural Park and Sineu (Pinya et al. 2008). Several introduced specimens without species designation have been reported from Italy, but positively identified *M. leprosa* specimens from Gabellino (Grosseto Province) likely represent escaped captives (Panzeri et al. 2014).

Habitat and Ecology. — *Mauremys leprosa* is thermophilic. It coexists with *Emys orbicularis* in some aquatic habitats (da Silva 1993; Segurado and Araújo 2004), and appears less selective in habitat requirements. In rivers it demonstrates a preference for deep, stony areas (Segurado and Figueiredo 2007; Segurado et al. 2012), but it inhabits moderately swift streams bordered by trees, as well as potholes in brooks and swampy meadows, perennial and temporary water bodies with rocky, sandy, or muddy bottoms, with or without vegetation, and anthropogenic habitats, including irrigation systems for agriculture (rice paddies), watering sites for cattle, and village ponds, but it may be absent from areas of intense agriculture. Basking sites include rock and soil terraces, roots, mud banks, solidified flotsam, and items protruding from, or overhanging the water (boulders, tree trunks, structural elements of bridges and dams).

Absence of salt glands, coupled with the inability to use urea as an osmoregulatory effector, prevent long-term adaptation to sea water (Gilles-Baillien 1970), but temporary tolerance of sea water has been demonstrated experimentally (Schoeffeniels and Tercafs 1965), and the species has been reported in the brackish water of estuaries (Ria Formosa/Faro, Ria Mira, Ribeira de Aljezur) within Portugal (Malkmus 2004).

In Morocco it may occur at high densities, even in shallow water (Busack, pers. obs.). During hot summer months (August–September), as ponds and watercourses begin

to dry, turtles crowd into remaining pools, their numbers contributing to the foulness of the stagnant water. When everything edible is consumed they seek shelter among the rocks where they bury themselves until the return of rainy weather (Stemmler-Morath 1952).

In Spain (Castellón, Doñana National Park, Ebro Delta) it is practically absent from marshes (Keller et al. 1995; Albert and Gómez-Serrano 2000; Bertolero and Oro 2009). In Doñana Natural Park it prefers the larger and more permanent ponds (Keller et al. 1995); in Castellón it is found only in rivers, but its distribution is not related to pH or salinity levels (Albert and Gómez-Serrano 2000). In Salamanca, where it and *E. orbicularis* occur together, it prefers permanent, deep and wide rivers over arroyos and stationary water where *Emys* is more frequently observed; 80% of observations were made in developed areas shared by humans (Gómez-Cantarino and Lizana 2000).

Most populations are distributed preferentially at elevations below 100 m in Catalonia (Franch et al. 2015). Some populations or individuals, however, are found at elevations as high as 1800 m in Morocco (Bons and Geniez 1996), 1250 m in Spain (Gúejar Serra [UTM 30S VG607145]; Benavides et al. 2001), 930 m in Portugal (Araújo and Segurado 2008), and up to 500 m in France (Geniez and Cheylan 2012). *Mauremys leprosa* tolerates eutrophic waters well, and may be found in heavily polluted waters. West of Marrakech in a segment of the Oued Tensift (32.019997°N, 9.340001°W, ca. 15 m above sea level) polluted by raw domestic and industrial wastewater discharges, *M. leprosa* appears as the most common aquatic vertebrate (Naimi et al. 2012). How pollutants affect individual health or long term population viability, however, is unknown.

Population Structure, Survivorship, and Longevity. — Araújo et al. (1997) noted that 67% of a population in Portugal was adult. Meek (1987) suggested that females grew faster than males in southern Morocco; his sample contained mostly individuals aged 4–7 yrs, with the oldest male being >23 yrs of age, and the largest female >20 yrs of age.

In a terrapin sample from the Parque Natural de los Arribes del Duero (Salamanca Province, Spain), secondary sexual characteristics became noticeable at a CL of 73 mm for males and 79 mm for females (Alarcos Izquierdo et al. 2009). The distribution of CL in females was unimodal, and concentrated between 100 and 165 mm; male distribution was bimodal, with 80–90 and 130–145 mm representing peaks. Juveniles comprised 12.2%, females 48.6%, and males 39.2% of the population, and the overall male:female ratio was 1:1.14.

