

***Mauremys reevesii* (Gray 1831) – Reeves' Turtle, Chinese Three-Keel Pond Turtle**

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SUMMARY. – *Mauremys reevesii*, Reeves' Turtle (or Chinese Three-keel Pond Turtle) (Family Geomydidae), is a moderate-sized aquatic species (carapace length to 300 mm) widely distributed in East Asia throughout central and eastern continental China, exclusive of the most southern, western, and northern regions, and including Taiwan, southern Japan, and part of the Korean peninsula. However, the native distribution has been extended by human-aided translocations. The turtle lives in freshwater habitats in lowland areas with still or slowly moving water. Although no concrete data are available regarding the status of most populations, it is apparent that most have experienced major declines as a result of habitat destruction and/or commercial over-exploitation. Intentional and accidental releases of specimens from continental Asia may be altering the genetic stock of Japanese populations. Effective conservation of the species will require habitat protection and regulations to control the collection and transportation of wild animals. Additional studies are needed on the status, life history, and demography of the species.

DISTRIBUTION. – China, Japan (introduced?), North Korea, South Korea, Taiwan (introduced?); introduced in Indonesia, Japan, Palau, Timor-Leste. Native distribution includes most of central and eastern continental China and the Korean peninsula, with populations in Taiwan and southern Japan possibly introduced in prehistoric and historic times.

SYNONYMY. – *Emys reevesii* Gray 1831, *Clemmys* (*Clemmys*) *reevesii*, *Geoclemys reevesii*, *Geoclemys reevesii reevesii*, *Damonia reevesii*, *Chinemys reevesii*, *Emys vulgaris picta* Schlegel 1844, *Emys japonica* Duméril and Bibron in Duméril and Duméril 1851, *Damonia unicolor* Gray 1873, *Clemmys unicolor*, *Damonia reevesii unicolor*, *Geoclemys reevesii unicolor*, *Geoclemys grangeri* Schmidt 1925, *Geoclemys reevesii grangeri*, *Chinemys grangeri*, *Geoclemys paracaretta* Chang 1929, *Chinemys megalcephala* Fang 1934, *Chinemys pani* † Tao 1985, *Mauremys pritchardi* McCord 1997 (partim, hybrid).

SUBSPECIES. – None.

STATUS. – IUCN 2011 Red List: Endangered (EN A2bcd+4bcd) (assessed 2011); CITES: Appendix III (China).



Figure 1. Adult female *Mauremys reevesii* from Honshu, Japan. Photo by Nobuhiro Kawazoe.



Figure 2. Adult melanistic male *Mauremys reevesii* from Honshu, Japan. Photo by Nobuhiro Kawazoe.

Taxonomy. — *Mauremys reevesii* was originally described from China by Gray (1831) as *Emys reevesii*. Generic allocation of the species was changed several times by subsequent authors. In the latter half of the 20th Century, it was usually regarded as the type species of the valid genus *Chinemys* Smith 1931 (e.g., Ernst and Barbour 1989; Iverson 1992; Zhao and Adler 1993), which was assigned to the subfamily Batagurinae (now Geoemydidae) on the basis of cladistic analysis of morphological data (Hirayama 1984; Gaffney and Meylan 1988; Yasukawa et al. 2001). However, this view has been challenged by recent phylogenetic studies.

Shaffer et al. (1997) used a combination of molecular and morphological data to suggest a possible close affinity of *Chinemys* with *Heosemys*. Moreover, more recent molecular studies have yielded phylogenetic trees on which *Chinemys*, as well as the genus *Ocadia*, are consistently located within a cluster with the genus *Mauremys* (Wu et al. 1998; McCord et al. 2000; Honda et al. 2002; Barth et al. 2004; Spinks et al. 2004; Feldman and Parham 2004; Sasaki et al. 2006; Jiang et al. 2011). In contrast, Parham et al. (2001) presented a phylogenetic hypothesis based on molecular data where *C. reevesii* and *C. nigricans* were clearly separated from *Mauremys* species recognized at that date. After reviewing these systematic incongruities, Spinks et al. (2004) proposed synonymization of *Chinemys* and *Ocadia* with *Mauremys*, and the Turtle Taxonomy Working Group (2007) placed *reevesii*, as well as a few other species, long assigned to *Chinemys* and *Ocadia*, in the genus *Mauremys*.

