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Cuora flavomarginata (Gray 1863) – Yellow-Margined Box Turtle

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Summary. – The yellow-margined box turtle, *Cuora flavomarginata*, (Family Geoemydidae), is a small species (carapace length to 190 mm), that occurs in eastern and southern continental China, Taiwan, and the southern Ryukyus of Japan. The species is mainly terrestrial and is found in and around primary and dense secondary forests, feeding on both small animals and plant materials, such as insects, earthworms, and berries. Clutch size usually ranges from one to four, and the female tends to be larger in body mass than the male, sometimes exceeding 1000 g. The yellow-margined box turtle is threatened by deforestation in its natural habitat, and large numbers have been exploited for food and traditional Chinese medicine and also exported from continental China for pets. This exploitation has caused the decline of many populations of this turtle. Capture and trade in Japanese and Taiwanese populations are currently regulated by national laws, but habitat destruction progresses in both countries. There is thus urgency that areas of habitat be set aside and protected. In order to devise effective conservation measures, it is also important to undertake research on life history and population status of the species; information on these aspects is insufficient, especially for the non-Taiwanese populations.

Distribution. —China (Continental), China (Taiwan), Japan. Distributed on Ishigakijima and Iriomotejima islands of the southern Ryukyu Archipelago (Japan), Taiwan, and Minjiang, Fuchun, and Yangtze River drainages of eastern continental China.

Synonymy. — *Cistoclemmys flavomarginata* Gray 1863, *Cuora flavomarginata*, *Terrapene flavomarginata*, *Cyclemys flavomarginata*, *Geoemyda flavomarginata*, *Cyclemys flavomarginata sinensis* Hsü 1930, *Terrapene culturalia* Yeh 1961.

Subspecies. — Two currently recognized by us: *Cuora flavomarginata flavomarginata* (Common Yellow-Margined Box Turtle) (synonymy: *Cyclemys flavomarginata flavomarginata*, *Cuora flavomarginata flavomarginata*, *Cistoclemmys flavomarginata flavomarginata*, *Cyclemys flavomarginata sinensis*, *Cuora flavomarginata sinensis*, *Cistoclemmys flavomarginata sinensis*) and *Cuora flavomarginata evelynae* (Ryukyu Yellow-Margined Box Turtle) (synonymy: *Cuora evelynae* Ernst and Lovich 1990, *Cistoclemmys flavomarginata evelynae*).

Status. — IUCN 2009 Red List: Endangered (EN A1cd+2cd) (assessed 2000); CITES: Appendix II (as *Cuora* spp.).

Figure 1. *Cuora flavomarginata flavomarginata,* adult female from Nantou, central Taiwan. Photo by Tien-Hsi Chen.

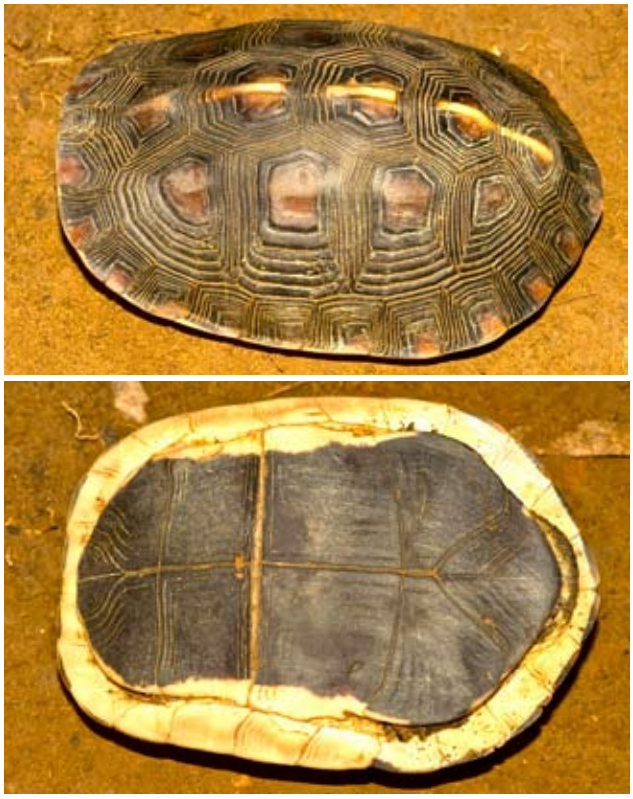

Figure 2. *Cuora flavomarginata flavomarginata*, adult male from Keelung, northern Taiwan. Photos by Tien-Hsi Chen.

