CONSERVATION BIOLOGY OF FRESHWATER TURTLES AND TORTOISES

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

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Emys trinacris Fritz, Fattizzo, Guicking, Tripepi, Pennisi, Lenk, Joger, and Wink 2005 – Sicilian Pond Turtle, Testuggine Palustre Siciliana

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Summary. – The Sicilian Pond Turtle, *Emys trinacris* (family Emydidae), is a small-sized freshwater turtle (straight midline carapace length to 172 mm in females, 156 mm in males), endemic to the island of Sicily in Italy. It appears to be more widespread in the northern and central-western parts of the island, with the exclusion of Monti Peloritani and most of the Madonie area and Monti di Termini Imerese. It is apparently rarer along the southeastern coastal areas, except for some coastal wetlands in the provinces of Trapani, Agrigento, Siracusa, and Ragusa. The species shows an altitudinal distribution range from sea level to about 1250 m a.s.l., with a higher prevalence in coastal and hilly territories, except for the Nebrodi area, where it is quite common in mountainous areas as well. *Emys trinacris* inhabits coastal and inland wetlands, mountain lakes and ponds, slow-moving river bends, and man-made aquatic environments, both in open areas and in woodlands. The few studied populations appear relatively robust at present, but others appear to be decreasing, and a lack of detailed recent field data prevents sound conclusions from being drawn about its overall status. Indeed, ongoing patterns of habitat loss and alteration, combined with climate change, release of non-native species in the wild, and poaching for the pet trade threaten this species.

Distribution. – Italy (Sicily).

Synonymy. – *Emys trinacris* Fritz, Fattizzo, Guicking, Tripepi, Pennisi, Lenk, Joger, and Wink 2005; *Emys orbicularis trinacris*.

Subspecies. – None recognized.

Status. – IUCN 2020 Red List: Data Deficient (DD; assessed 2009); TFTSG Provisional Red List: Least Concern (LC, assessed 2018); CITES: Not Listed.

Taxonomy. — This species was described as *Emys trinacris* by Fritz et al. (2005) based on specimens collected in several different areas of Sicily, Italy. The holotype (MZUF 11136, Museo Zoologico 'La Specola,' Florence) is an adult male collected by E. Kramer and S. Dereani on 9 May 1968 at "Lago Gian Fenaro, below the pass of Pizzo Laminaria approximately 1400 m above sea level, Monte Nebrodi, Sicily" (Fritz et al. 2005). Marrone et al. (2016a) corrected and emended the type locality to "Laghetto Gianferraro below Pizzo Luminaria; 14.497241 E, 37.951625 N; Elevation: 1007 m a.s.l." located in the Municipality of Caronia, Province of Messina, Sicily, Italy.

Emys trinacris was originally described based on molecular evidence of a clear gap in nuclear genomic fingerprinting with respect to its sister taxon, *E. orbicularis* (Fritz et al. 2005). Moreover, a strong genetic differentiation from *E. orbicularis* was recorded by other authors (Pedall et al. 2010; Manfredi et al. 2013; Stuckas et al. 2014). Fritz et al. (2006) considered *E. trinacris* as a cryptic species, because adults are difficult to distinguish morphologically from *E. orbicularis galloitalica* (Fritz et al. 2005), except for some males with an intensely reddish iris and for individuals that display a dark five-pointed star in the center of the pupil. In contrast to adults, hatchlings of *E. trinacris* are conspicuously different from hatchlings of all *E. orbicularis* subspecies, with an entirely yellow plastron or, if present, a much smaller dark plastral figure (Fritz et al. 2006).

Following the mtDNA haplotype nomenclature proposed by Lenk et al. (1999) for the genus *Emys*, *E.*

Figure 1. Adult male *Emys trinacris* with reddish eyes from Laghetto Gorgo, Sicily, Italy. Photo by Melita Vamberger.

trinacris represents lineage III, which is endemic to Sicily. Within this lineage, the most represented haplotype is IIIc, and rare haplotypes IIId and IIIe occur together locally with the former. Haplotype IIIb was found only in an introduced individual caught in Germany (Fritz et al. 2004), and haplotype IIIa, published by Lenk et al. (1999), proved to be a sequencing error and identical to haplotype IIIc (Vamberger et al. 2015).

Based on an extensive sampling and a data set of 15 microsatellite loci and one mitochondrial marker, Vamberger et al. (2015) found negligible gene flow between *E. trinacris* and its sister taxon *E. orbicularis*. The cline analysis of the contact zone of *E. orbicularis* and *E. trinacris* revealed a steep and geographically concordant transition in both genetic markers (microsatellites and mtDNA), whose center approximately matches the Strait of Messina—the narrow 3–5 km stretch of Mediterranean Sea that separates Sicily from the Italian mainland—that apparently constitutes a significant barrier to gene flow in *Emys* spp.

The presence of a modest genotypic impact of *E. orbicularis* on *E. trinacris* was observed in southeastern Sicily at a single site (Vendicari, Siracusa), suggesting the existence of some intrinsic barrier preventing large-scale admixture of *E. trinacris* and invading *E. orbicularis*, for instance, because selection might be acting against hybrid turtles (Vamberger et al. 2015).

