

***Manouria emys* (Schlegel and Müller 1840) –  
Asian Giant Tortoise, Giant Asian Forest Tortoise**

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**SUMMARY.** – The Giant Asian Forest Tortoise, *Manouria emys* (Family Testudinidae), is the largest tortoise species in mainland Asia, with a straight carapace length (CL) of up to at least 600 mm, and mass up to 37 kg. Two subspecies, *M. e. emys* and *M. e. phayrei*, are distinguished by geographic distribution, coloration, plastral scute pattern, and maximum size. *Manouria* is considered to be among the most primitive of living tortoise genera. The species occurs in hilly wet forest; its diet includes green vegetation, mushrooms, bamboo shoots, and fallen fruits. Unlike most tortoises, which tend to prefer relatively arid habitats, *M. emys* prefers a mesic habitat and is often found in and around cool flowing streams, sitting for days in water or mud, or foraging in such habitats. Although the species is active all year round, some individuals exhibit an inactive period of up to two months in the cool dry season. The species exhibits unusual nesting activity; females build mound nests of forest floor debris, deposit large annual clutches of up to 60 eggs, and guard the nest for the early portion of incubation. Despite their size, the behavioral ecology of *M. emys* has been little studied. The species has apparently been extirpated in the westernmost portion of its range and is highly threatened everywhere else. Healthy populations are known to occur in a few protected areas in Thailand and Indonesia, but most remaining habitat is being rapidly degraded and destroyed, and the species continues to be collected for food and smuggled into the pet trade.

**DISTRIBUTION.** – Bangladesh, Brunei (?), India, Indonesia, Malaysia, Myanmar, Singapore (extirpated), Thailand. From Assam in India and eastern Bangladesh in the west, through Myanmar and western Thailand, and south through peninsular Malaysia to Sumatra and Borneo in the east.

**SYNONYMY.** – *Testudo emys* Schlegel and Müller 1840, *Manouria emys*, *Manouria emys emys*, *Geochelone emys*, *Geochelone emys emys*, *Testudo emys emys*, *Testudo emydoides* Duméril and Bibron in Duméril and Duméril 1851, *Manouria emydoides*, *Manouria fusca* Gray 1854, *Teleopus luxatus* Le Conte 1854, *Manouria luxata*, *Testudo (Scapia) falconeri* Gray 1869 (partim, nomen dubium), *Testudo falconeri*, *Scapia falconeri*.

**SUBSPECIES.** – Currently two recognized: 1) *Manouria emys emys* (Asian Brown Giant Tortoise) (distribution: Brunei [?], Indonesia, Malaysia, Singapore [extirpated], Thailand), and 2) *Manouria emys phayrei* (Burmese Black Giant Tortoise, Burmese Mountain Tortoise) (synonymy: *Testudo phayrei* Blyth 1853, *Scapia phayrei*, *Manouria emys phayrei*, *Testudo (Scapia) falconeri* Gray 1869 (partim, nomen dubium), *Testudo falconeri*, *Scapia falconeri*, *Testudo nutapundi* Reimann in Nutaphand 1979, *Geochelone nutapundi*, *Manouria emys nutapundi*, *Geochelone emys nutapundi*, *Manouria nutapundi*) (distribution: Bangladesh, India, Myanmar, Thailand).

**STATUS.** – IUCN 2014 Red List: Endangered (EN A1cd+2cd; assessed 2000); TFTSG Draft Red List: Critically Endangered (CR, assessed 2011); CITES: Appendix II (as Testudinidae spp.).

**Taxonomy.** – Schlegel and Müller originally described *Testudo emys* in 1840; the etymology of the specific epithet is either from the Greek “*emus*”, meaning freshwater turtle (Ernst and Barbour 1989), or borrowed from the European pond turtle, *Emys* (Obst 1988). *Manouria*, according to Ernst

and Barbour (1989), means “rare domed one”. The subspecies *Manouria emys phayrei* is named for Arthur Purves Phayre, Commissioner of British Burma, who collected the specimen Blythe (1853) described as *Testudo phayrei*. The genus *Manouria* was described as separate from *Testudo* by Gray (1854).



