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Geographic Variation in the Asiatic Turtle *Chinemys reevesii* (Gray) and the Status of *Geoclemys grangeri* Schmidt

JEFFREY E. LOVICH,[1] CARL H. ERNST,[2] AND STEVE W. GOTTE[2]

[1]*Institute of Ecology, University of Georgia, Athens, Georgia 30602, USA and*
[2]*Department of Biology, George Mason University, 4400 University Drive, Fairfax, Virginia 22030, USA*

ABSTRACT.—The Chinese coin turtle *Chinemys reevesii* is widely distributed in eastern Asia from Japan to southern China. Within its range, three taxa have been described which are similar to *C. reevesii* except for minor differences (*Geoclemys grangeri, Geoclemys paracaretta,* and *Damonia unicolor*). Although these variants have been synonymized by some authors, no quantitative studies have been conducted to support or reject their validity. The present study examined 31 characters of specimens throughout the range. Analysis indicates that all variants are within the diagnostic extremes observed in this species. Low interpopulational variation in *C. reevesii* is due in part to several millennia of human disturbance.

The Chinese coin turtle, *Chinemys reevesii* (Gray, 1831), is a widely distributed aquatic emydid found in China, Taiwan, Korea and Japan (Fig. 1). Additional specimens have been recorded from Cochin China (=Vietnam) (Stejneger, 1907), Bering Island, U.S.S.R. (Nikolskii, 1915), and the Philippines (Casto de Elera, 1895), but these regions should be considered extralimital (Pope, 1935). Within this range three taxa have been described which are similar to *C. reevesii* (sensu stricto): *Damonia unicolor* (Gray, 1873), differs primarily in that the shell and soft parts are predominantly black. *Geoclemys grangeri* (Schmidt, 1925) differs from *C. reevesii* in having the axillary scute larger than the inguinal and the spots on the plastron smaller and more sharply defined. It should be noted that several authors (Smith, 1931; Wermuth and Mertens, 1977; and Pritchard, 1979) have erroneously referred to Schmidt (1927) as the original description of *G. grangeri*. The third questionable taxon, *Geoclemys paracaretta* (Chang, 1929) is based on a single specimen with five pairs of pleural scutes and 13 pairs of marginals instead of the usual 4 and 12 typical of *C. reevesii*. These taxa have been placed in the synonymy of *C. reevesii* by Stejneger (1907), Smith (1931), Pope (1935), and Wermuth and Mertens (1977), but Pritchard and McMorris (in Pritchard, 1979:221–222) consider *G. grangeri* to be at least tentatively valid based on several animals received from Taiwan through the pet trade. In spite of these suggestions, no studies have been conducted to actually determine the validity of these three questionable taxa. The objectives of our study were: 1) to determine the extent of geographic variation in *C. reevesii*, and 2) to determine the validity of *D. unicolor, G. grangeri,* and *G. paracaretta*.

METHODS AND MATERIALS

A total of 256 museum specimens were examined from throughout the known range of *C. reevesii*. Due to small sample sizes from many localities, it was necessary to group these localities into six larger regions for statistical comparison (Fig. 1): 1) Philippines; the northern island of Luzon. These animals were considered extralimital and we excluded them from the analysis; 2) Taiwan; 3) Korea and Japan; the southern portion of the Chosen Peninsula, the island of Kyosho, and southern Honshu Island; 4) Yantze River drainage, China; roughly defined as extending westward to Kiating in Sichuan Province, north to Nanking in Jiangsu Province, south to northern Jiangxi Province, east to