Domínguez and Villarán (2010), working with 488 individuals in Málaga Province, Spain, determined that adult females outnumbered adult males (2.56:1), but immature males outnumbered immature females (1.57:1) in

this population. Immature males had the highest recapture rate (46.6%), a statistically significant percentage difference when compared to rates for adult females (39.0%), adult males (33.3%), and immature females (31.7%). Further, when the number of individuals having been recaptured two or more times was considered, only immature males presented a statistically significant difference from other age classes. That immature males were recaptured with the greatest frequency and in large numbers, and immature females were rarely recaptured, may indicate site fidelity and/or a lower dispersal rate in immature males, coupled with a higher dispersal rate and/or a lower survival rate for immature females.

The terrapin population in Doñana National Park, Spain, was estimated between 1991 and 1995 as 67% adult, 27% subadult, and 5% juvenile; maximum age for males was estimated at 29 years, and for females at 32 years. Estimated annual survival for the adult population was 87.1%, and for juveniles, 77.1% (Keller 1997b). Following a period of severe drought (1998), Keller (1999) recorded an increase to 28% in the proportion of juveniles. This increase apparently continued, albeit somewhat reduced to 23%, into 2003 (Pérez-Santigosa 2007).

Growth and Sexual Maturity. — Maturation is correlated with size rather than age, but in natural habitats, females become sexually mature in about 7–8 yrs. In Spain, males reach sexual maturity between 135–140 mm CL and females between 138–150 mm CL (Pérez et al. 1979). In Morocco (Oued Tensift), females between 124 and 200 mm CL carried shelled eggs (Naimi et al. 2012), and in Spain (Salamanca) females with calcified eggs ranged between 141.9 and 175 mm CL (Alarcos Izquierdo et al. 2009). Carapace length in turtles released in Spain at the Ebro Delta increased at a rate of 9.8 mm/yr in females and 6.6 mm/yr in males, while body mass increased 100 g/yr for females and 48 g/yr for males (Bertolero and Oro 2009).

Females are ca. 28% larger than males overall, but this size difference can increase to 63% in some populations (e.g., northern Morocco; Naimi 2015). Total tail length is similar between sexes, but preanal tail length is greater in males than females (Keller 1997a; Muñoz and Nicolau 2006). After controlling for carapace length, females have longer plastrons, greater anterior and posterior carapace widths, and a higher domed carapace than males (Muñoz and Nicolau 2006). Regression slopes for carapace length against mass for specimens from southern Morocco were determined to be between 0.36 and 0.41 for 33 males and 0.37 and 0.39 for 51 females (Meek 1987), a difference not likely to have biological significance. In an analysis seeking to identify variation in size and shape related to sex, Rouault and Blanc (1978), using carapace and plastron characteristics in 45 specimens from Tunisia, suggested that only the difference in “perpendicularity” between

anterior and posterior gular and nuchal lengths in specimens with a mass of 300 g is useful for determining sex without dissection.

Keller (1997a), in a discriminant function analysis of more than 2500 live specimens from Doñana National Park, concluded that sexes may be distinguished for turtles two years and older on the basis of tail elongation and plastron edge to vent distance. Dissected males from a nearby site in Extremadura were found to be mature when they surpassed 85 mm CL, coincidental with the mean size of two-year-old males; empty shells, however, were difficult to sex, and the distance between rear margins of carapace and plastron, cited by Pérez et al. (1979), was found unreliable as a sex determinant.

Thermoregulation. — *Mauremys leprosa* can withstand an ambient temperature of 47°C for up to two hours without harm (Pagés et al. 1991). Cloacal body temperatures of 30 alternatively submerged and basking terrapins were regulated between 24–29.5°C (mean for males = 26.4°C, for females = 26.8°C; maximum voluntary temperature = 29.5°C) in a concrete-lined irrigation channel surrounded by sand in southern Morocco where sand temperatures varied between 45–60°C, air temperatures 30–39°C, and water temperatures 24–31°C, data consistent with the species using a behavioral strategy of limited heliothermy coupled with a large degree of thermoconformity to maintain a stable body temperature (Meek 1983). Polo-Cavia et al. (2012), working under controlled conditions with individuals captured in southern Spain, found that values for setting upper set point body temperatures for *M. leprosa* varied as much as 2.4°C depending upon feeding status (higher after feeding) and surface/body ratio. When body temperatures reached 31.9°C, terrapins ceased basking.