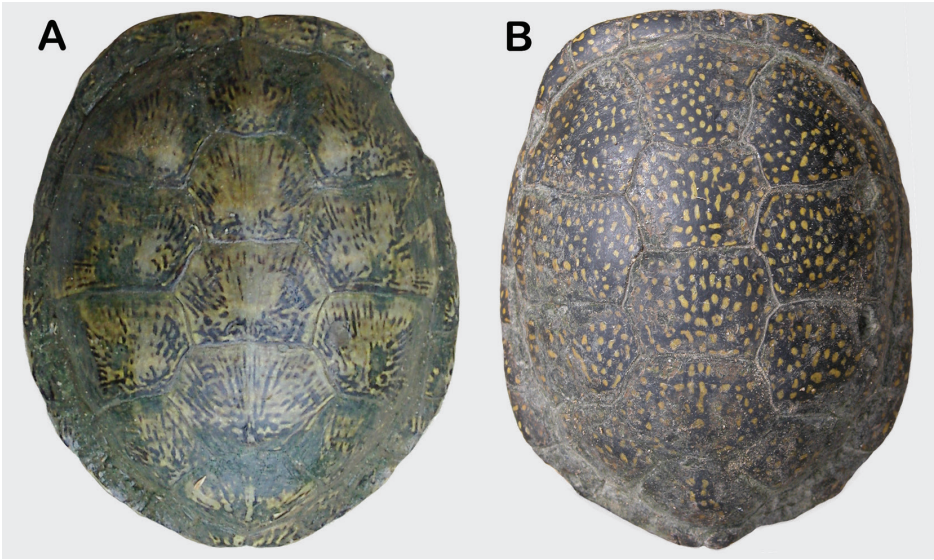

Figure 2. Carapacial color morphs in *Emys trinacris*. A. Light colored turtle ('*maculosa* morph'); black pattern may be entirely absent). B. Dark colored turtle ('*orbicularis* morph'). Photo from Fritz et al. (2006).

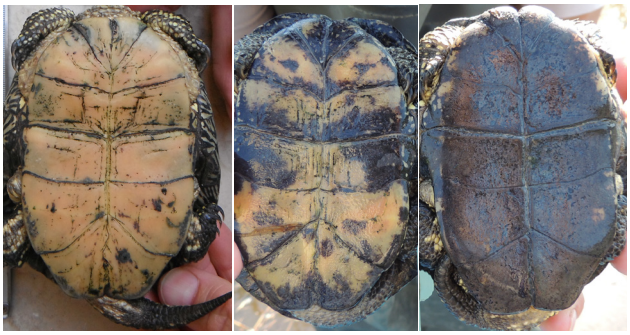

Figure 3. Variability of plastral coloration of males from Lago Preola and Gorghi Tondi Nature Reserve, Mazara del Vallo (Trapani), Italy. Photos by Dario Ottonello.

Figure 4. Variability of carapace coloration of females from Bosco della Ficuzza, Rocca Busambra, Bosco del Cappelliere e Gorgo del Drago Nature Reserve, Godrano (Palermo), Italy. Photo by Dario Ottonello.

The Sicilian Pond Turtle shows a strong population genetic structuring in five geographic clusters on Sicily, which suggests a long presence of turtles in their respective areas, most probably with few dispersal events during the Holocene (Vamberger et al. 2015; Vecchioni et al. 2020a).

Recently, the Taxonomic Committee of the Societas Europaea Herpetologica suggested taking a conservative stance and treated *E. trinacris* as a subspecies of *E. orbicularis*, pending further studies resolving the complicated relationships of the *Emys* complex (Speybroeck et al. 2020). However, the genetic divergence of *E. trinacris* exceeds that of other emydids that are currently regarded as distinct species (e.g., certain *Graptemys* spp.; Praschag et al. 2017; Thomson et al. 2018). Until new genetic evidence becomes available, we therefore follow Vecchioni et al. (2020a) and continue to treat *E. trinacris* as a distinct species.

The species name *trinacris* is a Latin adjective derived from the ancient Greek word for Sicily, Trinacria (= triangular island). Recorded vernacular names for *E. trinacris* include the Italian name *testuggine palustre siciliana* and the local dialectal names *cufuruna*, *scuzzaria*, *scurzaredda*, *tartaruca*, *pisciacozza*, and *tistunia*.

Description. — *Emys trinacris* is a small emydid species with a straight carapace midline length (CL) of up to 172 mm for females and 156 mm for males, and recorded maximum body mass of 900 g for females and 600 g for males (F. Oneto, unpubl. data). Males have longer and thicker tails than females and are smaller and lighter, although there are significant differences among populations (D'Angelo et al. 2008; Ottonello et al. 2017a). D'Angelo et al. (2008) observed that in the population from Lago Preola e Gorghi Tondi the best discriminating variable between sexes was bridge width (84.1% correct reclassification), while in the population from Torre Salsa it was carapace height (80.1% correct reclassification). Table 1 shows biometric data from four different areas.

Among the small-sized southern populations of *E. orbicularis*, *E. trinacris* most closely resembles *E. o. galloitalica* in gross morphology; however, in dorsal view *E. trinacris* has, on average, a more ovoid versus elongated shell. The coloration of the carapace shows marked variability both within and between populations, with two main patterns and intermediate morphs: 1) the '*maculosa* morph' (Fritz 1992) that frequently occurs also in several southern *E. orbicularis* subspecies, including *E. o. galloitalica* (Fritz 1995; Fritz et al. 2005)—these turtles have a light brownish to chestnut-colored carapace on which a radiating pattern of black dots and streaks may occur;

Figure 5. Subadult *Emys trinacris* from Gorgo Basso, Mazara del Vallo (Trapani), Sicily, Italy. Photo by Dario Ottonello.