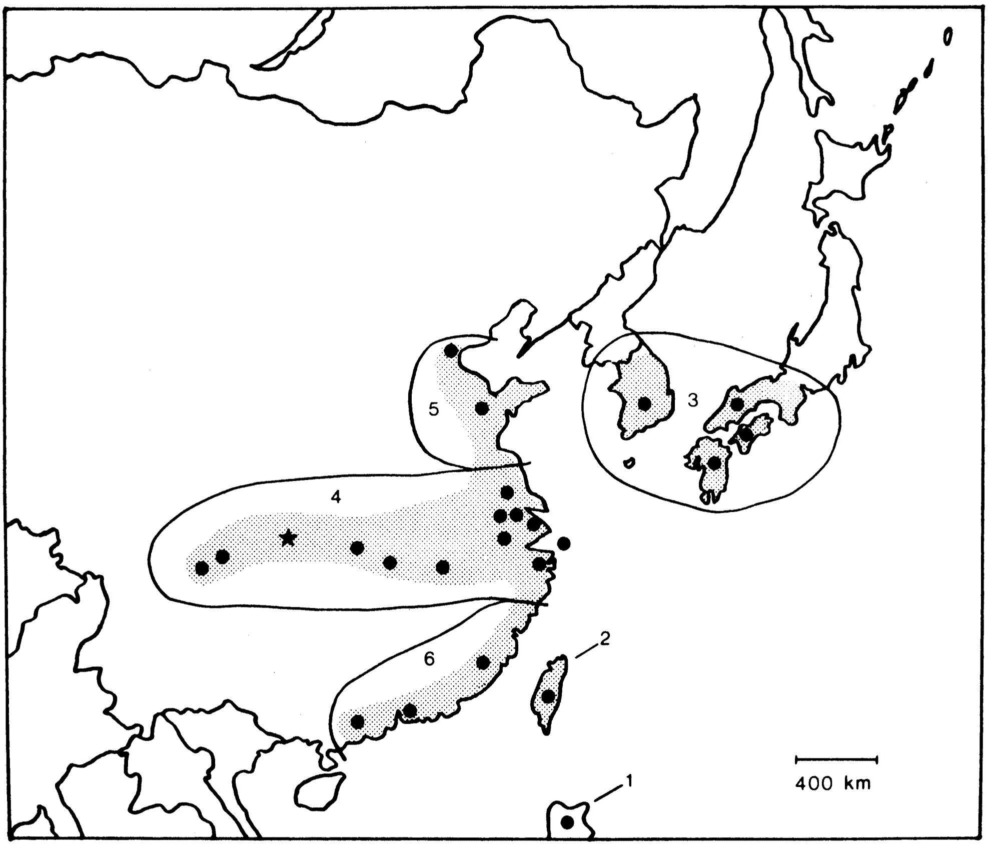

FIG. 1. Distribution of *C. reevesii.* Black dots indicate selected localities from which specimens were examined. Star designates the type locality of *G. grangeri.* Geographic regions (1-6) are discussed in the text.

Shanghai, and including Chusan Island; 5) Coastal drainages of northern China; Shandong Province north to Tianjin in Hebei Province; 6) Coastal drainages of southern China; Fujian Province south to Canton in Guangdong Province, and including Hong Kong. These regions are natural in that they are based on major drainage systems and geographical separation.

Dial calipers (accurate to 0.1 mm) were used to take twenty-seven straight-line measurements on the shell of each specimen: greatest length of carapace (CL); width and height of carapace between the second and third vertebrals; width and length of vertebrals (V1-5L, V1-5W); greatest plastral length; length of anterior and posterior lobes of plastron; width of anterior and posterior lobes of plastron; length of bridge; length of axillary scute; length of inguinal scute; and the mid-seam lengths of the gular, humeral (IH), pectoral, abdominal, femoral, and anal scutes.