Under experimental conditions, *M. leprosa* cools faster than it heats (heating/cooling ratio 0.49); the gradient between ambient temperature and equilibrium body temperature increases progressively when ambient temperature rises over 25°C, and thermoregulatory hyperventilation is detected at 40°C. At body temperatures between 5–35°C, lung ventilation per unit of O₂ uptake, and unit of CO₂ removed, both decline, and lung CO₂ partial pressure increases with temperature. Partial pressure of CO₂ is maintained within narrow limits at each thermal constant, suggesting suitable control throughout the complete ventilatory cycle. At 40°C, however, the ratio of ventilation to gas exchange increases compared with values at 35°C. The impact of increased breathing (lowering mean partial pressure of alveolar CO₂) was lower than expected, suggesting that relative hyperventilation in response to hyperthermia in *M. leprosa* is related to evaporative heat loss (Pagés et al. 1991, 1994). With a heating rate of 0.039°C/min, the female rate of cooling was 0.06°C/min in air, and 0.19°C/min in water under experimental conditions (Polo-Cavia et al. 2009a).

Behavior. — This species generally spends the night in the water and the cold season in the mud (Gadow 1901); activity patterns depend upon climatic conditions and hibernation can be intermittent during mild winters (Lortet 1887; Doumergue 1901; Aellen 1951). At Llobregat Delta (Barcelona, Spain), terrapins hibernate between mid-November and late February (Franch Quintana et al. 2007), while individuals in Andalusia hibernate between 37 and 114 days from late November to early April (Pérez-Santigosa et al. 2013). Hinckley et al. (2014) described the use of an abandoned iron mine tunnel at Valmayor (Ciudad Real, Spain; 38.406529°N, 4.167078°W) where the microclimate close to the entrance allows terrapins to be active during winter.

Males compete for females, and the sound of male carapaces colliding may reverberate during mating season. Courtship behavior involves the male swimming in a circle around the female; at each passage the couple reportedly touch noses, and horizontal movements and oscillations of the head are common (Tarrajat 1962). Copulation may take place on the ground or in the water with the male's gripping the female's carapace with all four feet (Tarrajat 1962). If in the water, copulation usually occurs on the surface, but mated pairs sometimes descend to the bottom where they may remain immobile (Lortet 1887). Extremely wary while basking, when a human approaches from up to 80 m, depending upon level of visibility for observer and turtle (López et al. 2005), *M. leprosa* generally scrambles or drops into the water or, on occasion, leaves the water to hide under rocks or in dense vegetation (Maran 1996). Under experimental conditions the length of time a male with bright limb coloration remains withdrawn into its shell is longer than that of a less brightly colored male; females, however, do not appear to exhibit this differential behavior (Ibáñez et al. 2014). When handled, freshly caught *M. leprosa* emit a foul-smelling musk derived from inguinal glands opening just behind the bridge (Gadow 1901; Busack, pers. obs.).

Chemosensory discrimination between sexes has been demonstrated under experimental conditions (Ibáñez et al. 2012, 2013b). Males preferred water in which chemical cues (odors) advertised females with higher-level immune responses, females preferred pools in which cues indicated larger, or relatively larger, males were present. Males avoided water where chemicals from heavier males were present, and preferred water with chemicals indicating the presence of smaller, or relatively smaller, males. Degree of boldness in males, associated with dominance, also affected responses to water-borne chemical cues; bold males preferred to associate with familiar males over unfamiliar males, whereas shy males avoided scents of both familiar and unfamiliar males (Ibáñez et al. 2013b).

Little is known about spatial ecology of *M. leprosa*, but in El Portil pond (Huelva Province, Spain) aquatic home

range for 4 males was 3.1 ha, and home range for 2 females was 3.6 ha when native (*E. orbicularis*) and exotic (*Trachemys scripta*) aquatic turtles were also present. Home range areas among the three species differed only in winter when *T. scripta* moved in larger areas and had a greater level of activity than natives (Pérez-Santigosa et al. 2013).

Reproductive Biology. — *Mauremys leprosa* mates in April and May in North Africa (Lortet 1887; Combescot 1954a,b, 1955; Combescot and Guyon 1955), but Naimi (2015) observed courtship and mating behavior most often between January and March at Oued Tensift, Morocco. In Doñana National Park courtship was observed during spring (March to May), and from late summer into autumn (late August into November) (Díaz-Paniagua et al. 2015). Nesting, dependent upon local conditions, has been recorded from May to August; calcified oviductal eggs may be detected from April to July (Lortet 1887; Tarrajat 1962; González de la Vega 1989; Keller 1997b; Díaz-Paniagua et al. 2014; Naimi 2015). The report of a female in Algeria having laid nine eggs between 2 and 3 September (Doumergue 1901) is exceptional.