Taxonomy. — Gray (1863), in establishing the monotypic genus *Cistoclemmys*, described the yellow-margined box turtle as *Cistoclemmys flavomarginata* on the basis of two specimens, one from Tamsuy (= Tanshui), northwestern Taiwan, and the other from continental China (Boulenger 1889). The type locality was restricted to Tamsuy by Mertens and Wermuth (1955). However, Günther (1864) synonymized the genus with *Cuora* Gray, 1856, and adopted the combination *Cuora flavomarginata*. Later, Boulenger (1889) considered *Cuora* to be synonymous with *Cyclemys* Bell, 1834, and referred to the yellow-margined box turtle as *Cyclemys flavomarginata*. This was followed by many subsequent authors (e.g., Stejneger 1907; Pope 1935).

However, Wermuth and Mertens (l961) resurrected the genus *Cuora* to accommodate most Asian box turtles, including *flavomarginata*. Recently Bour (1980) argued for the validity of *Cistoclemmys* and reassigned *flavomarginata* to this genus. Based on the results of cladistic analysis, chiefly using osteological characters, Hirayama (1984) also considered *Cistoclemmys* as valid and defined the genus as consisting of three species, *C. flavomarginata*, *C. galbinifrons*, and *C. hainanensis*. Since then, the validity of *Cistoclemmys* has been disputed (e.g., supported by Gaffney and Meylan 1988; King and Burke 1989; Ota 1991; Zhao and Adler 1993; and Yasukawa et al. 2001; but disputed by Sites et al. 1984; Ernst and Barbour 1989; Iverson 1992; Fritz and Obst 1997; and Ernst et al. 2000). Recent molecular analyses, however, invariably place the species of *Cistoclemmys* (as defined above), as well as the genus *Pyxidea*, within the *Cuora* clade on the resultant phylogenetic trees (Honda et al. 2000; Stuart and Parham 2004; Spinks et al. 2004; Parham et al. 2004), strongly supporting synonymization of *Cistoclemmys* under *Cuora*. Recent analyses also suggested a sister group relationship of *C. flavomarginata* with *C. yunnanensis* from southern continental China (Parham et al. 2004). The latter species had been considered extinct for nearly a century (Baillie and Groombridge 1996; Hilton-Taylor 2000) until recent re-discovery (Zhou and Zhao 2004; Blanck 2005).

Hsü (1930) described a new subspecies, *Cuora flavomarginata sinensis*, based upon a small sample from Tungting

Figure 3. Left: *Cuora flavomarginata flavomarginata* from Keelung, northern Taiwan. Photo by Tien-Hsi Chen. **Right:** *Cuora flavomarginata evelynae* from Iriomotejima Island, southern Ryukyus. Photo by Jarmo Perälä.

Figure 4. Hatchling *Cuora flavomarginata flavomarginata* from Keelung, northern Taiwan. Photos by Tien-Hsi Chen.

Figure 5. Hatchling *Cuora flavomarginata evelynae* from the Ryukyus. Photo by Hans-Dieter Philippen.