Mauremys reevesii occasionally hybridizes with other geoemydid species such as *M. japonica* (Kosuge et al. 2003; Kato et al. 2010; Yasukawa and Ota, *pers. obs.*), and *M. sinensis* (Fong and Chen 2010; Xia et al. 2011), sometimes leading to confusion in the taxonomy and relationships of this and allied turtles. For example, *M. pritchardi*, described by McCord in 1997, proved to be a hybrid between *M. reevesii*



Figure 3. Adult female *Mauremys reevesii* from Honshu, Japan. Photo by Nobuhiro Kawazoe.



Figure 4. Juvenile *Mauremys reevesii* from captive breeding in Japan. Photo by Nobuhiro Kawazoe.

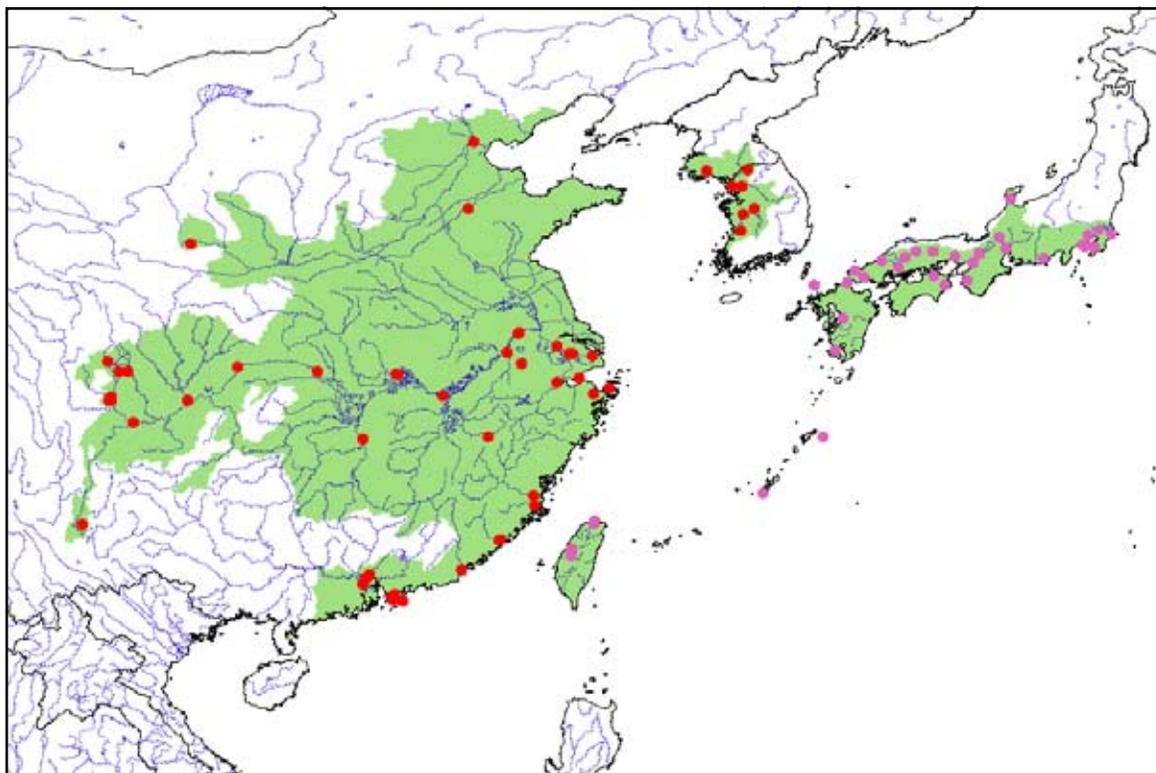


Figure 5. Distribution of *Mauremys reevesii* in China, North Korea, South Korea, Japan (introduced?), and Taiwan (introduced?). Red dots = museum and literature occurrence records of native populations based on Iverson (1992) plus more recent and authors' data; purple dots = occurrence records of apparently introduced populations; green shading = projected distribution based on GIS-defined hydrologic unit compartments (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), and adjusted based on authors' data.