**Figure 1.** *Manouria emys phayrei* in Kaeng Krachan National Park, Thailand. Photo by Craig Stanford.

Although Schlegel and Müller (1840) described *Testudo emys* as a terrestrial chelonian from Sumatra, throughout its early taxonomic history the species was considered aquatic. There was perhaps some credibility in this belief due to the species' primitive morphology and riparian habitat. Of the six specimens first collected, four remain in Leiden, and one in Paris, from which Duméril and Bibron in Duméril and Duméril (1851) described *Testudo emydoides*. Gray (1844) considered *T. emys* to be synonymous with *Geoemyda spinosa*, as did Cantor (1847), who collected two specimens from Penang, Malaysia. One of these specimens found its way to London and to Gray (1860), who designated it as *M. fusca* (Gray 1854). Strauch (1862) later examined and validated *Manouria* as a separate genus.

Nutaphand (1979) redescribed *M. emys phayrei* as *Testudo nutapundi* (Reimann in Nutaphand 1979). Bour

(1980) reassigned the species to *Manouria*, and Obst (1983) recognized *T. nutapundi* as *M. emys nutapundi*, with *M. emys emys* as the nominative subspecies. Bour (1984) resurrected the subspecies name *M. e. phayrei*, recognizing its nomenclatural priority over *nutapundi*. For a more extensive examination of *Manouria* taxonomy, see Bour (1998).

*Manouria* is considered by many authorities (e.g., Pritchard 1979; Moll 1989) to be the most primitive genus of living tortoises, based on a lack of many of the derived morphological features of other tortoises, such as mental glands (Winokur and Legler 1975), carpal bone alignment (Auffenberg 1966), and primitive gular scute structure (Crumley 1982, 1984; Highfield 1990), and preference for a wet rather than arid habitat (Crumley 1982). However, Heiss et al. (2011) noted that its oropharyngeal anatomy and tongue were more similar to other derived testudinids. Le et