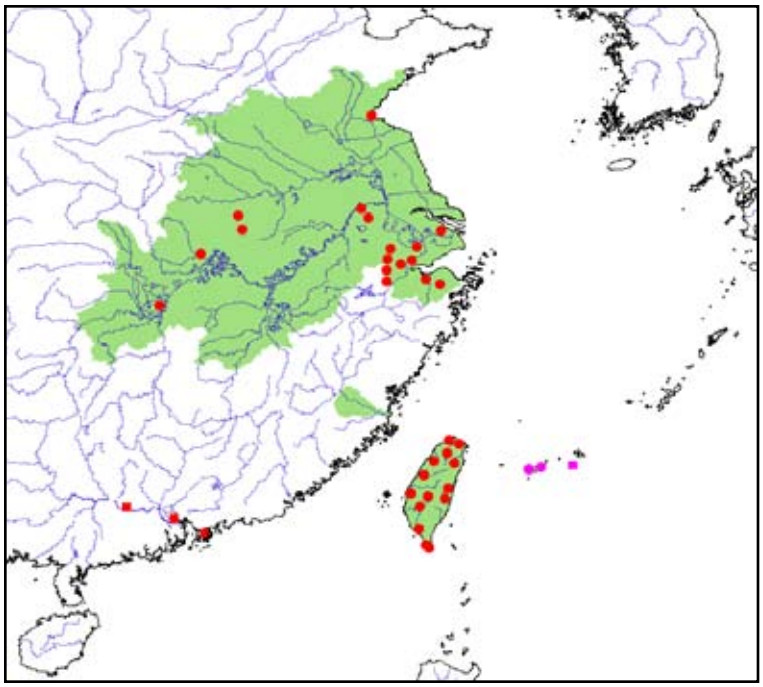

Figure 6. Distribution of *Cuora flavomarginata* in continental China, Taiwan, and the southern Ryukyu Archipelago of Japan. *Cuora f. flavomarginata* shown with red locality points, *C. f. evelynae* with purple points. Points = museum and literature occurrence records based on Iverson (1992), Fong et al. (2002), plus more recent and authors' data; 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., in press), and adjusted based on authors' data. The occurrence of *C. f. flavomarginata* in the Minjiang River drainage in Fujian in southeastern continental China has not been confirmed by detailed, specimen-based locality data. Localities representing assumed introduced populations in southern continental China and the Ryukyu Archipelago are indicated by color-coded squares.

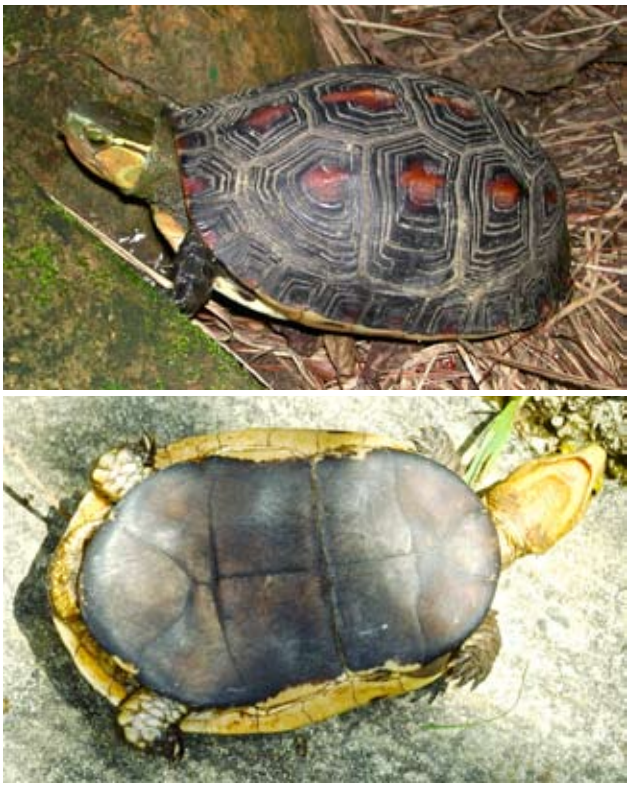

Figure 7. *Cuora flavomarginata evelynae* from Iriomotejima Island, southern Ryukyus. **Top:** adult female, photo by Iriomote Wildlife Conservation Center. **Bottom:** adult male, photo by Yuichirou Yasukawa.

Lake of Hunan Province, continental China. However, all diagnostic characters proposed to distinguish this subspecies from the typical form were either within the common kinds of variation to be expected in most geoemydid turtles, or were differences generally correlated with age or sex (Fang 1934; Pope 1935; Ernst and Lovich 1990).

Yeh (1961) described the box turtle *Terrapene culturalia* from a Neolithic archaeological midden site in continental China. However, this species was subsequently syonymized with *C. flavomarginata* by McCoy and Richmond (1966) on the basis of their morphological identity.

On the other hand, Ernst and Lovich (1990) made morphological comparisons among populations of continental China, Taiwan, and the Yaeyama Group of the Ryukyus, and described the Yaeyama populations as a distinct species, *Cuora evelynae*, chiefly on the basis of relatively large blotches of the carapace, shape of the dark plastral figure, and the relatively small number of enlarged scales on the anterior surface of the forelimbs. However, McCord and Iverson (1991) argued that, in the morphometric characters of the shell, the continental sample is the most divergent among those from the above three regions and that *C. evelynae* should be reduced to the rank of a subspecies of *C. flavomarginata*. Iverson (1992) regarded the species as consisting of three subspecies, *C. f. flavomarginata*, *C. f. sinensis,* and *C. f. evelynae*, but without providing diagnoses. Recently, Yasukawa and Ota (1999) analyzed larger samples of shell measurements than those examined by McCord

and Iverson (1991). They found that shell morphometrics demonstrated that the Taiwanese sample had the greatest divergence and that there was an absence of substantial differentiation between the Taiwanese and continental samples. Based on these results, they tentatively synonymized *C. f. sinensis* with the nominotypical subspecies, while still recognizing *C. f. evelynae* as valid. More recently, Ernst et al. (2008) re-analyzed the morphology (including color) of Taiwanese, continental Chinese, and Ryukuys populations of the *flavomarginata* complex and concluded that *evelynae* was distinct at the species level, with continental Chinese and Taiwanese samples conspecific. However, because our latest additional analysis confirmed Yasukawa and Ota's (1999) conclusion that morphological differences between the Ryukyus and the other populations are subtle (Yasukawa and Ota, in prep.), we continue to consider *evelynae* as a subspecies of *flavomarginata*.