Figure 6. Female *Emys trinacris* from Gallitello, Calatafimi (Trapani). Photo by Stefania D'Angelo.

Table 1. Straightline midline carapace length (mm), maximum plastron length (mm), and mass (g) of adult *Emys trinacris* in various populations in Sicily. NA = Not Available.

Site	Sex	Carapace Length Mean	Carapace Length Range	Plastron Length Mean	Plastron Length Range	Mass Mean	Mass Range	Reference
Gallitello	Females (*n*=6)	143.0	126.9-150.7	138.8	122.6-146.2	556.3	399-710	D'Angelo 2013
	Males (*n*=19)	128.6	104.6-144.4	120.3	97.3-128.6	348.2	236-473	
Siculiana	Females (*n*=9)	134.2	123.8-154.7	131.9	113.2-151.3	435.1	335-745	D'Angelo 2013
	Males (*n*=22)	132.3	107.2-151.6	121.2	100.4-133.8	332.4	236-598	
Gorgo Basso	Females (*n*=83)	130.3	105.8-146.7	NA	NA	402.6	229-583	Ottonello 2017
	Males (*n*=247)	120.1	104.4-141.1	NA	NA	283.1	192-414	
Gorghi Medio-Alto	Females (*n*=21)	116.5	106.2-132.1	NA	NA	294.7	211-422	Ottonello 2017
	Males (*n*=45)	111.1	99.7-124.9	NA	NA	223.2	154-310	

and 2) the '*orbicularis* morph' where turtles have a dark to black carapacial primary color with a radiating pattern of yellow dots or lines, with some older individuals having an indistinctly mottled yellow pattern (Fritz et al. 2005).

The plastral coloration can vary from immaculate yellow to completely black, with intermediate patterns, such as the presence of small black blotches at the distal seams of the central plastral scutes (distal blotches) or a streaked or mottled, diffuse dark pattern on single plastral scutes.

Most Sicilian Pond Turtles have an immaculate or nearly immaculate contrasting white or yellow iris, often with additional black elements; however, some males have an intensely reddish iris. The pupil of some *E. trinacris* individuals lies in the center of a dark five-pointed star, a very rare iris pattern in European pond turtles.

Clear sexual dimorphism in coloration of the soft parts is not evident, although males tend to have more irregularly spotted soft parts and a somewhat darker overall coloration than females. The extremities of most Sicilian pond turtles are irregularly speckled with yellow dots; these dots often appear on the forelegs as two confluent yellow lines. The crown of the head of most turtles is dark, with indistinct yellow spots or vermiculations in the occipital region. The throat is either immaculate yellow or speckled with black.

Hatchlings of *E. trinacris* are on average smaller and lighter than the hatchlings of all subspecies of *E. orbicularis*; they have relatively large heads and a mean maximum CL of 23.1 ± 0.4 mm (range, 20.4–25.0, $n = 14$) and a mean body mass of 3.4 ± 0.2 g (range, 2.0–4.0, $n = 9$) (Fritz et al. 2006). They have a uniform loamy brown carapacial coloration, sometimes with a few very small black speckles. The edges of the marginal scutes are slightly lighter colored, but without the well-defined yellow pattern seen in hatchlings of some Mediterranean *E. orbicularis* subspecies. The carapace color of hatchlings of *E. trinacris* is lighter than in *E. orbicularis* and the plastron is either

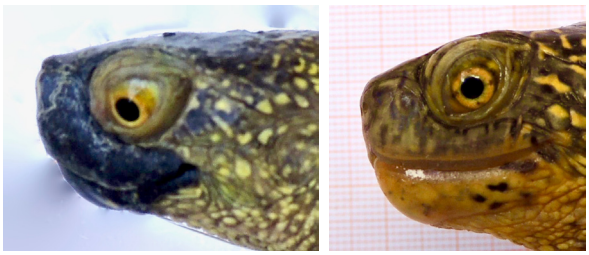

Figure 7. Sexual color dimorphism on rhamphotheca (*left:* male; *right*: female). Note: not all males have this dark upper jaw coloration. Lago Preola and Gorghi Tondi Nature Reserve, Mazara del Vallo (Trapani), Italy. Photos by Dario Ottonello.

Figure 8. Hatchling *Emys trinacris* from Lago Preola and Gorghi Tondi Nature Reserve, Mazara del Vallo (Trapani), Italy. Photo by Stefania D'Angelo.

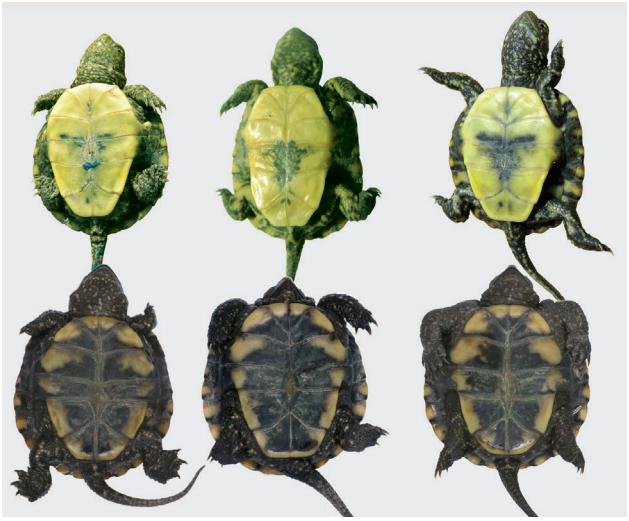

Figure 9. Ventral aspects of hatchlings of *Emys trinacris* (*top*; live turtles) from Torre Salsa near Siculiana, Sicily, and *Emys orbicularis hellenica* (*bottom*; preserved specimens, Zoologische Staatssammlung München, ZSM-SLM 162) from Metković, Bosnia and Herzegovina. Not to scale. Note different plastral patterns. Photo from Fritz et al. (2006).