Clutch size, generally, is correlated positively with carapace length (da Silva 1995; Keller 1997b; Naimi et al. 2012), but not always (Andreu and Villamor 1989). Clutch size ranges from 1–13 eggs, with means ranging from 3.8 to 9.6 eggs per clutch, depending upon the population examined (see Díaz-Paniagua and Andreu 2014, and references therein). Females normally lay only one clutch annually, but two clutches have been reported from Andalusian populations (Andreu and Villamor 1989; Keller 1997b; Díaz-Paniagua et al. 2014). The report by Lortet (1887) that the female's head remained withdrawn during oviposition and eggs were arranged and covered using her forelimbs seems unlikely, however, as hind limbs are used to close the nest cavity and smooth over disturbed substrate (Tarrajat 1962).

Eggs are white, elliptical, and semi-hard-shelled, and egg size is correlated with clutch size in Spain and Morocco (Andreu and Villamor 1989; da Silva 1995; Keller 1997b; Naimi et al. 2012). Egg length in Iberia ranges between 25.8 and 40.3 mm, width 17.7 to 24.9 mm, and mass 5.8 to 10.7 g (Andreu and Villamor 1989; da Silva 1995; Araujo et al. 1997; Keller 1997b; Díaz-Paniagua et al. 2014), and in North Africa egg length ranges between 27.6 and 40 mm, width 16.3 to 22.2 mm, and mass 3.4 to 9.3 g (Doumergue 1901; Tarrajat 1962; Naimi et al. 2012).

Incubation periods of 25 to 30 days have been reported for North Africa (Lortet 1887; Tarrajat 1962) but these periods seem somewhat brief in that southern European populations require between 55 and 108 days (González de la Vega 1989; Maran 1996; Segurado et al. 2005). Deposition to hatching required 92 days under a constant incubation temperature of 27°C (Pérez-Santigosa 2007).

Hatchlings in Doñana National Park average 27.8 mm in CL and 4.6 g body mass (Díaz-Paniagua et al. 2014), and in the Ebro Delta 29.1 mm in CL and 5.9 g body mass (L. Fortuño, pers. comm.). First year juveniles in Doñana have average CL of 30.8 mm and a mean body mass of 6.8 g (Keller 1997b). Doumergue (1901) reported the CL of numerous young specimens in Algeria to average 30 mm in April, and by mid-August to have increased, on average, to 45 mm. Upon emerging, hatchlings hasten to the water where they dig several millimeters into the mud; few remain near the surface. The carapace becomes flat and almost circular a few days after the turtle has left the egg (Lortet 1887). Hatchlings can overwinter in the nest (Gadow 1901; Díaz-Paniagua et al. 2014).

Gonadal differentiation and intersexuality have been examined under normal and hormonally-induced conditions; vestigial oviducts may be present for an extended period following hatching in males (Stéfan 1959, 1963). In North Africa interstitial cells are well developed between March and May, regress in June, become rare in August, and begin to enlarge again during November and December; spermatogenesis terminates at the end of August (Combescot 1954b; Combescot and Guyon 1955). Male cloacal and copulatory organ structures are illustrated in Wood Jones (1915). Neurosecretory manifestations of female puberty are illustrated in Aron et al. (1961). Secretory glands and cilia are absent in the oviduct of specimens with plastron lengths of 80 mm, but oviductal mucosa include ciliated and incipient epithelio-glandular cells in specimens 110 to 130 mm in plastron length. Two-thirds of the oviduct in sexually mature *Mauremys* contain cells with secretory granules, and secretory granules are present in acini of specimens 130 mm in plastron length (Combescot 1955). Embryogenesis of the skull has been described (Kunkel 1912), as has overall embryonic development (Dalcq and Pasteels 1954; Pasteels 1970).

Predation. — Five bird taxa have been recorded as predators; to date, the list includes Purple Herons (*Ardea purpurea*: Pellegrin 1926), White Storks (*Ciconia ciconia*: Cramp 1977), Egyptian Vultures (*Neophron percnopterus*: Garzón 1973; Pérez-Chiscano 1974; Bergier and Cheylan 1980), the Eurasian Eagle Owl (*Bubo bubo*: Hiraldo et al. 1975; Cramp 1985), and Black Kites (*Milvus migrans*: Fernández-Cruz 1974; Delibes Castro 1975).