Description. — A relatively small geoemydid species, up to 190 mm carapace length (CL) in adults and ca. 35 mm CL in hatchlings. The carapace is oval, distinctly domed, and scarcely serrated marginally. The median keel is distinct, whereas lateral keels are very weak. The eighth neural and the first suprapygal are much reduced or completely lacking, and the seventh and eighth costal pairs have midline contact. The plastron is large, oval, and is not notched either anteriorly or posteriorly. A plastral hinge is present between the pectoral and abdominal scutes and between the hyo- and hypoplastral bones. The hinge is well developed, even in juveniles, enabling them to close the plastron over the four limbs and tail. In most animals, the plastral formula is Abd >< An > Pect > Gul >< Fem >< Hum, although the seam between the anals is apt to become indistinct or to disappear in adults. The entoplastron is intersected by the gular-humeral and humero-pectoral seams.

The head is relatively large. Its dorsal surface is smooth and scaleless. The upper jaw is hooked and unnotched. The triturating surfaces of the upper and lower jaws are narrow without any ridges or cusps. The anterior surfaces of the forelimbs are covered with enlarged and imbricate scales, the tips of which are rounded. Slightly smaller scales of similar shapes cover the heels of the hindlimbs. The tail is short, bearing numerous small conical scales around its base.

The skull is relatively elongate and high. The right and left premaxillae are in contact with each other anteriorly, forming a hooked beak. The cranial cavity is much narrowed anteroventrally, and the anterior end of the processus inferior parietalis is separated from the palatine and jugal by the pterygoid. The quadratojugal is usually absent, making the temporal arch incomplete, but a vestige is occasionally present. The foramen praepalatinum is excluded from the vomer. The secondary palate is not well developed. The upper and lower triturating surfaces are narrow, ridgeless, and without serration.

The ground color of the carapace is usually dark brown, but sometimes almost black. On each carapace scute, a reddish brown blotch is located around the areola. A bright or pale yellow line extends along the median keel. The plastron is totally black or dark brown, except for narrow yellow or ivory margins on the pectorals and abdomina1s (at least), sometimes on the humerals, femorals, and anals as well, but rarely on the gulars. The ground color of the head and neck varies from pale tan to olive, and a lateral broad yellow stripe, usually bordered by narrow dark lines, runs from the orbit backwards. The outside of each limb is dark olive or dark brown, and the inside is pale tan. The dorsal surface of the tail is gray with an indistinct yellowish stripe. Its ventral surface and tip are light yellow.

Adult CL does not differ significantly between the sexes, although the female tends to be larger than the male of a same age (see below). The male has a lower shell and a broader head than the female. The posterior lobe of the male plastron is slightly concave medially; whereas, the plastron of the female is perfectly flat or even slightly convex medially. The tail of the male is long and thick, with the vent located beyond the carapacial rim when the tail is extended. In the female, the tail is shorter and thinner, with the vent located within the rim. The jaw and throat are usually pale yellow, but in males they change to an orange color during the mating season (Tanaka and Sato 1983; Yasukawa, pers. obs.).

The eggshell is relatively thin, with an outer surface with numerous fine pores and weak granules (Xu et al. 1997). The karyotype is 2n = 52 (Nakamura 1949).

Distribution. — The yellow-margined box turtle is known from three distinct areas: continental China, Taiwan, and the southern Ryukyus, Japan (Nakamura and Uéno 1963; Karsen et al. 1986; Zhao 1986; Ota 1991; Toyama and Ota 1991; Iverson 1992; Zhao and Adler 1993).

