

***Mesoclemmys tuberculata* (Luederwaldt 1926) – Tuberculate Toad-headed Turtle**

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SUMMARY. – The Tuberculate Toad-headed Turtle, *Mesoclemmys tuberculata* (Family Chelidae), is a medium-sized freshwater turtle (carapace length up to 250–300 mm) endemic to Brazil, ranging from the northeastern semi-arid region to the Atlantic-Northeastern basin. This species is usually associated with Caatinga and Atlantic Forest areas, and strongly associated with the basin of Rio São Francisco. Most aspects of *M. tuberculata* ecology remain unknown. Sexual dimorphism is prominent, with adult females larger than males. Reproductive parameters such as mean female size, mean clutch size and mass, egg size, volume and mass, incubation time, reproductive season, and nest site description are unknown for wild populations. Diet composition and feeding behavior are poorly known for wild *M. tuberculata*, but it has been noted that the species is carnivorous and consumes earthworms, fish, molluscs, freshwater shrimp, and insects. The species can often be found associated with anthropogenic environments, such as ponds, which can harbor small populations. *Mesoclemmys tuberculata* is not currently felt to be threatened, but the lack of population status and life history data for the species are relative limitations to proposing potential conservation measures.

DISTRIBUTION. – Brazil. Restricted to northeastern Brazil (Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Sergipe) with an apparently disjunct population in northern Minas Gerais.

SYNONYMY. – *Rhinemys tuberculata* Luederwaldt 1926, *Batrachemys tuberculata*, *Phrynops (Batrachemys) tuberculata*, *Phrynops tuberculata*, *Phrynops (Batrachemys) tuberculatus*, *Phrynops tuberculatus*, *Phrynops tuberculatus tuberculatus*, *Mesoclemmys tuberculata*.

SUBSPECIES. – None recognized.

STATUS. – IUCN 2015 Red List: Not Listed (Least Concern, LC, assessed 1996); TFTSG Draft Red List: Data Deficient (DD, assessed 2011); CITES: Not Listed; Brazil: Least Concern.

Taxonomy. – *Mesoclemmys tuberculata* was originally described by Luederwaldt (1926) as *Rhinemys tuberculata*, based on specimens collected in Villa Nova (currently known as Senhor do Bonfim), Bahia, and in Fortaleza, Ceará, northeastern Brazil. Fróes (1957), based on morphological characters, renamed the taxon as *Batrachemys tuberculata*, and expanded its known distribution in northern and eastern Brazil. Later, *Batrachemys tuberculata* was referred to *Phrynops tuberculatus* by Mertens (1970). For many years the genus was referred to as either *Phrynops* or *Batrachemys* (Zangerl and Medem 1958; Mertens 1970; Bour 1973; Freiberg 1981; Bour and Pauler 1987; King and Burke 1989). McCord et al. (2001) conducted a study on

the broad genus *Phrynops* and suggested the resurrection of the genus *Batrachemys*, redesignating the species as *Batrachemys tuberculata*. However, their analyses were not generally accepted (Rodrigues 2003; Bour and Zaher 2005; TTWG 2011; Costa and Bérnils 2014), mainly due to the lack of resolution within the phylogenetic relationships of South American chelids, and the species has since been placed in the broader genus *Mesoclemmys*, a former subgenus of *Phrynops* (Bour and Zaher 2005). *Mesoclemmys* currently includes the following species: *M. dahli*, *M. gibba*, *M. heliostemma*, *M. hogei*, *M. nasuta*, *M. perplexa*, *M. raniceps*, *M. tuberculata*, *M. vanderhaegei*, and *M. zuliae*.



Figure 1. *Mesoclemmys tuberculata* from Areia Branca, Sergipe, Brazil. Photo by Daniel O. Santana.

Description. — *Mesoclemmys tuberculata* is a medium-sized species that may reach 250 to 300 mm in straight carapace length (CL) (Vanzolini et al. 1980; Ernst and Barbour 1989; Vetter 2005). A maximum CL of 235 mm was recorded for a female in captivity at the São Paulo Zoo (McCord et al. 2001).