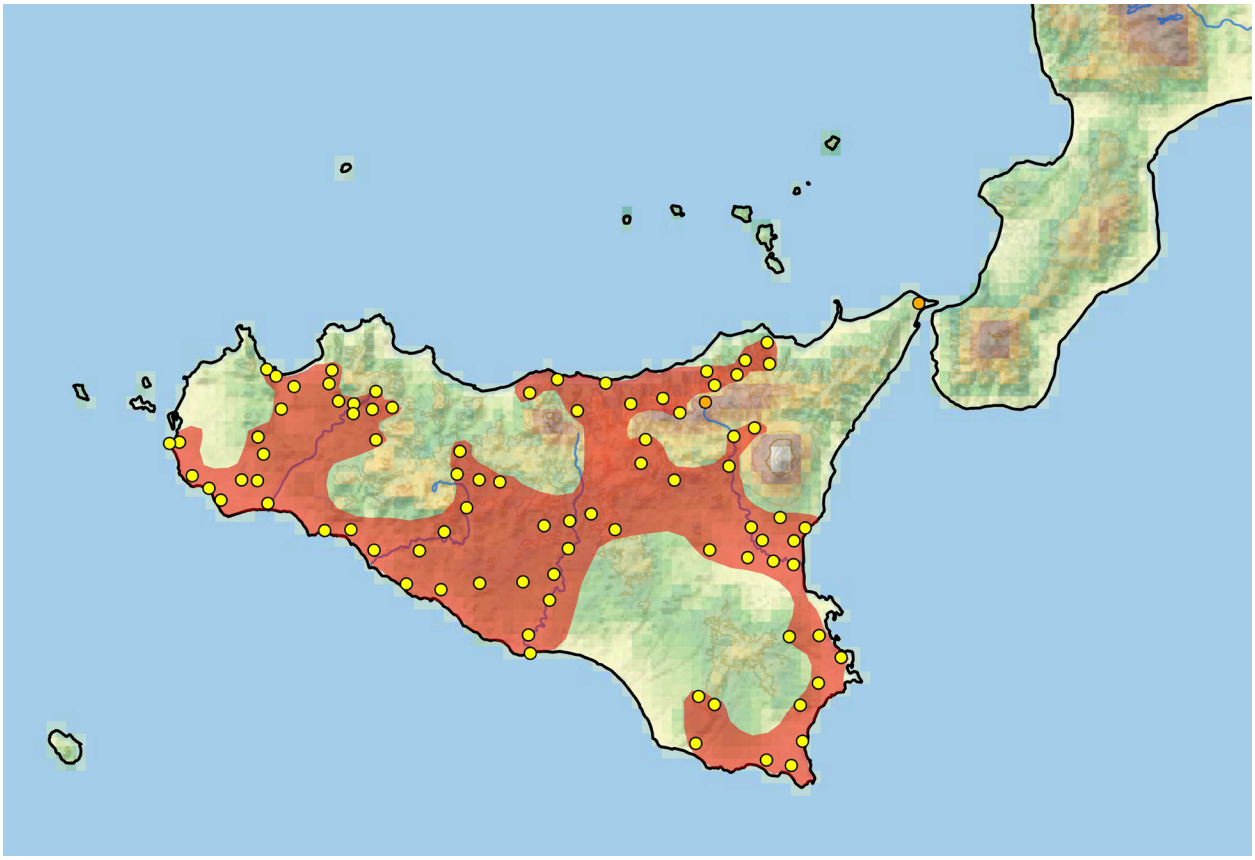

Figure 10. Distribution of *Emys trinacris* on the island of Sicily, southwestern Italy. Yellow dots = museum and literature occurrence records of native populations based on Iverson (1992) plus more recent and authors' data; orange dots = uncertain or introduced specimens; red shading = presumed native historic indigenous range. 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, in press), and adjusted based on authors' subsequent data and then refigured as a smooth polygon.

immaculate yellow or has a small dark plastral blotch in the central part of the plastron, while in hatchlings of *E. orbicularis* the plastron is distinctly darker with a yellow lateral rim.

Karyotype. — The karyotype of *E. trinacris* has a diploid chromosome number of 2n=50, consisting of eight pairs of metacentric macrochromosomes, five pairs of acrocentric macrochromosomes, and 12 pairs of acrocentric microchromosomes (Scardino et al. 2020). Comparative examination revealed similar cytogenetic features between *E. trinacris* and the closely related *E. orbicularis*, as well as among other previously studied emydid species, demonstrating a low rate of karyotype evolution, as chromosomal rearrangements are rather infrequent in this group of turtles (Scardino et al. 2020).

Distribution. — The Sicilian Pond Turtle is endemic to Sicily, a large island (25,711 km^2) off the southwestern coast of Italy. The species currently occurs only on the main island and is absent from all the surrounding minor islands. The distribution range of *E. trinacris* appears fairly wide, but fragmented, although there are uncertainties about its actual extent (D'Angelo 2013) and noticeably contradictory information among local, national, and international bibliographic data sources exists (Iannella et al. 2018). In particular, the species seems more widespread in the northern and central-western parts of the island, with the exclusion of Monti Peloritani and most of the Madonie area and Monti di Termini Imerese. It appears rarer along the southeastern coastal areas, except for some coastal wetlands located in the provinces of Trapani, Agrigento, Siracusa, and Ragusa (Turrisi 2008; Di Cerbo 2010). In the volcanic area of Mount Etna, *E. trinacris* is reported from Gurrida Lake and from the water catchment of the Simeto River (Turrisi and Vaccaro 1998).