In continental China, this species has been recorded broadly from the eastern and southeastern parts, including the Pearl River drainage: Henan, Sichuan, Hubei, Anhui, Jiangsu, Zhejiang, Hunan, Fujian and Guangxi Provinces, and Hong Kong (Iverson 1992; Zhao and Adler 1993; Fong et al. 2002). It is, however, very likely that the records from Hong Kong (M.W. Lau and A. Bogadek, pers. comm.) and other southeastern Chinese localities, exclusive of those in Fujian, represent translocations, and that the original continental range of the species was confined to the Minjiang, Fuchun, and Yangtze River drainages (Fong et al. 2002).

In Taiwan, this turtle is widely distributed in mesic lowland forests, although the population density is low in most localities (Chen, unpubl. data).

In Japan, distribution of this turtle was originally confined to Ishigakijima and Iriomotejima islands of the Yaeyama Group in the southern Ryukyu Archipelago (Nakamura and Uéno 1963). A number of individuals were, however, recently reported from Okinawajima and Kumejima islands of the Okinawa Group, Miyakojima Island of the Miyako Group, and Kuroshima Island of the Yeyama Group, suggesting the establishment of feral populations on these islands through translocations (Ota 1999, pers. obs.; Shiroma and Ota 2004; Maenosono and Toda 2007).

Habitat and Ecology. — Relatively little is known about the life history of the yellow-margined box turtle. Based on information from R. Swinhoe, the collector of the

type specimens, Gray (1863) wrote that this turtle inhabits the shallow waters of ricefield ponds. Recently, Ernst and Barbour (1989) repeated these remarks. However, other recent authors have more appropriately noted that this turtle is primarily terrestrial and occurs on the forest floor (Nakamura and Uéno 1963; Takara 1969, 1979; Mao 1971; Huang et al. 1990; Matsui 1991; Wang 1991; Ota and Toyama 1996; Ota 2000b).

Results of recent preliminary surveys on Iriomotejima, southern Ryukyus, suggest that the population on this island prefers moist lowland forests rather than montane forests (Ota 1995). In continental China, however, *C. flavomarginata* seems to prefer more hilly environments (200–500 m in altitude), and is usually found around the edges of humid forests or bushy areas not far away from water sources (Chen and Li 1979; Xia et al. 1991). Nevertheless, the turtle is rare in more aquatic habitats, such as paddy fields, ponds, and river valleys (Chen and Li 1979; Xia et al. 1983; Wang 1991). Chen and Li (1979), on the basis of some preliminary observations in southern Anhui, stated that the turtle often ventures farther from moist vegetation during the rainy season (June and July), but returns there after this season. During the summer (June to August), the turtle is primarily nocturnal; it usually hides itself under various objects, such as tree roots, fallen woods, and leaf litter during the day. Also, it sometimes uses rock crevices near mountain streams as shelters. During the cooler months (April and May, and September to November), the turtle becomes diurnal, being most active around noon (Wang 1991).

In Taiwan, the turtle is found within and in the vicinity of the primary and well-developed secondary forests (Chen and Lue 1999). Based on the results of mark-recapture and radio tracking, Lue and Chen (1999) reported that a northern Taiwan population exhibits distinct seasonal movements and that the patterns of the movements differ remarkably between sexes. Female *C. flavomarginata* tended to maintain higher shell surface temperature during the nesting season (May to July). In contrast, there were no obviously intersexual differences in the temperature prior to and after the nesting season (Chen and Lue 2008). Tsai (2007) also reported that the turtle stayed in bushes or litter layers and avoided open areas, such as forest gaps and areca palm plantations during the active period (March to October).

Nakamura and Uéno (1963) reported that the Japanese populations of this species are mainly herbivorous, but they also feed on small terrestrial arthropods, earthworms, land snails, and carrion, as well as acorns and berries (Takara l969, 1979; Matsui 1991; Yasukawa, pers. obs.). Likewise, Wang (1991) reported fragments of insects and plant matter from stomachs of continental specimens. In captivity, the species feeds on various food items, such as vegetables, rice, grain, earthworms, terrestrial arthropods, land snails, tadpoles, bivalves, shrimps, small fishes, frog meat, pork, and various meat or intestines of small animals; animal food tends to be preferred over the plant food as in many other turtles (Fu, pers. obs.). In Taiwan, land snails, earthworms, fruits of *Ficus septica*, berries of wild taro (*Alocasia odora*), mulberry (*Morus* spp.) and some other farmed fruits have been identified in the fecal samples of this turtle (Chen, unpubl. data).

Tanaka and Sato (1983) reported on the mating behavior of *C. flavomarginata* on Iriomotejima Island in May. In one courtship episode, a male continuously nipped at the front edge of the carapace of a female until she withdrew her head and stopped moving. The male then released the carapace of the female, and mounted her from behind, whereupon intromission followed. Similar behavior was observed in captive specimens (Hara and Furuya 1980).