The color of the carapace may vary from light to dark brown or can be entirely black. The surface of each scute may be roughened with raised striations (Ernst and Barbour 1989; Bonin et al. 2006). The plastron is yellowish and can present blackish spots, becoming completely dark with ontogeny (Bonin et al. 2006). The head and the neck have a completely dark gray back, and the ventral region is yellowish or grayish. The back of the head can be sprinkled with light dots, and the jaws are light yellow with a lighter stripe on the upper region (Vanzolini et al. 1980; Ernst and Barbour 1989; Bonin et al. 2006). The neck is covered with conical tubercles, a characteristic reflected by the species' name (Ernst and Barbour 1989; Bonin et al. 2006).



Figure 2. *Mesoclemmys tuberculata* from Areia Branca, Sergipe, Brazil. Photos by Daniel O. Santana.

Sexual dimorphism is marked, with adult females (mean CL = 207 ± 17 mm, maximum CL = 235 mm, n = 13) reaching larger body sizes than males (mean CL = 182 ± 8 mm, maximum CL = 190 mm, n = 5). Females also have deeper shells (carapace height; CH) (mean CH = 73 ± 7 mm, maximum CH = 85 mm, n = 13) than males (mean CH = 64 ± 3 mm, maximum CH = 67 mm, n = 5). Males have longer and thicker tails, with a more distal cloacal opening (Corazza and Molina 2004a). Several species of Testudines exhibit sexual dimorphism (Berry and Shine 1980; Gibbons and Lovich 1990; Bujes 2010) as do many Chelidae, including *Hydromedusa maximiliani* (Souza and Martins 2009), *Hydromedusa tectifera* (Chinen et al. 2004), *Acanthochelys macrocephala* (Métraiiller 2006), *Mesoclemmys vanderhaegei* (Marques et al. 2014), and *Mesoclemmys dahli* (Forero-Medina et al. 2013).

Hatchling *M. tuberculata* present morphological aspects and a color pattern that differ greatly from adults. The carapace is oval, with a poorly developed median keel on the second, third, and fourth vertebral scutes. The color of the carapace is dark brown, with gray and black spots, and an orange border. The plastron is mostly orange with a wide central black symmetrical patch, extending from the humeral to the femoral scutes, and extending over the intergular scute. Orange is the predominant color on the plastron bridges and ventral surfaces of the marginal scutes (Santana et al. 2015).

Distribution. — *Mesoclemmys tuberculata* is a freshwater turtle endemic to Brazil (Moura et al. 2014) ranging from the northeastern semi-arid region to the Atlantic-Northeastern basin (Vanzolini et al. 1980; Iverson 1992). It inhabits water bodies in the Brazilian states of Bahia (Santos et al. 2008), Sergipe (Morato et al. 2011), Alagoas (Santos et al. 2008; Lins et al. 2015), Piauí (Loebmann et al. 2006; Cavalcanti

et al. 2014), Ceará (Loebmann and Haddad, 2010; Moura et al. 2015), Maranhão (Batistella et al. 2008; Barreto et al. 2010), Paraíba (Barbosa et al. 2007), Pernambuco (Miranda and Santos, 2008; Moura et al. 2011), Rio Grande do Norte (Caldas et al. 2016), and an apparently disjunct population in northern Minas Gerais (Silveira and Valinhas 2010). This species is usually associated with Caatinga and Atlantic Forest areas, strongly associated with the basin of Rio São Francisco (Batistella et al. 2008; Santos et al. 2008; Loebmann and Haddad 2010; Moura 2010; Morato et al. 2011; Moura et al. 2011, 2014). Recently, it was also recorded from the Cerrado biome in northern Minas Gerais (Silveira and Valinhas 2010).

Habitat and Ecology. — *Mesoclemmys tuberculata* is associated with coastal ecosystems and semiarid regions, where it is able to use a wide array of habitat types, such as rivers, permanent lakes, and temporal streams (Vanzolini et al. 1980; Loebmann et al. 2006; Silveira and Valinhas 2010; Moura et al. 2012), preferring slow-moving waters (Bonin et al. 2006). The natural habitats identified for the species are the open formations in the semiarid Caatinga region and the Atlantic rainforest of northeastern Brazil (Souza 2005).

Most aspects of *M. tuberculata* ecology remain unknown (Souza 2004). In the last decade, few studies have focused on the ecology and biology of the species; instead, most have focused on its distributional extent (Loebmann et al. 2006; Santos et al. 2008; Batistella et al. 2008; Loebmann and Haddad 2010; Moura 2010; Silveira and Valinhas 2010; Moura et al. 2011, 2014; Morato et al. 2011; Cavalcanti et al. 2014), hatchling morphology (Santana et al. 2015), and demography and sex ratio at one locality in the Araripe Bioregion (Moura et al. 2015).