The species has an altitudinal distribution range from sea level to 1250 m a.s.l., with a higher prevalence in coastal and hilly territories, except for the Nebrodi area, where it is quite common in mountainous areas. Marrone et al. (2016a) reported that the pond Urio Quattrocchi, occurring at 1036 m a.s.l. on the Nebrodi mountain range (municipality of Mistretta), was the highest occurrence locality known for the species at that time. However, the presence of the species at about 1250 m a.s.l. in the Sambughetti – Campanito Nature Reserve was recently observed (F. Marrone, pers.

Figure 11. Habitats of *Emys trinacris* in Sicily. *Top left*: Lago Preola and Gorghi Tondi Nature Reserve, Mazara del Vallo, Trapani; photo by WWF Italia Archive. *Top right*: Fiume Imera meridionale, Caltanissetta; photo by Rita Scardino. *Middle left*: Laghetti Sambughetti, Nicosia, Enna; photo by Rita Scardino. *Middle right*: Gole del Frattina, Corleone, Palermo; photo by Federico Marrone. *Bottom left*: Stagno di Pantana, Caronia, Messina; photo by Federico Marrone. *Bottom right*: Pantano Longarini, Noto, Siracusa; photo by Federico Marrone.

obs.). The occurrence of the species at even higher altitudes is to date only anecdotal, and the isolated observations of *E. trinacris* individuals in Maulazzo Lake (1448 m a.s.l.) (F.P. Faraone and M. Romano, pers. comm.) are likely due to introductions of non-native animals. Introduced *E. trinacris* individuals have been reported in mainland Italy and in Germany (Lenk et al. 1999; Velo-Antón et al. 2011) and hybridization of introduced *E. trinacris* with a local population of *E. o. hellenica* has been found in northeastern Italy (Vamberger et al. 2015).

Analyzing 16 microsatellite loci, Vecchioni et al. (2020a) demonstrated the presence of five different geographic population clusters of *E. trinacris* on Sicily, probably corresponding to a "refugia within refugia"

pattern during the Plio-Pleistocene climatic fluctuations (Gómez and Lunt 2007; Vamberger et al. 2015): the Nebrodi mountains, the Sicani mountains, and southwestern, southeastern, and northwestern Sicily.

Habitat and Ecology. — *Emys trinacris* is closely linked with inland aquatic environments with standing or slow running waters. It inhabits a wide range of coastal and internal wetlands: small ponds and lakes both in open areas and woodlands, man-made reservoirs, marshes, slow-moving river bends, and peripheral ponds. The species is mainly diurnal, but it also exhibits nocturnal activity during the summer months (Di Cerbo 2010).

The phenology of *E. trinacris* is quite variable along its distributional range. Lo Valvo et al. (2008b) observed the absence of a prolonged period of winter inactivity for the population of the Torre Salsa Nature Reserve, which is probably due to the warmer climate at the low latitude of the study site. Turrisi (2008) reported the presence of a period of reduced activity between November and February for populations occurring along the southeastern coast of Sicily, and Lo Valvo et al. (2014) reported that turtles are inactive from mid-October until the end of April in the Monte Capodarso e Valle dell'Imera Meridionale Nature Reserve, located in central Sicily. Basking turtles have been observed in December and January in the Lago Preola and Gorghi Tondi Nature Reserve (D. Ottonello, pers. obs.). Along the Imera Meridionale river, Lo Valvo et al. (2014) observed that the home ranges (hr) and the core areas (ca) of *E. trinacris* were larger in males (hr = 7.31 ha; ca = 8.46 ha) than in females (hr = 4.09 ha; ca = 2.36 ha), with an average linear distance between the farthest points of 470 m (range 324–672 m) for females and 664 m (range 178–1267 m) for males. As already noted by Lo Valvo et al. (2008b), home ranges of individuals are often overlapping, suggesting the absence of any significant territorial defensive behavior. Moreover, the larger sizes of the home ranges and core areas for males indicate their greater mobility that could also be linked to searching for females during the breeding season.

Population Structure, Survivorship, and Abundance. — Ottonello et al. (2017a) studied the population of *E. trinacris* in Lago Preola and Gorghi Tondi (LPGT) Nature Reserve. They documented the overall sex ratio of adults to be male-biased (M:F = 2.9:1), as previously noted both in the same population (D'Angelo 2013) and in other populations: Bosco di Ficuzza (2.3:1, Lo Valvo et al. 2008a, 3.9:1, Vecchioni et al. 2020b), Torre Salsa (1.7:1, D'Angelo et al. 2008), Gallitello (1.7:1, D'Angelo 2013), and Laghetto Gorgo (1.8:1, Vecchioni et al. 2020b).

The LPGT population seems to be characterized by a distribution of sizes markedly shifted towards adults, with a bimodal trend related to the different sizes of the two sexes. Juveniles represent a small percentage of the sample, as also noted by Lo Valvo and D'Angelo (2006), but this could be due either to the sampling method that underestimates juveniles because of their greater crypticity and the use of different habitats as compared to adults (Zuffi 2000), possible low recruitment, or a combination of these factors (Keller et al. 1998).