Four mammal species, including Wild Boar (*Sus scrofa*: Venero 1984), Red Fox (*Vulpes vulpes*: Keller and Busack 2001), Egyptian Mongoose (*Herpestes ichneumon*: Palomares and Delibes 1991), and the European Otter (*Lutra lutra*: García and Ayres 2007) have been identified as predators. Extensive turtle predation by otters can occur all year long in southern Spain; carapaces between 100–150 mm may be found in droppings (Clavero et al. 2005; Saldaña and Prunier 2006). Introduced crayfish (*Procambarus clarkii*:

Araújo and Segurado 2008; Courmont and de Sousa 2011) and other invertebrates, such as the scorpion, *Buthus occitanus*, occasionally feed on juvenile terrapins (Bejarano and Pérez-Bote 2002).

Diet. — The diet of *M. leprosa* appears both opportunistic and omnivorous. In a study in Huelva Province, Spain, assessing food competition among *E. orbicularis*, *T. scripta*, and *M. leprosa*, Pérez-Santigosa et al. (2011) found *M. leprosa* to be primarily herbivorous at one pond (El Portal), and carnivorous at another (El Acebuche), and concluded that the species was capable of varying its diet in response to variability in feeding resources. Among aquatic plants associated with its diet are algae, grass (*Glyceria* sp.), starwort (*Callitriche* sp.), water crowfoot (*Ranunculus* sp.), and duckweed (*Lemna gibba*) (Labouysse 1857; Alarcos et al. 2008).

Vertebrate food sources include fish (*Cyprinus carpio*?), frogs (*Pelophylax perezii*), newts (*Triturus marmoratus*), anuran larvae (*Pelobates cultripes*, *Hyla meridionalis*, *Epidalea calamita*), anuran eggs (*Bufo bufo*), snakes (*Natrix maura*), and duck eggs (*Anas platyrhynchos*) (Gómez-Mestre and Keller 2003; Pérez-Bote et al. 2005; Alarcos et al. 2008; de Vries and Marco 2008; Domínguez and Villarán 2008; Pérez-Santigosa et al. 2011). Boscá (1880) and Domínguez and Villarán (2008) found *Natrix maura* remains in excrement and suggested the snake was taken whole, probably as carrion. Terrapins have been observed feeding on corpses of horses that had fallen in the water (Rozet 1833).

Among invertebrate prey, coleopterans represented 20%, while introduced crayfish (*Procambarus clarkii*) represented 80% of animal prey at El Acebuche. Crayfish were substantially less important as prey at El Portal, but midge larvae (Chironomidae, Diptera) were found in 43.7% of individuals (Pérez-Santigosa et al. 2011). Other crustaceans (Branchiopoda; *Cyzicus grubei* [ca. 12–13 mm carapace length]), insects (Heteroptera, Odonata, Hymenoptera, Ephemeroptera [Mayflies; *Ecdyonorus venosus*]), gastropods, and worms are also consumed (Pérez-Bote et al. 2005; Alarcos et al. 2008; Pérez-Santigosa et al. 2011).

Stemmler-Morath (1952) found individuals feeding on human excrement at least a meter from the nearest water, and a half dozen specimens found in a dry ditch used by local people as a toilet were in good health and said to have lived there as long as a local farmer could remember, and Werner (1912) reported wastewater discharged from slaughterhouses as constituting viable habitat. In more salubrious environments in Spain and Tunisia, this turtle forages and feeds nocturnally (Busack, unpubl. data), but it also feeds diurnally. In captivity it will eat lettuce, legumes, and scraps of bread (Doumergue 1901).

Parasites. — A summary of known parasites arranged following classifications available in the Encyclopedia of Life (<http://eol.org>) is provided in Table 1. Males parasitized by

Table 1. Parasites recorded for *Mauremys leprosa*; * North American origin; ** eggs only.