Mesoclemmys tuberculata often migrates between water bodies during summer nights (Vanzolini et al. 1980). The ability to migrate between aquatic habitats or even between distinct watersheds is a common feature in chelids, such as *Mesoclemmys* spp. (Brito et al. 2012), *Acanthochelys spixii*,

and *A. macrocephala* (Vinke and Vinke 2008). Migration usually occurs when resources become scarce in their habitats (Kramer 1995; Milan and Melvin 2001).

Moura et al. (2015) documented population density of *M. tuberculata* in a natural environment, recording a density of approximately 2 turtles/ha, but only a small number of females were recorded in their study. The species can often be found associated with anthropogenic environments, such as ponds, which can harbor small populations of the species (Santana, unpubl. data).

Courtship behavior of *M. tuberculata* has been observed in captivity between January and October, but more frequently between January and July (Corazza and Molina 2004b), with the initial sequence appearing to be similar to those previously reported for other chelids, such as *Phrynops geoffroanus* (Molina 1996), *Hydromedusa maximiliani* (Novelli and Souza 2007), and *Mesoclemmys vanderhaegei* (Brito et al. 2009). The animals were observed mainly in the water, where the male examined the cloacal region, tail, and carapace of the female and tried to bite her neck region. Interactions were also observed on land, with the animals facing each other while the male was biting or trying to bite (feebly) the female's neck and presenting rhythmic head movements. The male was then observed mounting the female, with hindfeet flat on the ground and forefeet placed on her costal scutes (Corazza and Molina 2004b).

Reproductive parameters, such as mean female size, clutch size, egg size, volume and mass, mean clutch mass, incubation time, reproductive season and nest site description are unknown for wild populations (Souza et al. 2006). The only record of nesting occurred in October, in captivity; a single egg dropped in water had a calcareous shell, was smooth and cream-colored, and slightly elongated in shape (31.6 x 29.0 mm) and weighed 11.5 g (Corazza and Molina 2004b). Nest depredation of *M. tuberculata* by the lizard *Salvator merianae* has been noted in a remnant of Atlantic forest at the Ecological Station Tapacurá, Pernambuco, Brazil (Moura, unpubl. data).



Figure 3. *Mesoclemmys tuberculata* from Tobias Barreto, Sergipe, Brazil. Photo by Daniel O. Santana.



Figure 4. Hatchling *Mesoclemmys tuberculata* from Itabaiana, Sergipe, Brazil. Photos by Daniel O. Santana.



Figure 5. Distribution of *Mesoclemmys tuberculata* in northeastern Brazil. Yellow dots = museum and literature occurrence records of native populations based on Iverson (1992), plus more recent and authors' data. Red shading = projected historic distribution of *M. tuberculata*. 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), and adjusted based on authors' subsequent data.

Diet composition and feeding behavior are poorly known for wild *M. tuberculata*, but it has been noted that the species is carnivorous and consumes earthworms, fish, and insects in captivity (Bonin et al. 2006). In crushed DOR specimens, fish operculi, mollusks, freshwater shrimp, and insects have been noted in the stomach contents (Moura, unpubl. data).

Population Status. — *Mesoclemmys tuberculata* is commonly encountered within its geographical distribution. The creation of reservoirs for water storage has provided useable habitat for *M. tuberculata*, but in view of the broad agricultural areas between these habitats, such populations may be reproductively isolated from each other. Studies on population structure and status surveys of *M. tuberculata* in both undisturbed and anthropogenic habitats are needed.

Threats to Survival. — The main threats to *M. tuberculata* are habitat degradation caused by deforestation due to cattle ranching and agriculture and hunting, and possible competition and disease from invasive exotic species such as *Trachemys dorbigni*, *T. scripta scripta*, and *T. s. elegans* (Santana et al. 2014; Moura et al. 2016).

The Atlantic Forest and Caatinga regions have a high degree of anthropogenic impact and relatively poor representation in protected areas (Leal et al. 2005; Tabarelli et al. 2005). The Atlantic Forest is included in the world biodiversity hotspots (Mittermeier et al. 1999), and is seriously threatened, being reduced to small and isolated fragments that represent only about 12% of its original distribution (Ribeiro

et al. 2009). The semi-arid Caatinga biome has been identified as one of the world's major tropical wilderness areas (Mittermeier et al. 2002). However, inappropriate land use has caused serious environmental damage, accelerating the desertification process in the biome. In addition, this biome is poorly protected, with less than 1% of its area represented in strict protected areas (Leal et al. 2005).