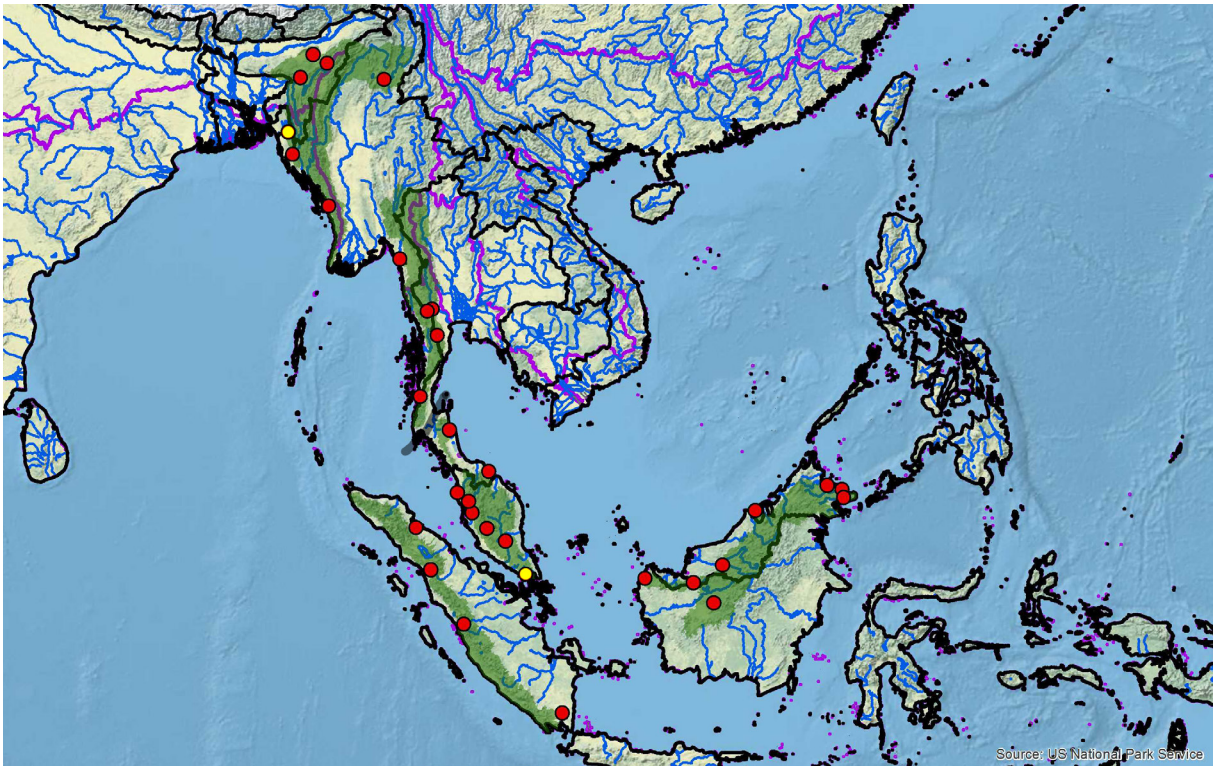


**Figure 2.** *Manouria emys emys* in the wild in Tabin Wildlife Reserve, Sabah, East Malaysia (Borneo). Photo by Chuck Schaffer.



**Figure 3.** Plastrons of *Manouria emys emys* (left) and *Manouria emys phayrei* (right), showing the typical lack of midline pectoral scute contact in *M. e. emys*. Photo by Chuck Schaffer.





**Figure 4.** Historic distribution of *Manouria emys* in Southeast Asia. Purple lines = boundaries delimiting major watersheds (level 3 hydrologic unit compartments – HUCs); red dots = museum and literature occurrence records based on Iverson (1992) plus more recent data, and the authors' personal data; yellow dots = historic observations where populations have likely been extirpated; broad gray line = approximate boundary between the two subspecies, north of the Thailand–Malaysia border, with *M. emys phayrei* to the north and *M. emys emys* to the south and east; green shading = projected historic native distribution based on GIS-defined level 10 HUCs 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.

al. (2006) examined the phylogenetics of the Testudinidae and confirmed the basal position of *Manouria* within the family, and most closely related to *Gopherus*, while also noting only minor differences in mitochondrial DNA patterns between the two recognized subspecies, *M. e. emys* and *M. e. phayrei*.

**Description.** — Compared to most other tortoise taxa, *M. emys* has a low-domed carapace. Prominent spurs are located in the region between the tail and rear legs, making the tortoise appear somewhat to have six legs, leading to the

Thai name for the species, *tao hok*, and the Sabahan name, *kura-kura anamkaki*. The species has a fairly uniform color as adults; light brown in *M. e. emys* and darker brown to black in *M. e. phayrei*. Hatchling *M. e. emys* are light brown, while *M. e. phayrei* are nearly gray.

*Manouria emys* is Asia's largest tortoise, with carapace lengths up to 600 mm and mass of up to 37 kg. *Manouria emys phayrei* is the larger of the two recognized subspecies. It is distinguished from *M. emys emys* by somewhat larger average maximum size and its darker color, although whether



**Figure 5.** *Manouria emys phayrei* female in captive assurance colony. Photo by Chuck Schaffer.



**Figure 6.** *Manouria emys emys* from peninsular Malaysia. Photo by Mark Auliya.



the maximum recorded size for *M. e. phayrei* is larger than that of *M. e. emys* is unclear. The two subspecies can usually be distinguished by the arrangement of the pectoral plastral scutes (Aranyavalai 1996). These meet medially in *M. emys phayrei*, but do not reach the midline and do not meet in *M. e. emys*. Much individual variation occurs, however, and the pectoral scute arrangement typical of *M. e. emys* can be found in individual *M. e. phayrei* in Kaeng Krachan National Park, Thailand, several hundred kilometers north of the recognized overlap zone of the two subspecies (Stanford, pers. obs.).