and *M. mutica* (Dalton 2003; Wink et al. 2001; Honda et al. 2007). Likewise, several variants of *M. reevesii* were erroneously described as distinct species (e.g., *Damonina unicolor* Gray 1873, *Geoclemys grangeri* Schmidt 1925, and *Geoclemys paracaretta* Chang 1929). These taxa were placed in the synonymy of *M. reevesii* by numerous authors as reviewed by Lovich et al. (1985), although Pritchard (1994) subsequently considered *G. paracaretta* to be synonymous with *M. nigricans*. Iverson et al. (1989) also included *C. megaloccephala* Fang 1934 in the synonymy of *C. reevesii*; an arrangement that was not adopted by Zhao and Adler (1993). Recently Barth et al. (2003, 2004) reported the absence of sequence variation in mitochondrial cytochrome *b* gene between *M. reevesii* and *C. megaloccephala*. Their result supports Iverson et al.'s (1989) synonymy.

No subspecies are currently recognized. After making morphological comparisons among samples from several regions, including mainland Asia, Taiwan, and the Japanese-Korean region, Lovich et al. (1985) concluded that, although the coloration of *M. reevesii* varies to some extent, there is no geographically correlated variation within the species. In Japan, however, individuals belonging to western Honshu populations (Shibata 1967) appear distinct in plastron coloration and morphology compared to those imported from China in the early 1970s that established breeding colonies in eastern Honshu (Aoki 1974, 1990; Yasukawa, *pers. obs.*). Based on the almost complete absence of old

Japanese literature referring to this species and the absence of Pleistocene-Holocene fossils and sub-fossils in Japan, several recent authors argued for the exotic origin of all current Japanese populations of *M. reevesii* (Hirayama et al. 2007; Hirayama and Isaji 2010; Hikida and Suzuki 2010). Suzuki et al. (2011) tentatively attributed distinct morphological and mitochondrial haplotype variations observed among Japanese populations to their originating from artificially introduced continental individuals belonging to diverse haplotype lineages. Indeed, genetic diversity in the continent (e.g., Hubei Province, China) is considered to be high (Zhu et al. 2005).

Based on the recent genetic surveys of *Mauremys* in Taiwan, Fong and Chen (2010) surmised that *M. reevesii* on this island are also derived from artificial introductions from mainland Asia. Harvesting, commercial trading, and even intentional releases (for religious reasons) of this turtle still happen in China (e.g., Lau and Shi 2000; Shi et al. 2008; Gong et al. 2009). Therefore, additional studies of geographic variation are needed to elucidate differences among local populations before artificial gene flow caused by translocations and introductions completely obfuscates natural patterns.

Description. — *Mauremys reevesii* is a medium-sized geoemydid turtle attaining a straight line carapace length (CL) of at least 300 mm. The carapace is oval and low-arched, possesses three longitudinal keels that are more-or-less

parallel to each other, and is not serrated at the posterior margin, even in juveniles. The bridge is long and possesses axillary and inguinal scutes. The plastron is large, elongate, hingeless, and unnotched anteriorly, but deeply notched posteriorly. Variation in plastral formula is extensive as shown by Lovich and Ernst (1989). The entoplastron is intersected by the humeral-pectoral seam but not the gular-humeral seam. Plastron buttresses are well-developed, and firmly connected to the carapace. The head is large, and its dorsal surface is subdivided into small scales. The upper jaw is slightly notched and unhooked medially. Triturating surfaces of the upper and lower jaws are wide, without any ridges, serrations, or cusps. The four limbs have fully webbed digits. Cloacal bursae are well-developed.

The skull of *M. reevesii* is massive and wide. The anterior end of the processus inferior parietalis is in contact with the palatine, jugal, pterygoid, and quadratojugal bones, but is separated from the maxilla by the palatines. The foramen nervi vidiani is lost. The jugal, postorbital, and quadratojugal are connected with each other, forming a well-developed temporal arch. The postorbital does not usually contact the squamosal and quadrate. The fissure ethmoidalis is narrow and keyhole-shaped.