Taxon	Target Organ	Country	References
Eukaryota (Amoebozoa: Entamoebidae)			
<i>Entamoeba invadens</i>	cloaca	Tunisia	Mishra & Gonzalez 1978
Eukaryota (Coccidia: Haemogregarinidae)			
<i>Haemogregarina bagensis</i>	erythrocytes	Algeria, Tunisia	Billet 1904; Ducloux 1904 (see also Dvořáková et al. 2014)
<i>Haemogregarina stepanovi</i>	erythrocytes, liver	Algeria, Tunisia	Mishra & Gonzalez 1978; Dvořáková et al. 2014
Eukaryota (Coccidia: Hepatozoidae)			
<i>Hepatozoon</i> sp.	erythrocytes	Spain	Ibáñez et al. 2015
Platyhelminthes (Trematoda: Polystomatidae)			
<i>Neopolystoma elisabethae</i> **	conjunctival sac	France	Héritier et al. 2017
<i>Neopolystoma euzeti</i>	urinary bladder, rectum	France, Spain, Algeria, Tunisia, Morocco	Combes & Ktari 1976; Meyer et al. 2015 Héritier et al. 2017
<i>Neopolystoma orbiculare</i> *	urinary bladder**	France, Spain	Meyer et al. 2015; Héritier et al. 2017
<i>Neopolystoma</i> sp. nov. 3*	urinary bladder**	France, Spain	Meyer et al. 2015; Héritier et al. 2017
<i>Neopolystoma</i> sp. nov. 4	urinary bladder**	France	Meyer et al. 2015; Héritier et al. 2017
<i>Neopolystoma</i> sp. nov. 6*	conjunctival sac	France	Meyer et al. 2015; Héritier et al. 2017
<i>Polystomoides tunisiensis</i>	pharynx, esophagus	France, Spain, Algeria, Tunisia, Morocco	Mishra & Gonzalez 1978; Fraysse 2002; Meyer et al. 2015; Héritier et al. 2017
<i>Polystomoides orys</i> *	pharyngeal cavity	France	Verneau et al. 2011; Meyer et al. 2015 Héritier et al. 2017
<i>Polystomoides</i> sp. nov. 1	pharyngeal cavity**	France	Meyer et al. 2015; Héritier et al. 2017
Unidentified sp.**	unspecified	Spain	Héritier et al. 2017
Platyhelminthes (Trematoda: Telorchiiidae)			
<i>Telorchis temimi</i>	posterior gut	Tunisia	Mishra & Gonzalez 1978
<i>Telorchis qabensis</i>	unspecified	Tunisia	Gonzalez & Mishra 1977
<i>Telorchis solivagus</i>	intestines, posterior gut	Spain, Tunisia	López-Román 1974; Mishra & Gonzalez 1978; Roca et al. 2005
Platyhelminthes (Trematoda: Auridistomidae)			
<i>Patagium pellucidum</i>	intestines	Spain	López-Román 1974; Roca et al. 2005
Nematoda (Ascaridida: Kathlaniidae)			
<i>Falcaustra</i> sp.	intestines	Spain	Roca et al. 2005; Hidalgo-Vila et al. 2009
<i>Falcaustra donanaensis</i>	intestines	Spain	Hidalgo-Vila et al. 2009
<i>Falcaustra lambdiensis</i>	large intestine, cloaca	Algeria, Tunisia	Seurat 1918; Mishra & Gonzalez 1978; Fraysse 2002
Nematoda (Spirurida: Physalopteridae)			
<i>Physaloptera</i> sp.	intestine	Spain	Hidalgo-Vila et al. 2009
Nematoda (Spirurida: Gnathostomatidae)			
<i>Spiroxys</i> sp.	stomach, intestines	Spain	Roca et al. 2005; Hidalgo-Vila et al. 2009
<i>Spiroxys contortus</i>	stomach, large intestine	Algeria, Tunisia	Seurat 1918; Mishra & Gonzalez 1978; Fraysse 2002
Unidentified larvae	gall bladder	Tunisia	Mishra & Gonzalez 1978; Fraysse 2002
Annelida (Hirudinea: Glossiphoniidae)			
<i>Placobdella costata</i>	hind limbs	Tunisia	Mishra & Gonzalez 1978; Fraysse 2002; Ben Ahmed et al. 2008

Hepatozoon (Coccidia: Hepatozoidae) demonstrate higher levels of basking activity and have lower leukocyte volumes than unparasitized individuals. Ibáñez et al. (2015) suggested that increased basking may serve to strengthen immune systems in parasitized individuals; they further noted that males with bright limb stripe coloration bask less than those more conspicuously colored, and suggest that color conspicuity may increase predation risk for parasitized individuals.

Population Status. — Substantial populations exist in Morocco, Algeria, and Tunisia, but recent detailed information is unavailable.