Among the few observations of the reproductive habits of this species in nature are those of Takara (1969, 1979), who noted that *C. flavomarginata* in the southern Ryukyus lays four to six eggs in the sandy soil near a stream or in an agricultural field between June and September, but he failed to provide citations or details.

Sexual maturity is reached at about 280 g in males and 400 g in females (Zhao 1993), or about 110 mm CL in both sexes (Yasukawa and Ota 1999). Mating occurs from early May to late September, often in the afternoon or evening. In some instances, the male steps on the female's tail with his hind limbs before mounting, at which time the tails of the male and female are entwined (Wang 1991). In captivity, mating attempts were observed during mid-June and early October (Zhang 1986). Wang (1991) reported that the duration of mating was around ten minutes. From Wang's examination of ovaries of specimens sacrificed during different seasons, it appears that in continental populations ova start to enlarge toward the end of hibernation, and eggs are laid from late May to mid-September (usually June and July). Moreover, Wang reported that only two eggs (i.e., one in each oviduct) usually mature at once. Such a small clutch size is compensated by the production of multiple clutches; 4–8 eggs are laid per nesting season. Oviposition usually occurs in the evening or during the night. Larger females lay larger eggs, but in general they range from 40–46 mm in length, 20–26 mm in width, and 8.5–18.5 g in mass ($n = 31$: Wang 1991). Huang et al. (2000) reported slightly smaller egg numbers per season (2–5). The number of enlarged follicles reported by them is slightly greater (4–9), and this suggests the production of multiple clutches annually and/or frequent follicular atresia. Measurements of eggs given in Huang et al. (2000) are more variable than those in Wang (1991), ranging from 39.1–50.0 mm in length, 20.2–27.5 mm in width, and 8.3–19.1 g in mass.

In Taiwan, the nesting season is known to extend from May to July. Clutch size may differ slightly between northern and southern populations, ranging from one to three in the former, reaching four in the latter. Females sometimes produce more than one clutch per nesting season (Chen and Lue 1999; Chen et al. 2000). Egg mass was 12.0–26.7 g ($n = 11$), and measured from 39.6–53.4 mm in length ($n = 18$) and from 22.6–28.0 mm in width ($n = 18$: Chen and Lue 1999).

Wild females are usually larger in CL and body mass than males of the same age (Chen and Xie 1988; Huang et

al. 1990; Chen and Lue 2002) and sometimes exceed 1000 g; whereas, males are usually smaller than 500 g. Females continue to grow even after maturity; whereas, in males the growth rate drops remarkably after maturity (Chen and Xie 1988).

Zhang (1986) reported, on the basis of field observations in continental China, that a gravid female usually selected a quiet, moist, sandy site in an open environment, but without exposure to the direct sunlight. Using her hind-limbs, the female dug a nest-hole to a depth of ca. 5 cm. Two eggs, 17.5 and 17.7 g in mass, were laid in approximately 25 min; whereas, covering of these eggs by soil, also by using the hind-limbs, took another 30 min. In the wild, embryonic development takes approximately 80 days, without diapause or late embryo estivation, unlike many other geoemydid species (Ewert 1991). The two hatchlings (38.2 and 38.4 mm in CL, 30 and 31 mm in carapace width (CW), and 20 and 21 mm in shell height, and 12.2 and 12.7 g in mass) needed an additional 30–40 hours to emerge from the eggs completely. The hatchlings started to forage within 10–15 hours. In captivity, nesting females may forgo excavating egg chambers and simply lay eggs beneath leaf litter or bushes instead. Incompletely covered eggs may be subjected to predation by conspecific individuals, including their mothers. Tanaka (1984) and Tanaka and Tsuji (1985) observed remains of juvenile turtles obtained on Iriomotejima, and tentatively concluded that these were victims of predation by birds or by the wildcat *Felis iriomotensis*. One of us (Chen, pers. obs.) noted that, in Tawian, eggs of *C. flavomarginata* are often preyed upon by *Oligodon formosanus*, a colubrid snake that specializes in eating reptile eggs (Coleman et al. 1993).

In eastern continental China, hibernation usually begins in October, and activity is resumed in early April. Elevated temperatures during hibernation may stimulate activity episodes. Wang (1991) reported that the hibernaculum is usually located on a south-facing slope, under leaves, grasses, or branches (Chen and Li 1979; Wang 1991). Tsai (2007) reported that in Taiwan *C. flavomarginata* became inactive after November and stayed motionless in creek areas during the winter.