In non-melanistic individuals, the carapace is light to dark brown, sometimes with broken stripes along the longitudinal keels. The carapace of hatchlings is usually more light-colored, especially around its outer margin. The coloration of the plastron is highly variable, from uniform dark brown to horn-colored with a smear of darker pigments (Sachsse 1975a; Lovich et al. 1990). Most specimens have dark blotches in the center of each plastral scute, some with radiating lines on the periphery. The ground color of the head and throat varies from grayish to dark brown. Lateral surfaces of the head and neck possess a series of broken yellowish stripes extending from the snout (sometimes from the posterior margin of the orbit). The limbs and tail are brown or dark gray, but irregular light spots are sometimes scattered on the basal portions of limbs. Adult male *M. reevesii* tend to become melanistic as they grow older and larger, and large males occasionally lose all light markings on the shell and soft parts. Females do not exhibit this trend in coloration (Mao 1971; Sachsse 1975a; Sengoku 1979; Lovich et al. 1990; Yabe 1994). Yabe (1994) reported an extreme case of male melanism in a central Honshu population, in which males, including an individual of 120 mm CL and all those greater than 145 mm CL, lost all light markings. He assumed that the degree of the melanistic change in this species is correlated more with body size than with age. Later, he reported regional variation in male size at which melanism starts, with eastern Honshu males tending to become melanistic at a smaller CL size (Yabe 2009). Melanistic males from Japan also exhibit changes in iris color and characteristics of the liver and fat, relative to non-melanistic males (Yasukawa, *pers. obs.*).

Pritchard (1979, 1994) suggested that Japanese *M. reevesii* may attain greater carapace lengths than Chinese populations. The largest specimen examined by Lovich et al.

(1985), a female measuring 236 mm CL, was from Szechwan Province, China (Ernst and Barbour 1989), whereas Aoki (1990) mentioned a gigantic female from Japan with a carapace measuring 355 mm in length. Although this latter value was actually for curved CL, the straightline CL greatly exceeded 300 mm (R. Aoki, *pers. comm.*). This figure is much larger than those reviewed by Pritchard (1994) for the record size of *M. reevesii*, including the megaloccephalic form (previously recognized as *C. megaloccephala*: Iverson et al. 1989). Males are much smaller than females, attaining a CL of 200 mm at most (Yabe 1994; Yasukawa, *pers. obs.*). Yabe (1994) reported on a population in Gifu Prefecture, Japan, in which adult females and males exhibited a modal CL of 185–195 mm (max 237.0 mm) and 145–155 mm (max 185.3 mm), respectively.

Mauremys reevesii shows distinct sexual dimorphism (Mao 1971; Gibbons and Lovich 1990). Males have a lower and narrower carapace, a shorter and narrower plastron, and shorter bridges compared to females. The plastron is flat in females and slightly concave in males. In males the tail is long and thick, with the vent located beyond the posterior rim of the carapace. Du and Shen (2007) reported that in body mass males and females are similar for the first three months after hatching, but then females grow much faster than males, leading to female-biased sexual size dimorphism.

The karyotype of *M. reevesii* consists of $2n = 52$ chromosomes, including nine pairs of metacentric or submetacentric macrochromosomes, five pairs of telocentric or subtelocentric chromosomes, and 12 pairs of microchromosomes (Bickham and Carr 1983; Kojima and Yamamoto-Yamazaki 1987).

Distribution. — *Mauremys reevesii* is widely distributed in eastern Asia, including central and eastern continental China, Taiwan, Kimmen Island, southern and central Japan, and Korea (Ota 1991; Szyndlar 1991; Iverson 1992). In Japan, this species occurs in Honshu, Shikoku, and Kyushu on the main islands, as well as on several adjacent small islands such as Sadogashima, Awajishima, Ikijima, Mishima, and Tsushima, and the Okinoshima Group (Ohno 1968; Sengoku 1979; Ota 2001, Yasukawa, *pers. obs.*); all these may have originated as introductions from mainland Asia before (western Japan) or after World War II (eastern Japan) (Shibata 1967; Aoki 1974, 1990; Hikida and Suzuki 2010; Suzuki et al. 2011: see above). This species was more recently introduced to Kikaijima Island of the Amami Group, and Okinawajima and Kumejima islands of the Okinawa Group, central Ryukyus (Masuno et al. 1998; Okada and Ota 2003; Maenosono and Toda 2007), as well as to Hokkaido in northern Japan (Ota 2001). Also, turtles recorded from Taiwan may be nonnative as well (Fong and Chen 2010: see above).