In France, *M. leprosa* is localized, and it is considered the most threatened reptile in that nation (Franck 1998; Cheylan and Verneau 2012). Guillaume (1976) considered the species to be introduced by humans into France, but Franck (1998) hypothesized that it had arrived naturally from adjacent Spanish populations. Knoepffler (1979) considered the small population of regularly reproducing individuals in the Baillaury River upstream from Banyuls-sur-Mer, France, to be autochthonous, and Palacios et al. (2015) have found populations from Catalonia, Spain, and those from the Baillaury River and adjacent streams, to

share Cytochrome b haplotypes. Fossil evidence, coupled with these haplotype data, support the hypothesis that *M. leprosa* is present naturally as far north as St. Hippolyte (Department Haut-Rhin; ~42.78453°N, 2.96649°E) in French Catalonia. Individuals or populations found outside of French Catalonia are suspected to have arrived there by uncontrolled release of captives from as far south as Morocco (Palacios et al. 2015).

Populations are declining in the Spanish regions of Valencia and Extremadura (Jiménez et al. 2002; da Silva 2002), but apparently increasing in Catalonia (Franch et al. 2015). The presence of the species in northwestern Portugal has become greatly reduced during the past century (Araújo and Segurado 2008).

Threats to Survival. — Once marketed in Spain as food and pets, sale of terrapins is currently illegal. Hundreds were once sold at the Algiers fish market (Strauch 1865) and in Morocco the species is sometimes fashioned into objects sold to tourists. Other threats include killing by fishermen; north of Bonanza (Cádiz Province, Spain) in late June 1970, Busack (unpubl. data) recorded many (ca. 160) dead juvenile and large adult *M. leprosa* (and 3 *Natrix maura*) in trash piles along access roads next to the Guadalquivir River (see also Honegger 1981).

As inhabitable wetland areas become less available (climate change, agricultural re-distribution of rainfall and groundwater), migration in search of suitable nesting areas over less suitable terrain (highways, etc.) presents variable threats. The species may also be affected by biocide-laced drainage, and by competition from the North American slider turtle *T. scripta*. Predation on juveniles by introduced crayfish (*Procambarus clarkii*) may also be a problem.

Conservation Measures Taken. — The Mediterranean Pond Turtle is considered Vulnerable in the European Red List of Reptiles (Cox and Temple 2009), and is included in Appendix II of the Bern Convention (European Wildlife and Natural Habitats), and in Annexes II (conservation requires special area designation) and IV (in need of strict protection) of the European Union Habitat Directive (92/43/CEE). *Mauremys leprosa* inhabiting wetlands in National Parks, Natural Parks, Reserves, or within the Natura 2000 network, are partially protected. Specific conservation-related actions for populations inhabiting France, Portugal, Spain, Morocco, and Algeria are as follows:

France. — Previously undiscovered populations of *M. leprosa* have been identified (Groupe Ornithologique du Rousillon [GOR]; Courmont and Rodriguez 2004); the species is included on the protected species list, Ministerial Decree, Article 2, 19 November 2007, and classified Endangered in the national Red List (IUCN France et al. 2009); and the Baillauray population is being monitored by the University of Perpignan (Verneau, 2010). A national action plan has been formulated (Courmont and de Sousa 2011).

Portugal. — The species is included in Law 316/1989 (Annex II) and Law 140/1999 (Annex B-II and B-IV), but classified Least Concern in the Red Book (Cabral et al. 2005).

Spain. — The species is included in royal decree 1193/1998 (Annex II); law 42/2007 (Annex II); royal decree 139/2011 (wildlife species with special protection); and royal decree 1015/2013 (Annex II) nationally. Regionally, the government of Aragón decree 181/2005 (Annex IV), the government of Catalonia laws 3/1988 and 12/2006, the government of Euskadi order 10 January 2011 (Vulnerable), the government of Extremadura decree 37/2001, and the government of Madrid decree 18/1992 (Vulnerable) provide varying degrees of protected status. Balmori (2014) provides an assessment of the utility of legislation addressing invasive species for the conservation of turtle species in Spain. The Spanish Red Book classifies the species as Vulnerable (Pleguezuelos et al. 2002).

Reintroduction projects involving 537 specimens were undertaken between 1987 and 2001 in two lagoon systems at the Parc Natural del Delta de l'Ebre (Tarragona Province). However, the assessment of this reintroduction concluded that the project was unsuccessful, perhaps because low-quality habitats had been selected. Estimates of survival rates from the second year following release were 65.3% for males, and 53.2% for females (Bertolero and Oro 2009). Later attempts at reintroduction 30 km upstream from the Ebro Delta between 2009 and 2014 appear to have been successful; two hatchlings were reported for the period autumn 2010 – spring 2011, and four were reported for autumn 2011 – spring 2012 (Baiges et al. 2012; Baiges, pers. comm.). Reintroductions to the Llobregat Delta (de Roa 1994; Franch Quintana et al. 2007) also appear to have been successful.