Population Status. — It is highly likely that in the Ryukyus, the Ishigakijima population is much smaller than the Iriomotejima population, because the forested area is much smaller in the former (Takara 1979). In Taiwan, the population density of this turtle appears to be much lower than in the two southern Ryukyu islands (Ota pers. obs.), although the area of the potential habitat is much more extensive. The largest populations doubtlessly occur in continental China. There, the species is reported to be in decline, largely becoming endangered as a result of over-collecting for food, the pet trade, and habitat destruction and degradation (Lau and Shi 2000; Lau et al. 2000). Nevertheless, the species remains common in Anhui and Hunan provinces, where village people sometimes keep and breed them in their yards.

Threats to Survival. — Habitat destruction caused by land development seems to be the primary threat to *C. flavomarginata* in the southern Ryukyus (Matsui 1991) and Taiwan (Chen et al. 2000).

On Iriomotejima, there are steep-sided (U-shaped) gutters along the highways running through the natural habitat of this species. Also, numerous artificial ponds, with steep concrete walls, were recently constructed within drainages running from agricultural lands to the sea, primarily for the purpose of intercepting topsoil washed off by the rainfall. Such gutters and ponds seem to function as dangerous traps for *C. flavomarginata*, as well as for *Geoemyda japonica* on Okinawajima Island (Chigira 1989; Yasukawa and Ota 2008); dead, dried-up turtles have occasionally been observed in such gutters and ponds (Ota, pers. obs.; S. Murata, pers. comm.).

On Iriomotejima, turtles of this species often venture on to the highway that passes alongside its major habitat on the island, sometimes to eat road-killed animals, and at such times they are occasionally run over themselves (Matsui l99l; Ota 1995).

In Taiwan, deforestation and habitat fragmentation in low altitude evergreen forest seem to be serious threats to this species (Chen et al. 2000). Illegal collecting for the pet and food markets in China has also impacted wild populations in Taiwan. Many cases of cross-border trades to continental China have been reported in the last few years; over 500 turtles were confiscated in 2007 alone (Chen pers. obs.).

Large numbers of turtles captured in continental China have been exported (Aoki 1990), and it is probable that such commerce constitutes a serious impact upon some continental populations (Lau and Shi 2000; Lau et al. 2000). It is also likely that, in the southern Ryukyus and Taiwan, this turtle is occasionally collected illegally as a personal pet or for sale (Chigira 1991; Matsui 1991; Kato and Ota 1993; Ota, pers. obs.), but such actions are impossible to quantify at present. In continental China, human use of these turtles for food is quite extensive also, seemingly constituting another major threat to many populations (Lau and Shi 2000; Lau et al. 2000).

Conservation Measures Taken. — Japanese populations of the yellow-margined box turtle have been designated as National Natural Monuments by the Japanese Government since 1972, and capture or trade is strictly regulated by law. Likewise, the Taiwanese Government recently started to protect this turtle as a rare and valuable species, the legislation entering into force in June 1989 as the Wildlife Conservation Act (Chen et al. 2000). These actions have presumably reduced legal exploitation of this species, but as mentioned previously, there still seems to be a certain level of illegal collecting and trade of this turtle in both countries.

The Japan Ministry of Environment also listed the yellow-margined box turtle as a Vulnerable species in the 1991 and 2000 editions of the Japanese Red Data Book (Matsui 1991; Ota 2000b). On each of Ishigakijima and Iriomotejima, habitat of the yellow-margined box turtle is partially covered by The Iriomote-Ishigaki National Park. However, due to the limited areas for strict preservation of natural habitats and wildlife in this national park, its contri-

bution to the potential conservation of the southern Ryukyu populations of the yellow-margined box turtle appears quite limited. Additionally, Taketomi Town, the governing community of Iriomotejima, recently arranged for the placement of a gentle slope in each steep-sided artificial pond to enable trapped animals to escape, but the effectiveness of this measure remains to be seen.

In Taiwan, habitat of the yellow-margined box turtle partially overlaps a few national parks, such as Yangmingshan, Taroko, Yushan, and Kenting National Parks. This obviously contributes to conservation of turtle populations to some extent. In continental China, the turtle has been placed under provincial government regulation in Anhui, Guangdong, and Guangxi, but no detailed executive orders or regulations have been promulgated, and the species is still collected for traditional medicinal purposes and for food.