In addition, four qualitative characteristics were examined: Plastral patterns which were highly variable could be divided into five classes (Fig. 2). Class A specimens were characterized by extensively pigmented plastrons with light seams. Class B had sharply defined radiating blotches similar to those on the type specimen of *G. grangeri.* Class C contained melanistic specimens with entirely black plastrons. Class D was characterized by moderate dark areas on the plastron, and Class E specimens had

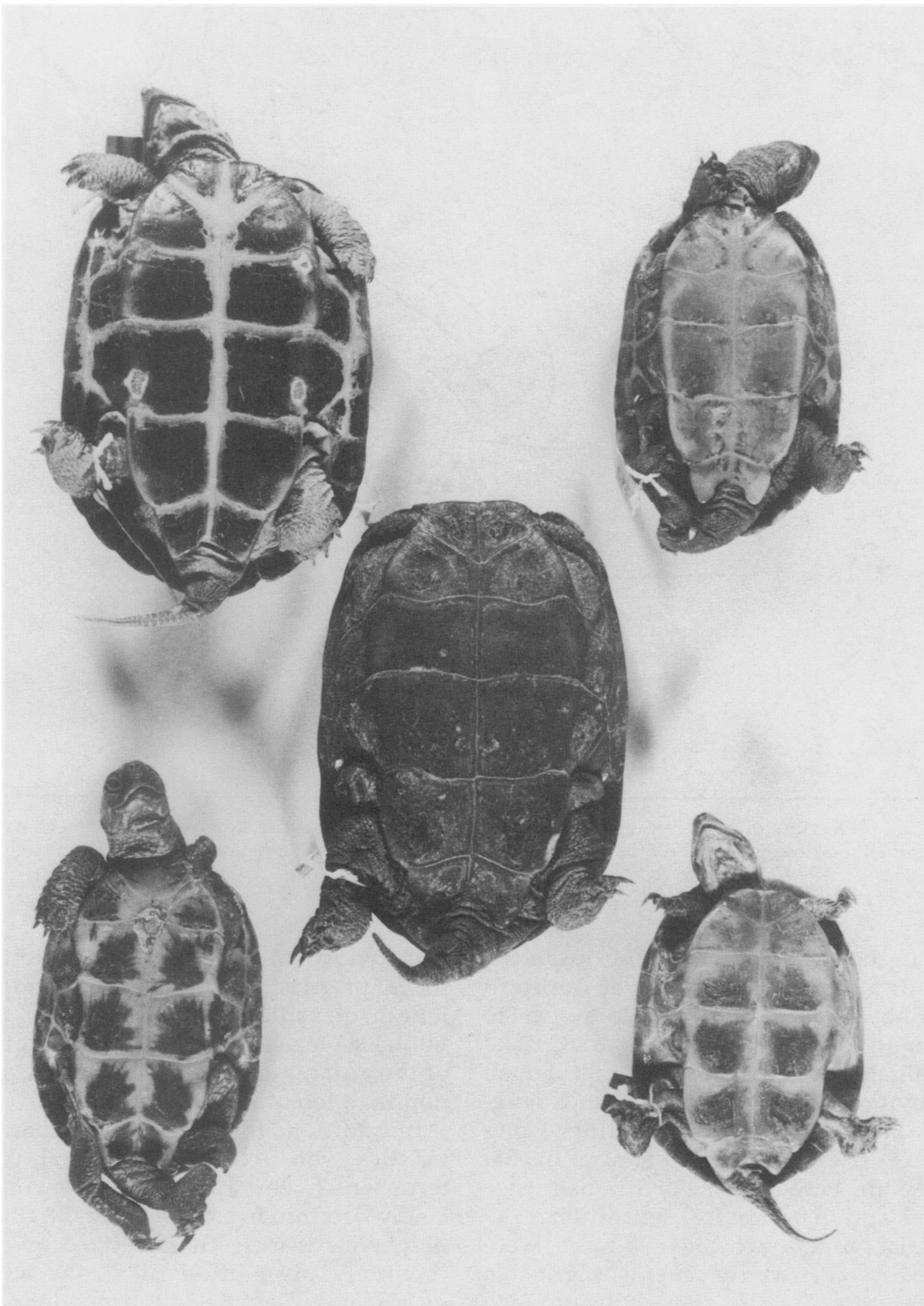

FIG. 2. Variation in plastral patterns of *C. reevesii*. Class A, upper right; Class B, upper left; Class C, center; Class D, lower left; Class E, lower right. See text for explanations of the various patterns.

lightly pigmented plastrons. The number of neck stripes on one side of the head, the presence or absence of a pigmented ring around the tympanum, and the presence or absence of mottled spots on the chin were also recorded.