Zhao and Adler (1993) stated that this species is currently distributed throughout China exclusive of the western and northern regions. However, Pope (1935) assumed that the probable native distribution of this species within China was confined to the Yangtze River Valley from the junction of the Min River eastward and along the coast from Kiangsu to Kwangtung. Thus, the apparent wide range of this turtle in China, as well as in Japan, may be partially attributable to

artificial translocations (see below), a situation that is likely mirrored by *Cuora flavomarginata* in China (Fong et al. 2002; but see Ernst and Lovich 1990 and Ernst et al. 2008 for details on range-wide variation in *C. flavomarginata*). Records from the Philippines and Russia are considered to be extralimital (Ernst and Barbour 1989). This species has also been introduced into Canada and the United States (Cooper 1961; Iverson 1992), Palau (Crombie and Pregill 1999), and Timor-Leste (Kaiser et al. 2010), although breeding populations have not been reported in those countries.

Early Pleistocene remains of *M. reevesii* have been reported from Hsiatsaohwan, in the Shihhung district of northern Anhwei (Chow 1955). A fossil specimen of the Late Pleistocene age was dredged up from a depth of 150–200 m in the Taiwan Strait near Penghu Island (Tao 1988). Tao (1985) also described *Chinemys pani* from fossils that she considered to be similar to *M. reevesii*, and the two taxa are often synonymized. Differences between *Chinemys pani* and *M. reevesii* include an abdominal scute that is shorter than the femoral scute and a wider body in the former. Other minor differences in the size relationships between scutes invite caution in recognizing *Chinemys pani* as separate from *M. reevesii* given the high degree of variation in plastron scute length relationships in *M. reevesii* (Lovich and Ernst 1989). No fossil specimens of *M. reevesii* are known from Japan, and some Japanese authors have therefore suspected that the current Japan mainland populations of *M. reevesii* were introduced (Hirayama et al. 2007).

Habitat and Ecology. — Little information is available regarding the habitat and ecology of *M. reevesii*. The species is closely associated with aquatic habitats, inhabiting still or slow moving freshwaters such as the middle and lower reaches of rivers, lakes, ponds, swamps, marshes, and irrigated rice paddies. Proof of its aquatic proclivities is shown by the frequent presence of filamentous green algae on the carapace; a condition that has generated the colloquial name “green-haired turtle” (Pope 1935). In Japan, *M. reevesii* and the Japanese pond turtle (*M. japonica*) are frequently found in sympatry in the lowlands, but the former seems to prefer more open habitat compared to the latter, and is rarely found in semi-montane environments (Yabe 1993, 2006; Nakajima et al. 2000; Kosuge et al. 2003). This sympatry results in hybridization between *M. reevesii* and *M. japonica* throughout the Koito River in central Japan, even though the former is only found in the lower part of the river basin (Kosuge et al. 2003). *Mauremys reevesii* is chiefly diurnal, and fond of basking.

Few data are available on the population structure of *M. reevesii*. Takenaka and Hasegawa (2001) estimated a population of 1179 turtles (1123 individuals captured) in 15 ha of aquatic habitats on Ishima Island, a small island (190 ha) in Japan. Of the turtles captured, 833 were males, 214 were females, and 76 were juveniles or of undetermined sex. Mean carapace length and weight of old individuals whose age was unknown were 131.9 mm and 353.1 g in males, and 165.5 mm and 743.3 g in females. The sex ratio was basically 1:1 in the 3–6 yr age classes, but significantly

biased toward males in the 12 yr and older age classes. A significant female bias was noted in turtles that were found dead (26 of 31 carcasses), suggesting that differential mortality contributed to the male-biased sex ratio observed in the living population. Most of the carcasses were larger than the minimum size of mature females and they were found in areas frequented as hibernacula, suggesting mortality during overwintering.