Sexual dimorphism is slight; males acquire longer, thicker tails at maturity, and sometimes possess a carapace bulge on the fifth vertebral scute (Schaffer and Morgan 2002) and scute differences in the 4th pleural and 5th vertebral scutes (Aranyavalai 1996). Fahz (2010) noted slight plastral concavity in males, but visual sexing of subadult and even adult animals is often unreliable. Captive observations suggest larger body size in females (C. Schaffer, pers. obs.), but no definitive data are available.

**Distribution.** — *Manouria emys* is found in hilly wet forests from approximately 600 m to 1500 m elevation, from eastern Assam in India (Bhupathy 1994; Choudhury 1996) and eastern and southern Bangladesh through Myanmar, central and southern Thailand, and south through peninsular Malaysia and Sumatra, and east to Sarawak, Sabah, and eastern Borneo (Lim and Das 1999; Høybye-Mortensen 2004).

The species is present in the Rakhine area of southwestern Myanmar, and occurs broadly sympatrically with *Manouria impressa* in some forests in west-central Thailand (Nutaphand 1979; Thirakhupt and van Dijk 1995). In Kaeng Krachan National Park, Thailand, *M. e. phayrei* is broadly sympatric with the tortoise *Indotestudo elongata* at lower elevation portions of its range (Wanchai, pers. obs.).

The ranges of the two subspecies apparently meet in peninsular Thailand north of the Thailand–Malaysia border, along the tectonic fault line of the Surat Gap between Khao Luang Massif of northern Nakhon Sri Thammarat Province and northern Phang-nga Province, Thailand (Nutaphand 1979,

P.P. van Dijk, pers. comm.). The southern subspecies, *M. e. emys*, ranges into Malaysia, Sumatra, and Borneo, and has been extirpated in Singapore. The northern subspecies, *M. e. phayrei*, ranges into Thailand, Myanmar, India, and Bangladesh.

**Habitat and Ecology.** — Relatively little is known about the behavior and ecology of this species in the wild. It inhabits dense forest at mid-level elevations (typically 600–1500 m) across its range. It is adapted to life in wet forests, and is usually found in proximity to water. It may be a mid-elevation counterpart to or even broadly sympatric with *M. impressa*, which usually occurs at somewhat higher elevations in some of the same forests in Thailand (Thirakhupt and van Dijk 1995). It is also sympatric with the Yellow-headed Tortoise, *Indotestudo elongata*, in much of its range, but does not appear to share its characteristic habitat with either of these species.

A one-year radiotelemetry study of *M. e. phayrei* in Kaeng Krachan National Park, Thailand, has revealed some aspects of its behavioral ecology (Wanchai 2008). Kaeng Krachan National Park in Phetchaburi province, about 150 km southwest of Bangkok, is the largest national park in Thailand, with an area of approximately 2920 sq. km. It is a mixture of moist evergreen forest, with some mixed deciduous forest, dry evergreen forest, and grassland. Floristically, the park lies at the juncture between the mainland Asian and Malaysian peninsular biomes, and so flora from both regions are diverse and abundant. Kaeng Krachan is in area of heavy rainfall on the eastern slope of the Tenasserim Mountain Range along the border with Myanmar. Kaeng Krachan is a sanctuary that protects some of the larger mammals in southeast Asian forests. Important tree genera in the park include *Azelia*, *Hopea*, *Dipterocarpus*, *Lagerstroemia*, *Pterocarpus*, and *Aquilaria*.

The elevation of the study site ranges from 700–1300 m, and the terrain is hilly and rugged. Annual rainfall averages 1100 mm, with a hot, rainy season from April to October and a drier cool season from November to March; temperatures in the area range from 10 to 35°C.