The data were then analyzed using the Statistical Analysis System (SAS) (Helwig and Council, 1979). Simple statistical tests such as Chi-square, Student's *t*-test, analysis of variance (ANOVA), and Duncan's Multiple Range Test (DMRT), were performed. Ratios were not employed and juveniles were excluded from the mensural analysis to help eliminate bias due to size differences. Males and females were analyzed separately due to statistically significant size differences (Lovich et al., in prep.).

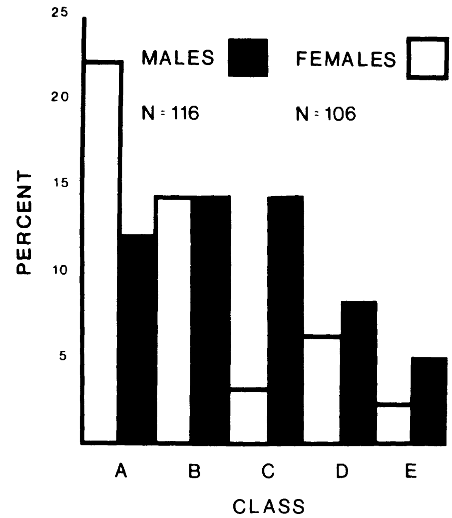

FIG. 3. Frequencies of plastral pattern types in *C. reevesii* by sex.

RESULTS

Analysis of plastral patterns indicates they do not occur in equal frequencies (χ^2, $P < 0.05$). Specimens in Class A and Class C represented the highest frequency in all categories (total sample, males, females, and juveniles), and lighter colored or Class E specimens represented the lowest. Class frequency varied by sex in most cases (Fig. 3), but only Class A and Class C differed significantly (χ^2, $P < 0.05$). There was also a general tendency for plastral pigmentation to increase with age and size; a phenomenon not uncommon in other emydid genera (Pritchard, 1979). Melanistic juveniles were not observed. The frequency and distribution of each class by region is shown in Fig. 4. Class B specimens, representative of *G. grangeri*, were no more common near the type locality than elsewhere, and were present in 68 percent of all localities, accounting for 28 percent of the specimens examined. However, they were conspicuously absent from Region 3. Melanistic or Class C specimens, occurred throughout most of the range. Class E specimens were absent in the eastern portion of the range (Regions 2 and 3).

Statistical data on neck stripes by region are presented in Table 1. Specimens with more than four neck stripes were rare (N = 4), and were only observed in Region 2 and Region 5. Only Region 4 differed significantly from any of the others (t, $P < 0.05$). Chin and tympanic pigmentation varied at random.

An ANOVA performed on the mensural data did not show significant differences between any regions. In contrast, a DMRT for the variables CL, V1L and IH found that the means for these characters grouped together and were statistically similar ($P < 0.05$) in Regions 2 and 6. Regions 3 and 4 also grouped together, but based on these criteria specimens from Region 5 do not share affinities with any other regions.

DISCUSSION

The results indicate much pattern variation in *C. reevesii*, however, there is little correlation with geographic regions and, as such, subspecific partitioning is not warranted. All variants of *C. reevesii* previously described fall within the diagnostic extremes for this species. *Damonia unicolor* is a melanistic form distributed throughout the range.