Mesoclemmys tuberculata is consumed by human populations in the semi-arid regions of northeastern Brazil (Barbosa et al. 2007; Alves 2009; Barbosa and Barbosa 2011; Alves et al. 2012; Mendonça et al. 2014; Moura et al. 2014) and is also used in popular medicines in the treatment of diseases such as rheumatism, thrombosis, bronchitis, diarrhea, bleeding, asthma, sore throat, and hoarseness (Marques 1995; Costa-Neto 1996; Alves 2009; Alves et al. 2012; Mendonça et al. 2014). When incidentally captured in fishnets, it can be used as a food resource, as a medicine, or can be sold as a pet, but it is often discarded by local people (Alves et al. 2012; Mendonça et al. 2014).

Conservation Measures Taken. — The species is not listed on the IUCN Red List or CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) nor on the Brazilian National List of Endangered Species, where it is considered as Least Concern. It was assessed as Least Concern by the IUCN SSC Tortoise and Freshwater Turtle Specialist Group in 1996, and Data Deficient in 2011 (TTWG 2011).



Figure 6. Habitats used by *Mesoclemmys tuberculata*. (A) Larger water body in the Atlantic Forest, Itabaiana, Sergipe, Brazil; (B) temporary lake with aquatic vegetation; (C) perennial lake; and (D) temporary streams in the Caatinga, Tobias Barreto, Sergipe, Brazil. Photos by Daniel O. Santana.

The species occurs in several protected areas in Brazil, including Parque Nacional de Ubajara, Reserva Particular do Patrimônio Natural Serra Grande, Área de Proteção Ambiental do Complexo do Planalto da Ibiapaba and Área de Proteção Ambiental da Chapada do Araripe in Ceará (Loebmann and Haddad 2010; Moura et al. 2015), Parque Nacional Serra da Capivara in Piauí (Cavalcanti et al. 2014), Monumento Natural do São Francisco in Bahia, Sergipe and Alagoas (Santos et al. 2008), Refúgio de Vida Silvestre Mata do Junco Mata do Junco, Monumento Natural Grota do Angico, Parque Nacional Serra de Itabaiana in Sergipe (Morato et al. 2011; Santana et al. 2015), Refúgio de Vida Silvestre Mata do Camucim, Refúgio de Vida Silvestre Mata do Toró, and Estação Ecológica do Tapacurá in Pernambuco (Moura et al. 2011), and Estação Ecológica do Seridó in Rio Grande do Norte (Caldas et al. 2016). These areas are relatively small compared to the species' overall distribution; however, there are a significant number of conservation areas that provide protection to its populations, and the species probably also inhabits other unsampled protected areas.

Conservation Measures Proposed. — No specific conservation measures are considered immediately necessary, but the lack of adequate population status and life history studies for the species is a major limitation for proposing po-

tential conservation measures for *M. tuberculata*. Therefore, there is a need for long-term ecological studies to evaluate its population status and possible threats.

Captive Husbandry. — Reproductive data for *M. tuberculata* are from captivity at the São Paulo Zoo (Corazza and Molina 2004b), where a group of adults was kept in natural air temperatures between 6 and 35°C with water temperatures between 20 and 28°C. Adults were fed mainly with red meat, fish, bone meal and, sporadically, flour beetle larvae and newborn mice. Mating was observed on several occasions, from January to October, and a single egg was recorded in October. Marques (2009) evaluated captive behavior of *M. tuberculata*, observing three individuals (two males and one female) kept in a small artificial pond with a fallen trunk and two artificial terrestrial shelters. The males spent most of their time using the shelters, while the female demonstrated territorial behavior and spent most of its time in the pond. The species was noted by Alves et al. (2012) to be used as a pet in the semiarid region of northeast Brazil, but no detailed information was provided.

Current Research. — Santana and collaborators are analyzing population structure, reproduction, morphometric aspects, diet, and parasites of *M. tuberculata* in the Caatinga and Atlantic Forest areas of Sergipe. Moura and collaborators

are studying ecology, demography, parasites, morphometric aspects, home range, and genetic heterogeneity in freshwater turtles, including *M. tuberculata*, in Pernambuco and Alagoas. However, further research is needed to investigate basic biological aspects of this species, mainly in natural environments.

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