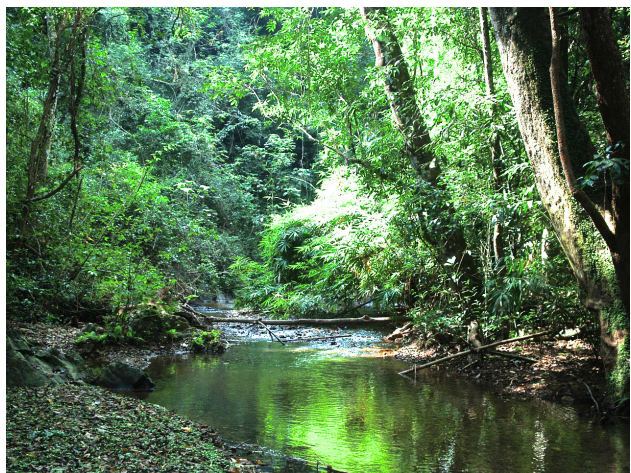


**Figure 7.** Captive-bred hatchling *Manouria emys phayrei*. Photo by Rick Schaffer.



**Figure 8.** Captive-bred hatchling *Manouria emys phayrei*. Photo by Chuck Schaffer.





**Figure 9.** *Manouria emys phayrei* habitats in Kaeng Krachan National Park, Thailand. Photos by Craig Stanford.

Wanchai's (2008) study of *M. e. phayrei* found that it utilizes a range of habitat types, including bamboo forest, dry evergreen forest mixed with bamboo, dry evergreen forest, stream courses, and swampy stream edges. The species spends much of its life under the forest canopy, although we have observed large individuals basking in patches of sun on the forest floor. Juveniles are highly associated with watercourses and swamps bordering them, and were rarely observed more than 20 m from streams. At least one juvenile was located half buried in mud along a stream edge. Adults were also found mainly near streams, except during the rainy months when they ascend steep surrounding ridges and are seen feeding in bamboo forest on bamboo shoots growing at higher elevations (Wanchai, 2008; Wanchai et al., in prep.).

At such times adults are more than 1 km from the nearest water. Most observations of adults (40%) were made in bamboo forest, while only 4% of juvenile sightings were in bamboo. About one third of all sightings of juveniles were sighted in swampy stream-edge habitat, while only 2% of adult sightings were stream-side.

Because of these habitat preferences, adults were far more likely to be found on steep hill slopes (two-thirds of all adults sighted), while juveniles were mainly seen on flat terrain (three quarters of all sightings). Wanchai (2008) found that home ranges for adults were 0.6 km<sup>2</sup> for both males and females, and 0.1 km<sup>2</sup> for juveniles. At least one juvenile traveled 1 km up a stream course and then returned to the exact spot where it had been seen a year earlier. During the dry season most individuals in the study became inactive for a period of up to two months, remaining under bamboo litter or buried under tree falls. Some individuals remained active during this period, however. During the hot wet season, adults were seen soaking in clear shallow streams (in water temperature of approximately 15°C). Lambert and Howes (1994) recorded shorter ranging distances for *M. e. emys* in peninsular Malaysia; Høybye-Mortensen (2004) recorded daily movement of up to 390 m and home ranges over six months of between .01 and 1.81 km<sup>2</sup> for *M. e. emys* in Sabah, Borneo.

*Diet.* — *Manouria e. phayrei* in Kaeng Krachan National Park consumed at least eleven plant species over the course of an 18-mo field study, plus two species of fungus (Wanchai, 2008, Wanchai et al., in prep.). Bamboo shoots of the genus *Bambusa* were the most frequently recorded food item, and were mainly eaten in the dry season, during which the new growth occurs. *Zingiber* sp. was the second most eaten plant. Unidentified mushrooms were also included in the diet; in at least one instance a tortoise fed in a stream on mushrooms growing on an overhanging log. This is quite similar to the



**Figure 10.** *Manouria emys phayrei* foraging for fungi in a stream, Kaeng Krachan National Park, Thailand. Photo by Pratyapom Wanchai.

mix of green plants and fungi recorded for *M. e. emys* in Sabah by Høybye-Mortensen (2004).

**Reproduction.** — Little is known about the reproductive biology of *M. emys* in the wild. Males engage in combat for access to females, and are quite vocal with one another (J. Juvik, pers. comm.). In Kaeng Krachan, Thailand, *M. e. phayrei* was seen mating during the month of May, which accords with a general assumption that the species reproduces mainly in the hot wet months across its range. Breeding behavior in captive *M. emys* can occur throughout the year. It is often accompanied by loud male vocalization, and breeding behavior can be very aggressive, both between and among the sexes (Schaffer and Schaffer 2008).