Figure 12. Nesting *Emys trinacris* at Lago Preola and Gorghi Tondi Nature Reserve, Mazara del Vallo (Trapani), Italy. Photo by Maurizio Marchese.

Ottonello et al. (2017a) estimated that the population inhabiting the Gorgo Basso in the LPGT Nature Reserve was composed of 719 ± 47 turtles, with a mean density of 239.7 ± 15.7 individuals/ha. The population was characterized by a dominance of individuals (72%) with straightline midline CL between 110 and 129.9 mm. The most represented range class for males was 120–129.9 mm (46%), whereas for females it was 130–139.9 mm (48%), and for juveniles: 100–109.9 mm (64%). The estimated standing crop biomass was 65.92 ± 4.32 kg/ha.

The annual adult survival rate of the two sexes at LPGT Nature Reserve is quite similar: 76% for males and 80% for females (Ottonello et al. 2017a). However, the overall survival in the population is lower (about 71%), most likely due to the higher mortality rates of juvenile and sub-adult individuals in general (compare Paul [2004] for *E. orbicularis*). Survival in adults of the congeneric *E. orbicularis* is generally higher (Canessa et al. 2015, 2016) than the estimated survival for the studied population of *E. trinacris*, although in this case it must be considered that for the estimate obtained for *E. orbicularis* it was not possible to distinguish emigration from mortality and it is therefore plausible that the actual survival may be similar to that found for *E. orbicularis*.

Growth and Sexual Maturity. — The estimated sexual maturity at LPGT Nature Reserve is 5–6 yrs for males at a minimum midline CL of 102.8 mm and 7–8 yrs for females at a minimum midline CL of 112.1 mm (Ottonello 2017). The latter data were reinforced by endoscopic examinations of females showing follicular activity starting at a medial CL between 106 to 112 mm, corresponding to a maximum

plastron length of 103 and 110 mm, respectively. Generation time for the species is estimated to be approximately 14–16 years.

Reproductive Biology. — Females studied by Ottonello (2017) at LPGT Nature Reserve showed an ovarian cycle typical of temperate zones (see Moll 1979). Vitellogenesis (enlargement of the follicles) begins in late summer or autumn (September), with a probable phase of quiescence or slowed growth during the coldest winter period. At the end of the winter and in spring (March) vitellogenesis resumes to produce ovulation in late spring (May) and egg deposition between late spring and early summer (June–July). Some females produce a second ovulation and egg deposition in July after going through a phase of reduced ovarian activity. This annual cycle resumes again in September. Ottonello (2017) observed females with calcified eggs only in May–July, with a peak in the first half of June, confirming a known pattern for the genus (Zuffi et al. 2015).

The eggs of *E. trinacris* are elongated, with a mean length of 31.2 mm (28.4–35.0 mm; $n = 22$), mean width of 19.0 mm (17.9–20.3 mm; $n = 22$) and mean mass of 7.5 g (7–9 g; $n = 22$) (D'Angelo 2013). The mean clutch size in the LPGT Nature Reserve was 4.4 ± 1.5 (range 2–8, $n = 25$) with larger females producing more eggs (Ottonello 2017). The mean minimum egg diameter was 19.8 ± 1.2 mm (range 16.0–22.5 mm, $n = 25$). The minimum egg diameter was positively correlated with female size, as an increase in body size allows a larger pelvic opening, a mechanical limiting factor for egg size. The observation of hatchlings and small juveniles in September and also between March and June would suggest that some individuals may overwinter inside the nests before emerging in the spring, a common event in *E. orbicularis* (Fritz et al. 2006).

Predation. — No data are available concerning specific predation on *E. trinacris,* but a high predation rate on eggs, hatchlings, and juveniles is likely, as reported in mainland Italy for *E. orbicularis* (Zuffi and Rovina 2006). Predation on nests has been reported by Termine and Turrisi (2020) in the Lago Pergusa Nature Reserve (Enna). Potential predators of *E. trinacris* in Sicily are the Red Fox (*Vulpes vulpes*), Wild Boar (*Sus scrofa*), rats (*Rattus norvegicus* and *R. rattus*), Pine Marten (*Martes martes*), Weasel (*Mustela nivalis*), stray dogs, and birds (mostly Corvidae and Ardeidae).

Diet. — The feeding strategy of *E. trinacris* resembles that of *E. orbicularis* (Ficetola and De Bernardi 2006), following an opportunistic and generalist pattern (Ottonello et al. 2017b). Males and juveniles showed a broader trophic niche than females, but no significant difference in composition was found. The main prey taxa were aquatic invertebrates, including the allochthonous Red Swamp Crayfish *Procambarus clarkii*, while non-aquatic prey were found only sporadically. Plant matter was also found with a high frequency and consisted mainly of the leaves and roots of aquatic macrophytes, with high occurrence of fruits and seeds in the spring. Focused consumption of plant material has also been confirmed by the observation in the wild of some individuals intent on feeding on the basal part of *Typha* leaves (Ottonello, pers. obs.).