Mauremys reevesii is omnivorous and feeds on various plants and live and dead animals. One and two year old juveniles stop feeding when ambient temperatures are below 15°C. Growth rate and average daily food intake are positively correlated with temperature, while passage time was negatively correlated, all as expected for an ectotherm (You et al. 1993). Food items include algae, aquatic macrophytes, fallen fruits, earthworms, aquatic and terrestrial insects, aquatic and terrestrial snails, crayfish, shrimp, crabs, fish, tadpoles, and frogs (Fukada 1965; Sengoku 1979; Noda and Kamata 2004; Yabe and Yasukawa, *pers. obs.*). The wide triturating surfaces and well-developed masticatory muscles are probably adaptations for feeding on animals with hard shells, such as mollusks and crustaceans. However, the bite force for *M. reevesii* is relatively modest compared to other turtle species (Herrel et al. 2002).

Courtship behavior of *M. reevesii* involves movements by the male to gain a position whereby he can rub his snout or forelimbs against those of the female (Pope 1935; Yasukawa, *pers. obs.*). Based on captive observations in outdoor enclosures in Japan, Fukada (1965) surmised that mating season begins in early spring, but in captivity courtship behavior is also observed in autumn (Yasukawa, *pers. obs.*). In Japan, the egg-laying season of *M. reevesii* is usually from June to July (Fukada 1965). In outdoor captivity, nesting has been observed from 6 June to 7 August. Yabe (1994) reported that the smallest egg-bearing female in a natural population was 173 mm CL, and that clutch size, positively correlated with female CL, ranged from 4–13 (8.3 on average).

Based on observations of individuals kept in outdoor enclosures in Kyoto, Japan, Ishihara (1986) reported that females start to lay eggs at 9–12 yrs of age, and that the smallest egg-laying female measured 149.6 mm CL. The annual number of clutches ranged from 1–3 and clutch size ranged from 1–14 (7.7 on average). When two clutches are produced the internesting interval is about one month. Nests are constructed with the hind limbs. The nest dug by one female (175 mm CL) was 8 x 7 cm in diameter x depth and contained 6 eggs. Another female (172 mm CL) dug a nest that was 10 x 10 cm that also contained 6 eggs; mean egg size was 38 x 22.5 mm and mean mass 11 g. Some hatchlings emerge from the nest in October, but most overwinter until April or May of the following year. The newly emerged hatchlings have a CL between 24.6–36.6 mm, weigh ca. 6 g, and look like miniature adults with long tails and large heads (Fukada, 1965; Fukada and Ishihara 1974).

Saka et al. (2011) examined seasonal variation in serum vitellogenin (VTG) levels and its relationship to the gonadal cycle in female *M. reevesii* from Kyoto. Two peaks were

recognized for VTG levels: one in late spring, apparently corresponding to rapid acceleration of vitellogenesis, and the other occurring in autumn, supposedly corresponding to a gradual enlargement of ovarian follicles in preparation for initial ovulation the following spring.

Wang et al. (1995) reported that the lengths of incubation periods (days) in eggs of a continental sample were 66.91 ± 3.70 , 62.29 ± 9.00 , and 56.57 ± 2.85 days at 28, 30, and 33°C, respectively. They also reported that the masses of hatchlings from incubation at those temperatures averaged 4.83, 4.66, and 4.12 g, respectively. Other authors tested the effects of different moisture levels on incubation (Du and Zheng 2004). At 30°C, incubation time is just over 60 days on both wet (-12 kPa) and dry (-300 kPa) substrates, although hatchling success rates were 69.2% and 88.0%, respectively. Wet body mass and carapace width are greater for hatchlings on wet substrates, but dry body mass, carapace length, tail length, limb length, measures of hatchling components (e.g., residual yolk and fat body mass), swimming performance, and critical thermal maxima, were similar between the two water potentials (Du and Zheng 2004). Hatchlings from eggs incubated at 27 and 30°C crawled and swam faster than hatchlings incubated at 24 and 33°C. The critical thermal minima for hatchlings incubated at 30 and 33°C were higher than those for hatchlings incubated at 24 and 27°C (Du et al. 2006). Du et al. (2007) found that hatchlings from eggs incubated at 24, 26, and 28°C are larger and have greater mass than those incubated at 30, 32, and 34°C. However, eggs incubated at the two high temperature regimes had lower hatching success. By an age of 3 months, the size superiority displayed by hatchlings from lower incubation temperatures disappeared. After 3 months, females from 28°C incubation temperatures grew faster than males from the same temperature. The authors concluded that the differences in growth rates were attributable more to between-sex differences rather than temperature effects.