*Manouria emys* engages in behaviors such as nest-building and nest-guarding, which occur in no other tortoise species except the congeneric *M. impressa* (Schaffer and Morgan 2002; Ruby and Senneke 2003). Gravid females scrape together leaf litter using both hind and forelimbs to form a high nest mound, depositing their eggs inside and sitting on the mound for days or weeks before abandoning the clutch. While on the nest, females are aggressive toward intruders.

Clutch size has previously been reported to be up to 53 eggs, recorded in captivity, with incubation times in captivity ranging from 63 to 84 days (McKeown et al. 1991). Clutch size typically ranges from 30 to 60, with larger females producing more eggs. Eggs are round and typically measure 49–56 mm and have a mass of 48–62 g. They require relatively high humidity of 75–80% and hatch in 60–90 days at 29°C. Sex ratio of the clutch is determined by incubation temperature, with a predominance of male hatchlings at the lower end of the incubation temperature range (24.99–27.18°C) and more females at the higher end (30.79°C), with the pivotal temperature at approximately 29.29°C (Emer 2007).

*Manouria e. phayrei* has been maintained in captivity primarily outdoors at the Turtle Conservancy Behler Chelonian Center in southern California since October 2005 (P. Gibbons, C. Light, and E. Goode, unpubl. data). Adult tortoises nested annually in 2008–2014, except in 2012 when no nesting occurred, but eggs were found scattered on the surface of the ground. Multiple annual clutching was never observed. Nesting followed nest building behavior that lasted a few days to several weeks in some cases. Eggs were deposited in layered, fairly uniform rows with approximately 15 cm of leaf litter above, and moist, composting leaf litter below. Single eggs were occasionally deposited on the surface, and properly formed nests ( $n = 10$ ) contained a mean of 47 eggs, ranging from 29 to 60 eggs per nest. Older tortoises deposited more eggs per nest ( $n = 6$  nests, mean 57, range 50–60) than young individuals ( $n = 4$ , mean 34, range 29–38). The earliest egg in any year was deposited on 27 February 2014 and the latest egg of any year was deposited on 9 July 2012. Eight of the 10 nests occurred in

April, May, and June; the earliest and latest nests occurred on 7 March 2014 and 2 July 2010, respectively. Mean egg mass ( $n = 172$ ) was 61.9 g, ranging from 49 to 76 g. Eggs were slightly oval and the mean greatest dimension was 48.5 mm, ranging from 43.7 to 58.3 mm. Mean egg mass and dimensions varied among individual females. Incubation time varied with incubation temperature, ranging from approximately 68 days at 30.0°C, to about 76 days at 27.5°C. The shortest recorded incubation time was 63 days and the longest was 96 days. Mean hatchling mass ( $n = 124$ ) was 45 g, ranging from 33 to 54 g; mean minimum straight line carapace length was 57 mm, ranging from 46 to 63 mm (P. Gibbons, C. Light, and E. Goode, unpubl. data).

In captivity, the first copulation of *M. e. phayrei* was observed after 10 years (Fahz 2010). The same author noted that sexual maturity in captivity of this subspecies was reached at about 15 years. Longevity in captivity has only been recorded up to about 20 yrs (Slavens and Slavens 2000), but would be expected to be longer.

**Population Status.** — The status of the species in its known range countries is poorly known, and few population estimates are available, though most areas of previous occurrence have few remaining healthy populations. Das (1991) previously suggested that it was extirpated in Bangladesh, but it has recently been recorded as persisting in the Chittagong Hills of southern Bangladesh (Rahman et al. 2015). Wanchai's (2008) study of *M. e. phayrei* was conducted in a well-protected area in the center of Kaeng Krachan National Park in Thailand; the density of tortoises was  $> 1/\text{km}^2$ , and new individuals continued to be discovered throughout the study. No population data appear to be available from other portions of the species' range.