The *Sociedad para el Estudio y Recuperación de la Biodiversidad Almeriense* (SERBAL) assesses population status in Almería (<http://serbal-almeria.com/proyectos/mauremys>) and the *Centre de Recuperació d'Amfibis i Reptils de Catalunya* (CRARC-COMAM, Masquefa, Catalonia) manages captive populations, breeding, and reintroduction programs. Between 1999 and 2011 it has released 1016 Mediterranean Pond Turtles in the Llobregat River, the Gaia and Masquefa streams, and the Natural Parks of Aiguamolls de l'Empordà (Girona) and El Prat del Llobregat (Barcelona). The LIFE Potamo Fauna project (2014–2017; <http://www.lifepotamofauna.org/en/>) as undertaken by *El Centre de Reproducció de Tortugues de l'Albera* (CRT; Garriguella), seeks to monitor and strengthen populations at the Natura 2000 site Riberes del Baix Ter (409,830 ha) via creation of micro-wetlands and monitoring in Girona province. Several NGOs conduct educational programs about turtles and promote the concept that it is a wild species, not a pet animal (e.g., *Acció Ecologista Agró*, *Asociación Herpetológica Española*, CRARC-COMAM,

CRT, *Grupo de Rehabilitación de la Fauna Autóctona y su Hábitat*, and *Sociedad Herpetológica Valenciana*, among others).

Algeria. — Decree 83-509, 20 August 1983, provides limited protection.

Morocco. — The terrapin is protected in the annual hunting decree (Ministerial decree 582-62, 3 November 1962).

Conservation Measures Proposed. — It is unlikely that species-wide conservation is urgent, but wholesale destruction of animals incidentally captured by fishermen should be discouraged, and the localized population in France should certainly be protected. *Mauremys leprosa* avoids interaction with the North American *T. scripta* (Polo-Cavia et al. 2009b) and removal of this introduced species seems warranted, as it competes efficiently for food and basking areas under experimental conditions (Polo-Cavia et al. 2010, 2011; for feeding under natural conditions see Pérez-Santigosa et al. 2011). Neither captive breeding nor introduction of new populations appears to be a priority; conservation of aquatic habitat and surrounding ecotonal areas is the most efficient action for conservation.

Captive Husbandry. — Under captive conditions, the normal breeding seasons may be upset, and mating may occur at any time of the year; eggs may be laid during November in captivity. The male, in eagerness to secure a mate, is apt to bite at the collar-like folds of skin within which the female withdraws her head. Repeated action of this nature often produces sores that prevent the female from wiping her eyes with the back of her forefoot — a practice common to many species. Ultimately the eyes fester and the turtle becomes almost blind, ceases feeding, and leaves the water in a condition very difficult to cure (Gadow 1901). Cross-taxon courtship has been observed in captives; Eglis (1962) described a male *M. leprosa* vibrating the ventral aspect of his neck on the dorsal side of a *T. scripta* female's head while repeatedly attempting courtship. Care in aquaria is discussed by Tarrajat (1962) and Keller (1965), and Adams (1964) described outdoor captive maintenance. Klingelhöffer (1953) reported 17 year longevity in captivity; Slavens and Slavens (1999) recorded a still-living animal in captivity at 24.6 yrs old.

Current Research. — The Université de Perpignan Via Domitia, *Centre de Formation et de Recherche sur les Environnements Méditerranéens* (CEFREM-UPVD), has been involved since 2008 with monitoring populations and investigating the interaction between polystome parasites and *M. leprosa* in southwestern France (Verneau et al. 2011; Meyer et al. 2015). Courmont and de Sousa (2011) described the current program for the study of status and distribution.

In Spain, J. Martín and P. López and students (Museo Nacional de Ciencias Naturales-CSIC) are studying ecology and behavior of the species. Long term monitoring focused

on changes in distribution and population structure is being carried out by the *Estación Biológica de Doñana-CSIC* (Andreu 2014) and the population of the Sebes Natural Reserve (Ebro River) has been monitored since 2008 by Bertolero.

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