The opportunistic feeding strategy of *E. trinacris* is confirmed by the difference in diet composition observed among the seasons, with a high importance of Heteroptera throughout the year and an increase of Ostracoda with a decrease of Malacostraca from spring to autumn (Ottonello et al. 2017b). Additionally, *E. trinacris* has the ability to feed in different microhabitats within each wetland. Bottom foraging was suggested by the presence of benthonic invertebrates such as juvenile Coleoptera, Odonata, Plecoptera, and Trichoptera. Nektonic and surface feeding was indicated by the presence of active swimmers (e.g., imagines of Heteroptera) and non-aquatic invertebrates (e.g., Formicidae and imagines of Odonata), whose bodies were frequently observed floating on the water surface. Ottonello et al. (2017a) observed a clear dietary difference between a site where allochthonous fishes occurred and a fish-free site, with a more abundant and wider diet spectrum in the latter as a result of the increased availability and diversity of prey items.

Hematology. — Arizza et al. (2014) described morphological parameters, sizes and frequencies of peripheral blood cells (erythrocytes, leukocytes, thrombocytes) of wild-caught *E. trinacris*. The leukocyte types recognized in *E. trinacris* correspond with those found in other species of the family Emydidae, with seven cell types: nucleated erythrocytes, eosinophils, basophils, monocytes, thrombocytes, heterophils, and lymphocytes. Males possessed significantly higher numbers of red blood cells and eosinophils, while females showed a significantly higher percentage of lymphocytes.

Parasites. — Marrone et al. (2016b) reported the occurrence of the glossiphoniid leech *Placobdella costata*, a hematophagous parasite specialized on chelonian hosts, feeding on *E. trinacris* in the Nebrodi area. Interestingly, *P. costata* populations from Sicily are genetically identical to those occurring in southern Italy, which is in contrast to the genetic differentiation between their vertebrate hosts, i.e., *E. trinacris* in Sicily and *E. orbicularis* in mainland Italy. Such an unexpected decoupling might be due to a recent, human-mediated introduction of the leech to Sicily, or to a natural long-range passive dispersal event for the species, which has been reported to be able to be dispersed by non-chelonian vertebrates with aquatic affinity (Vamberger and Trontelj 2007; Marrone et al. 2016b). Moreover, Marrone et al. (2016b) also observed the predatory leech *Helobdella stagnalis* on *E. trinacris*, but molecular analysis of its stomach contents ruled out the possibility of a trophic

relationships between these two taxa, in contrast to what was previously suspected, and suggested that *H. stagnalis* individuals were instead attached to the turtles for non-nutritional reasons.

Arizza et al. (2016) observed the intracellular presence of *Haemogregarina stepanowi* in erythrocytes of several individuals from two *E. trinacris* populations (Contrada Pantana, Caronia, present in all 6 studied individuals, and Urio Quattrocchi, Mistretta, present in 3 of 4 studied individuals) where *P. costata* was also present. Indeed, *H. stepanowi* uses turtles as an intermediate host, and the leech *P. costata* as its definitive host, thus needing the co-occurrence of these taxa to complete its biological cycle.

A microbiological survey by Governale et al. (2017) based on 82 *E. trinacris* individuals from 14 different populations showed the absence of Herpesviridae and microorganisms belonging to the genera *Campylobacter* and *Pseudomonas*. Analysis of the predominant cultivable bacteria showed that *Citrobacter* spp. and *Aeromonas* spp. were the most common bacteria that also included *Salmonella* spp., *Escherichia coli,* and *Klebsiella* spp. (Governale et al. 2017).

Population Status. — No specific data are available. The distributional data for *E. trinacris* collected over the years suggest that it is in decline mainly due to habitat alteration and degradation (Di Cerbo 2010); however, the historical indigenous range of the species on Sicily remains uncertain. The species is threatened by human activities and development, mainly in the wetlands of coastal areas, such as the marshes of southwestern and southeastern Sicily, but specific population data through time are lacking.

Threats to Survival. — *Emys trinacris* may be considered inherently at risk due to being endemic to a densely populated island (195 inhabitants/km^2) and exposed to several impacts, including destruction, fragmentation, and pollution of its habitats, release of non-native species in the wild, and illegal capture for the pet trade (Di Cerbo 2010). Moreover, due to its low dispersal potential (Lo Valvo et al. 2008, 2014), the reduction in the number of populations and consequential decreased gene flow (Turrisi 2008; Vecchioni et al. 2020a) further exacerbate its status, preventing long-range metapopulation dynamics such as "source-sink dynamics" and "rescue effects."

Iannella et al. (2018) highlighted a potential critical situation for the long-term conservation of *E. trinacris*, documenting that more than half of the currently inhabited sites are located outside of the Sicilian Protected Areas network.

Vecchioni et al. (2020b) investigated the possible impact of recreational fishing on *E. trinacris* in two populations in western Sicily. None of the 120 X-rayed turtles showed any evidence of ingested fishhooks or other fishing gears, thus suggesting a limited impact of recreational fishing on this species in the studied sites. However, the occasional, but not negligible, findings of *E. trinacris* injured by fishhooks or entangled in abandoned fishing lines confirms the existence of such impacts, which deserves further investigation. Spadola et al. (2010) reported the incidence of trauma in 41 *E. trinacris* individuals in three rescue centers: fractures (66%), wounds (20%), ocular lesions (12%), and hook ingestion (2%).

Emys trinacris inhabits aquatic environments such as estuaries, wetlands, and lentic habitats (Turrisi 2008; Di Cerbo 2010) which are highly threatened because of land use modifications and ongoing and future climate change. The Mediterranean area seems to be particularly sensitive to these modifications, which may cause severe alterations in water balance (Millán et al. 2005; Somot et al. 2008; Garcia et al. 2017) and a higher risk of extreme meteorological events (Romera et al. 2016), such as increasing drought. Furthermore, Markovic et al. (2017) showed that the Mediterranean islands have the most vulnerable freshwater ecosystems, with respect to future climate change, if compared with those of continental Europe. Censi et al. (2012, 2013) found a relationship between lanthanide contents in *E. trinacris* and environmental exposures, hypothesizing that lanthanide incorporation into the phosphate exoskeleton could be a physiological response to lanthanide contamination of the environment.