Mauremys reevesii exhibits temperature-dependent sex determination. On the basis of laboratory experiments, Ling (1985) reported that an incubation temperature of 32°C produced only females, whereas those ranging between 23–27°C produced males. Similar results were reported by Ishihara (1989), Du et al. (2007), and Li and Cui (2011). Based on observations in an outdoor terrarium in Kyoto, Ishihara (1985) reported that eggs laid from 28 May to 2 July (nest temperatures 23.7–28.3°C) produced only males, whereas 78.8% of eggs laid after 7 July (nest temperatures 26.5–28.7°C) produced females.

In a Chinese population of *M. reevesii*, growth was rapid and relatively constant during the first five years, and then slowed dramatically after the sixth year at which point sexual maturity is probably attained (Liu and Hu 1940). In contrast, rapid growth seems to continue until about ten years after hatching in Japanese populations (Ishihara 1986; Yasukawa, *pers. obs.*). The smallest male from Japan that had well-developed gonads measured 132 mm CL (Yasukawa, *pers. obs.*). Captives have lived for over 24 years (Snider and Bowler 1992).

The Japanese striped snake *Elaphe quadrivirgata* occasionally preys on eggs of *M. reevesii* (Fukada 1959; T. Yabe, *pers. comm.*). Hirai (2003) reported a case of predation on juvenile *M. reevesii* by the introduced bullfrog *Lithobates catesbeianus* in western Honshu. It is probable that feral dogs also sometimes prey on the turtle (Yasukawa, *pers. obs.*). *Mauremys reevesii* often emits strong-smelling volatile fluids from its axillary and inguinal musk glands.

Population Status. — In the 20th Century, several authors documented that *M. reevesii* was abundant in various areas of continental China (e.g., Sowerby 1925; Pope 1935; Liu and Hu 1940) and Taiwan (e.g., Mao 1971). However, judging from the fact that this turtle is disappearing from markets in continental China and the island of Taiwan (Chen et al. 2000; Lue et al. 1999; Lau and Shi 2000; Lau et al. 2000; Chen and Lue 2010; R. Aoki, *pers. comm.*), substantial population declines in these regions is highly likely, although no concrete population data are available. Ades et al. (2000) and Bhupathy et al. (2000) noted that *M. reevesii* was one of the commonest species seen in the food markets of China, Hong Kong, and Taiwan in the 1970s and early 1980s, but that they disappeared almost completely after the influx of turtles from other Asian countries. Recent surveys have revealed that this turtle is quite common on Kimmen Island, a small island off the coast of Taiwan (Chen et al. 2000; Lue et al. 1999), but may be rare on Taiwan itself (Chen et al. 2000; Chen and Lue 2010). In Hong Kong and other parts of China the species was previously considered a common species, but is now infrequently recorded (Lau et al. 2000; Lau and Shi 2000). In Japan, there is little fear of immediate extinction, since the turtle is often found in large numbers in various areas. Even so, it is highly likely that many populations have recently declined.

Threats to Survival. — The greatest threats to the survival of *M. reevesii* populations seem to be intense overexploitation for the food and pet trades, as well as habitat destruction caused by land development and various modifications to inland waters. Van Dijk (2011), in the current IUCN Red List assessment of this species, noted that *M. reevesii* has become increasingly subjected to intensive exploitation for food and medicine and the aquaculture industry, as well as being extensively impacted by habitat degradation and loss. Over the past 30 years the species has disappeared from at least half its original area of occurrence as a result of targeted collection.