While little is known of the population biology of the species, Wanchai (2008) continued to record new individuals in his study site even after two years in the field; at least 15 adults were recorded in the approximately 1.5 km<sup>2</sup> watershed study site. This is a well-protected site and suggests that *M. emys* can occur at relatively high densities in the proper habitat without undue human pressures.

**Threats to Survival.** — Conservation threats include habitat loss, overharvesting for local consumption and illegal export to food markets in China and elsewhere, and overharvesting for the pet trade. Malaysia imposed a zero exportation quota for *M. emys* in 2014, and India, Myanmar, and Thailand do not allow commercial collection or export of wild-collected specimens. The species continues to be hunted and eaten in much of its range, which has led to its probable extirpation from Bangladesh and from populated areas across montane southeast Asia. Although a healthy population persists in Kaeng Krachan National Park in Thailand, the species is still collected for food outside park boundaries (Thirakhupt and van Dijk 1995; van Dijk and Palasuwan 2000; Thirakhupt, pers. obs.). Habitat alteration



and forest clearing have led to serious declines in *M. emys* populations throughout its range, although its preference for rugged wet montane forests may have provided some protection from habitat loss.

Poaching still occurs for the pet trade and for sale into the Asian food markets, attested to by a recent confiscation of 65 *M. e. phayrei* in Myanmar (Turtle Survival Alliance, unpubl. data). Adult *M. e. emys* specimens are widely distributed in captive holdings of traders on Java; several traders from Java reported to Auliya (2009) that they wanted to try and breed them. In March 2006, registered reptile breeders from Java and Bali claimed to possess 53 wild specimens and 50 F1 specimens (Auliya 2009). Auliya has also observed both subspecies in retail shops in Japan in 2007. At that time prices of *M. e. emys* ranged between ca. 500 and 650 USD and prices for *M. e. phayrei* between ca. 1300 and 1575 USD (Kanari and Auliya 2011).

**Conservation Measures Taken.** — *Manouria emys* has been listed as Endangered on the IUCN Red List since 2000 ([www.iucnredlist.org](http://www.iucnredlist.org)), but was provisionally re-assessed as Critically Endangered by the IUCN Turtle and Freshwater Specialist Group in 2011. It is included on Appendix II of CITES with all Testudinidae ssp. It is accorded special protection in Thailand's wildlife laws.

In India, the species occurs in at least one protected area: Nongkhyllam Wildlife Sanctuary. In Bangladesh it occurs in the Sangu Wildlife Sanctuary (Rahman et al. 2015). In Myanmar, *M. emys* occurs in at least one protected area: Rakhine Yoma Elephant Sanctuary. In Thailand, the species occurs in several protected areas, including: Kaeng Krachan National Park, Mae Wong National Park, Khlong Lan National Park, Khao Pra Bang Kram Wildlife Sanctuary, Umphang Wildlife Sanctuary, Huai Kha Khaeng Wildlife Sanctuary, protected areas in the Nakhon Sri Thammarat mountains, and Bang Lang National Park in southern Yala Province (van Dijk and Thirakhupt 1995; Wanchai 2008; P.P. van Dijk, pers. comm.). In peninsular Malaysia, it occurs in one protected area: Taman Negara National Park (Lim and Das 1999; Norsham et al. 2000). In Indonesia, the species occurs in three protected areas: Gunung Leuser National Park, Danau Sentarum National Park, and Kerinci Seblat National Park. In Sabah, Malaysia, the species occurs in at least two protected areas: Tabin Wildlife Reserve (Høybye-Mortensen 2004) and Danum Valley Conservation Area (Lambert and Howes 1994).

Assurance colonies of *M. emys* exist both in-range and *ex-situ*. Three such facilities currently exist in Myanmar alone, with others established or proposed throughout southern Asia. A large assurance colony of 24 *M. e. phayrei* has been established at the Zeepin Forest Reserve in Shan State, Myanmar. An assurance colony composed of village-confiscated *M. e. phayrei* has been established at the Rakhine Yoma Elephant Sanctuary in Myanmar. A much larger assurance colony has been established at the Mandalay

Zoo in Myanmar, which will be stocked with confiscated animals (Turtle Survival Alliance, unpubl. data, 2012). The hardiness of captives of this species when maintained in the proper climate, and their high rate of reproductive fecundity, bode well for maintaining sizeable captive colonies. In fact, some *ex-situ* facilities in the United States and elsewhere are producing more captive-bred hatchlings of both subspecies than they can easily care for.