The IUCN/SSC Tortoise and Freshwater Turtle Specialist Group (1989) did not provide an Action Plan Rating for this species, implying that it was not at that time known to need conservation action. We now conclude, based on our data, that the species deserves an APR rating of 3, indicating a species that requires some conservation action. Recent editions of the IUCN Red List listed the species as Vulnerable (Baillie and Groombridge 1996) and then as Endangered (Hilton-Taylor 2000). In July 2000, the yellow-margined box turtle was added to the Appendix II of CITES together with the other species of the genus *Cuora*.

Conservation Measures Proposed. — The most essential effective measure for the conservation of the yellow-margined box turtle is to secure and preserve the natural forests of its habitat. It is also highly desirable to monitor illegal capture and trade in this species, especially when conducted on a commercial basis. But to develop an effective and comprehensive conservation program for this species, detailed ecological and population studies are much needed. For this purpose, mark and recapture studies and radiotelemetry monitoring, as recently attempted for a Taiwanese population (Chen and Lue 1999; Lue and Chen 1999), will be invaluable. Discrimination of native from translocated feral populations will be also crucial (Fong et al. 2002).

Captive Husbandry. — The yellow-margined box turtle is very hardy and breeds freely in captivity, and there are numerous captive breeding records. Fukada (1965) reported that a female captured on Ishigakijima, 143 mm in CL, laid two single-egg clutches six days apart in July. The eggs were 39.4 x 23.8 mm and 13.8 g, and 37.0 x 23.0 mm and 12.6 g in length, width, and mass, respectively. Hara and Furuya (1980) reported several cases of captive breeding of this turtle from the Yaeyama Group at Ueno Zoo, Tokyo. Mating behavior was observed from September to March. Females excavated a cavity in which they laid one to four eggs from January to June. These eggs (32.4–47.3 x 20.1–35.4 mm in length and width and 11.2–19.4 g in mass) produced hatchlings (32.4–39.9 x 23.7–33.8 mm in carapace length x width and 7.6–12.8 g in body mass) 71–81 days after being laid.

Recently, Otani (1988a) observed the nesting of this species in an open-air environment at Zoo Okinawa, Okinawajima Island, and reported that nests, 8 cm or less in depth, were made from 29 April to 9 June. He also stated that the clutch size ranged from 1 to 3 (n = 9), egg dimensions from 40.10–50.55 x 24.20–26.60 mm, and egg mass from15.6–20.8 g (n = 15), respectively. Of the 15 eggs obtained, five hatched after 72–94 days incubation at room temperature. The hatchlings measured 32.40–37.90 CL x 29.40–32.80 carapace width x 17.45–19.20 mm carapace depth and 8.4–11.4 g in body mass, respectively (Otani 1988b).

Huang et al. (2004) reported that *C. flavomarginata* in continental China could mature at four or five years of age in captivity; although, they usually mature six or seven years in the wild. Captive turtles showed mating in the periods from March to May and from September to October, with highest frequencies in April and October. The nesting season began in late May or early June and ended in late July. The number of eggs laid per season ranged from one to seven (usually two to four eggs), and only one clutch was usually laid per season. The activity of *C. flavomarginata* was also affected by temperature and light intensity under the captive environment; turtles could act normally with a light intensity of lower than 400 lux (Huang et al. 2007). With the increase of light intensity from 400 lux, the activity level greatly decreased. The turtles showed a maximal feeding rate under ambient temperatures between 26 and 31°C. Hibernation began when temperatures dropped to 12°C (Huang et al. 2004). Hatchlings (13.2 g in mean body mass: n = 12) emerged in August and September (Chen and Xie 1988).

Recently a number of reports have been published regarding captive husbandry and breeding of *C. flavomarginata* of unknown origins. These observations confirm the omnivorous dietary preferences and clutch size ranging from 1 to 4, but occasionally reaching 5 (Becker 1996; Shaeffer and Felsner 1997; Anonymous 2003; Schilde 2004; Klerks 2006; Gomez and Valverde 2008). Farrell (2008) stated that this species has temperature-dependent sex determination, similar to many other turtles so far examined.

Current Research. — Recently, a long-term monitoring project on the Iriomotejima population of *C. flavomarginata*, planned by the Japan Ministry of Environment, was launched with the full cooperation of the inhabitants of the island. In Taiwan, a population monitoring project is also in operation in a northern isolated habitat by T.-H. Chen. To detect the origins of smuggled or illegally possessed turtles, genetic surveys of confiscated individuals and of natural populations have been conducted by S.-H. Wu at National Chung Hsing University, Taichung, Taiwan.

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