Conservation Measures Taken. — The Sicilian Pond Turtle is listed as Data Deficient (DD) on the IUCN Red List (van Dijk 2009; TTWG 2017; Rhodin et al. 2018), but was more recently considered as Least Concern (LC) on the TFTSG Provisional Red List (TTWG, in press). It 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 "Habitats Directive" (92/43/CEE).

The Italian Red List (Andreone et al. 2013) includes *E. trinacris* in the category of Endangered, EN/A2c (A2: population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased or may not be understood or may not be reversible; c: a decline in area of occupancy (AOO), extent of occurrence (EOO), and/or habitat quality). However, the Report on the main results of the surveillance under Article 11 for Annex II, IV and V species of the Directive 92/43/CEE (period 2013-2018) lists the "Overall assessment of Conservation Status" of *E. trinacris* as Favourable (FV) and the "Overall trend in Conservation Status" as Stable (=).

We consider that *E. trinacris* should most likely be assessed as Least Concern (LC) on the IUCN Red List at this time, although data are still somewhat deficient and a precautionary approach should be considered. No severe threats are yet evident, nor has there been a major demonstrable population decline or decreased area of

occupancy (AOO) over the past approximately 10 years, although there is uncertain knowledge of the historic indigenous range of the species. However, it is likely that in view of ongoing habitat loss and degradation, the species' small range, and increasing effects of climate change with increased risk of drought, that *E. trinacris* might meet the criteria for being listed as Near Threatened (NT).

The species is included on the protected species list of the Italian Ministerial Decree n. 357/1997, but listed as *E. orbicularis*. As a result, it is forbidden to: a) capture or kill individuals in the wild; b) disturb individuals during all reproductive stages or during hibernation, wintering and migration; c) destroy or collect eggs and nests in the wild; d) damage or destroy the nesting area; e) possess, transport and exchange individuals taken from the wild.

Emys trinacris inhabiting wetlands in Sicilian Regional Natural Parks, Regional Reserves, or within the "Natura 2000" network, are partially protected. The species occurs in several protected areas, including the following Nature Reserves noted in this account: Lago Preola and Gorghi Tondi; Bosco della Ficuzza, Rocca Busambra, Bosco del Cappelliere e Gorgo del Drago; Sambughetti – Campanito; Torre Salsa; Monte Capodarso e Valle dell'Imera Meridionale; and Lago Pergusa.

Specific conservation-related actions (long-term monitoring, land purchase, and nesting habitat management) are being carried out only for populations inhabiting the Lago Preola and Gorghi Tondi Nature Reserve (Mazara del Vallo, Trapani) in southwestern Sicily (D'Angelo et al. 2013; Ficetola et al. 2013; Ottonello 2017).

Conservation Measures Proposed. — A comprehensive and detailed inventory of the sites of occurrence of the species is needed, including a list of local threats. Poaching of animals for the pet trade should be confronted and prosecuted, and smaller localized populations should especially be protected.

In the last few decades, several non-native turtle species, such as the North American slider turtle *Trachemys scripta*, have been extensively introduced in Sicily (Naselli-Flores and Marrone 2019), and although successful breeding in native *E. trinacris* habitats is likely, it has not yet been documented (Liuzzo et al. 2020). *Trachemys scripta* poses a threat, as it is known to be able to outcompete *Emys* spp. for both food and basking sites, thereby reducing the individual fitness of the latter (Macchi et al. 2008; Zuffi et al. 2011; Ficetola et al. 2012). Therefore, eradication actions directed at non-native turtles are necessary where they occur in syntopy with *E. trinacris*.

Effective conservation of aquatic habitats with their surrounding buffer zones and ecological corridors are the most efficacious actions needed for long-term conservation of *E. trinacris*. Neither captive breeding nor reintroduction actions appear to be a priority at present.

In order to preserve the genetic variability of *E. trinacris*, Vecchioni et al. (2020a) proposed that the five Sicilian population clusters identified in their study should be considered as independent Management Units. As already proposed by Vamberger et al. (2015), it is necessary to avoid the translocation of turtles, even when restocking or release of treated or seized individuals are carried out. It is therefore most important that all individuals be genotyped before any translocation actions can be approved. The molecular identification of *Emys* individuals confiscated by poachers and hobby breeders is also necessary in order to avoid the unintentional release of *E. orbicularis* in Sicilian inland waters.

Current Research. — To the best of our knowledge, there is little active research on *E. trinacris*. The University of Genoa and the University of Palermo are investigating the impact of introduced allochthonous fishes on *E. trinacris* using radioisotopes. The realization of a low-cost and effective method for genetically identifying large numbers of *Emys* individuals is currently under study at the Museum für Tierkunde, Senckenberg Dresden, and at the University of Palermo. The Faculty of Veterinary Medicine of the University of Messina is developing an endoscopic technique to diagnose cloacal pathologies and to study reproductive biology (Spadola and Insacco 2009). The most recent research has included studies on the biology, morphology, and diet of the species, population genetics, conservation units, phylogeography, and habitat use and behavior. More research needs to be done on the distribution, behavior, reproductive biology, and conservation biology of *E. trinacris*.

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