**Conservation Measures Proposed.** — All conservation measures that create more protected areas in appropriate habitat in range countries will contribute to the species' protection. Because this species is a habitat specialist in mid-elevation montane forests, maintaining protected areas that include those habitats in mainland southeast Asia will be critically important in the long-term preservation of this species. Raising public awareness of the uniqueness of *M. emys* will be effective given the large size and visibility of the animal in its range countries. In range countries in which ecotourism exists, as increasingly among the Thai people, public education is likely to be effective in preventing poaching from protected areas. In regions where widespread subsistence collecting still occurs, education must be aimed at villages and rural areas where such collection is a major threat.

**Captive Husbandry.** — Private collectors and zoos are currently actively breeding and keeping both subspecies of *M. emys*, and veterinarians have become adept at dealing with common maladies afflicting the species.

The ideal enclosure for captive adult *M. emys* is a large shaded area with fencing approximately 1.5 m high. The species is a proficient climber and sufficient height and overhang is necessary. If the enclosure is not naturally shaded, shade cloth is necessary to prevent overheating. High humidity (70–90%) combined with moderate temperatures are key to the health of captive specimens (Nutaphand 1979; Fife 1989). Ambient temperature ranging from 25–28°C is preferred, but *M. emys* is remarkably cold-tolerant and may be active and feeding in temperatures as low as 5–10°C. When supplemental heat has been applied, it is better if heated from below; animals generally avoid heat lamps, preferring to burrow into a warm substrate of damp bark chips.

Compared to other species, *M. emys* possesses a low-domed carapace and is often unable to right itself if flipped over. This has led to unexpected mortality in captive conditions when animals are unable to escape hot sunlight (Schaffer and Morgan 2002a). Care of hatchlings and juveniles is very similar to that of adult animals, except that the younger animals are more prone to dehydration. Hatchlings should be soaked daily for the first few months to ensure they remain adequately hydrated, and their enclosures should be misted regularly.

A mix of moist leaf litter and humus is an ideal substrate. The substrate is also important for keeping the humidity

high, especially in drier areas. Nesting tortoises will often require the addition of appropriate nesting materials such as sandy soil, leaf litter, and pine straw (Schaffer and Morgan 2002a,b).

There is some controversy regarding the ideal captive diet for *M. emys*. Most keepers advocate a high fiber diet (Schaffer and Morgan 2002a), but some suggest that some animal protein should be included in their diet (Louwman 1982; Highfield 1996), and captive animals have been observed feeding on everything from earthworms and slugs to dead rodents. Grazing on native plants should be supplemented with adequate nutritional feeding, as unsupplemented grazing has resulted in weight loss of up to a third of the animal's weight (Schaffer and Morgan 2002a). A recommended captive diet should be primarily greens with some fruit, which accords with its diet in the wild. A recent study of 51 captive *M. emys* indicated the preferred dietary item to be the aroid plant *Xanthoma*, followed by corn, banana, mushrooms, and papaya (Schaffer 2010).

Timing of oviposition in captivity varies widely throughout the year. Females build large nests constructed of dead leaves and plant debris that are swept into a mound using front and hind legs. The nest may be continually revised until egg deposition, after which the female often remains on the nest for days or weeks and exhibits defensive nest-guarding behavior (Schaffer and Schaffer 2008). Males often display violent combat behavior and it is best to keep fewer males and more females in the same enclosure. Males may often require separation during the peak breeding season (Schaffer and Morgan 2002a).

**Current Research.** — Only a few field research projects have been carried out on this species, and at time of publication the authors know of none that are ongoing. Wanchai's (2008) study of *M. e. phayrei* and Høybye-Mortensen's (2004) study of *M. e. emys* stand as the most detailed field studies of the two subspecies.

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