Yabe (1993) reported that, at two small ponds in Gifu Prefecture of Japan, populations of this species, as well as *M. japonica*, declined dramatically and rapidly after development in and around their habitats.

Drugs derived from turtles have been used in Traditional Chinese Medicine since at least 2700 B.C., and *M. reevesii* has traditionally been one of the most popular species in the drug trade (Moll 1982). According to Moll (1982), the supply of turtles even back then was insufficient to satisfy the demand, leading to the importation of several non-Chinese species of turtles into Hong Kong to substitute for *M. reevesii*, implying that local stocks were already being depleted. Mao

(1971) reported that the species had no economic value in Taiwan at the time, but shells from *M. reevesii* are now the most valuable in the high-volume Traditional Chinese Medicine market in Taiwan (Chen et al. 2009).

A large number of *M. reevesii* have been imported from continental China into Japan, the United States, and elsewhere for the pet trade since the early 1970s (Aoki 1990; Cheung and Dudgeon 2006). Such trade activities have severely impacted many Chinese populations of this species along with massive turtle farming efforts. The latter threatens wild stocks through replenishment of breeding stock from the wild and genetic pollution (Shi et al. 2008). In Japan, *M. reevesii*, apparently imported from China since the 1970s, are occasionally found in natural habitats mixed with populations (Yasukawa, *pers. obs.*) of animals from possible earlier introductions (Suzuki et al. 2011). The introduced U.S. slider turtle (*Trachemys scripta*) may compete with the native *M. reevesii* for resources (Noda and Kamata 2004; N. Ohtaishi, *pers. comm.*). Although xenobiotic estrogens have not been demonstrated to be a threat to the species, immunological assay of baseline serum vitellogenin levels are established for *M. reevesii*, making it a useful bioindicator for exposure to such compounds (Tada et al. 2004).

Conservation Measures Taken. — In Japan, one pond on Mishima Island, inhabited by *M. reevesii* and *M. japonica*, was designated as a National Natural Monument in 1928, and is protected by the Japanese Government. No other effective conservation measures have been implemented for the Japanese populations of *M. reevesii*. In Taiwan, this turtle is protected as a rare and valuable species under the Wildlife Conservation Law of the national government (Chen et al. 2000). Also, the species is protected as Vulnerable by the National Law in South Korea (KACN 1989). The IUCN 2000 Red List (Hilton-Taylor 2000) assessed this turtle as Endangered, which was reaffirmed through its most recent re-assessment (van Dijk 2011). In 2005, *M. reevesii* (as *Chinemys reevesii*) was added to Appendix III of CITES by the People's Republic of China.

Although not oriented toward conservation, large-scale captive propagation of this species occurs in Hainan Province, China, indicating that there is a potential for captive breeding efforts (Shi and Parham 2001).

Conservation Measures Proposed. — Effective conservation of *M. reevesii* will require preservation of habitat consisting of a variety of terrestrial and aquatic microenvironments, in which individuals can make seasonal home range shifts for feeding, breeding, and hibernation (Kume et al. 2008; Tempaku et al. 2009; Haramura et al. 2010). Regulation of collecting and trade activities will also be essential. Detailed population studies are needed for each major population.

Captive Husbandry. — It is easy to keep *M. reevesii*, and some aquaria and pet keepers breed this species regularly. Fukada and Ishihara (1974) reported 15 cases of captive breeding of *M. reevesii* in outdoor pens in Kyoto, Japan. Acclimatization to conditions of outdoor captivity may take several years before reproduction occurs (Sachsse, 1975b).

Mauremys reevesii is one of the most abundant turtle species in Chinese turtle farms. Shi et al. (2008) estimated that there were over 2.7 million specimens in a subsample of officially recognized turtle farms (684 of 1499) that responded to a questionnaire asking about species and numbers of turtles held.

Current Research. — Populations in Kyoto, Gifu, and Chiba prefectures of Japan have recently been the focus of mark release-recapture studies by T. Yabe, Y. Kosuge, and several other researchers and students.

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