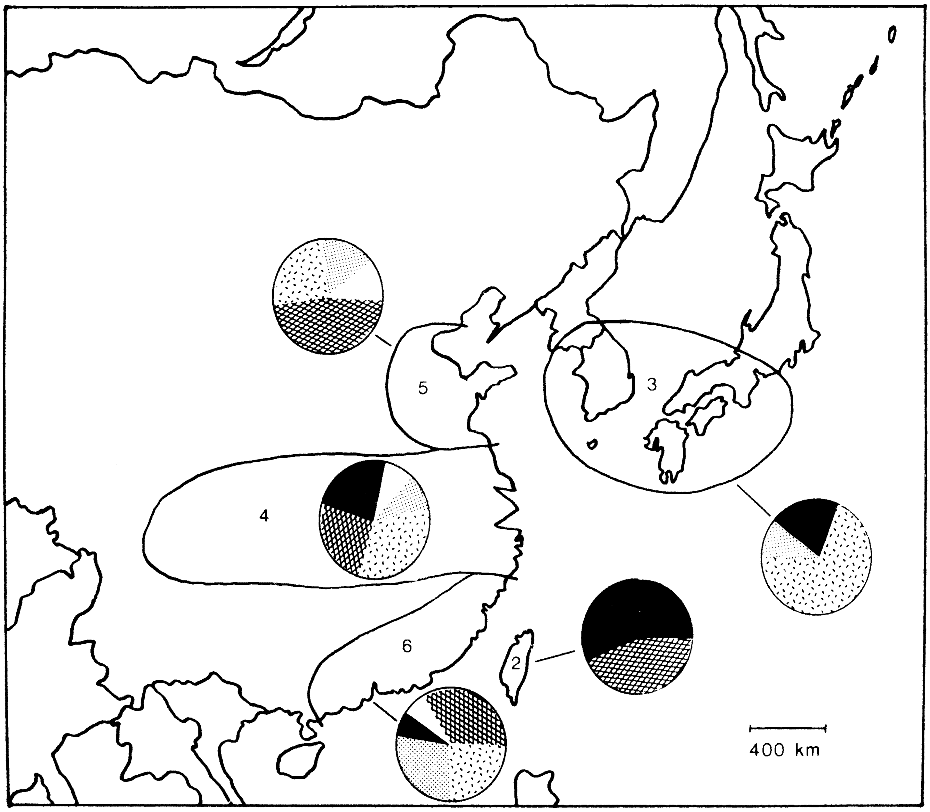

FIG. 4. Frequencies of plastral patterns and their distributions in *C. reevesii* (N = 224). Class A, random dashes; Class B, cross-hatched; Class C, black; Class D, stippled; Class E, open.

Geoclemys grangeri is based on variable characters and is not confined to any geographic area. Examination of the type-specimen (AMNH 23481) found that one of Schmidt's (1925) diagnostic characters was poorly chosen. The axillary scute is indeed larger than the inguinal scute on one bridge but not on the other, and the paratype (AMNH 35239) exhibited the normal axillary inguinal relationship typical of *C. reevesii*. *Geoclemys paracaretta* is based on a single specimen with several scute anomalies. The illustration in Chang (1929:5) reveals that this specimen also had at least one deformed vertebral scute.

Although there is a lack of consistent geographic differentiation, certain trends can be seen. The striking difference between the number of neck stripes found on some specimens from Taiwan and those from most other regions is one example (Table 1). The sample from Taiwan contained the only specimens with more than five neck stripes. Although only seven Taiwanese specimens were seen, regions with much larger sample sizes contained only individuals with less than five neck stripes. Unfortunately, high character overlap and the lack of statistically significant differences weakens any further discriminating power in this comparison. Specimens from Region 4 did have significantly fewer neck stripes than those from other regions (t, $P < 0.05$). Regions 2 and 6, and Regions 3 and 4 were grouped together by DMRT on the basis of statistical similarities between means for several morphological

TABLE 1. Variation in neck stripes in *C. reevesii*. The mean for Region 4 differs significantly ($P < 0.05$) from all others.

Region	N	$\bar{x}$	SD	Range	Percent	
					0–4 stripes	5–7 stripes
2	7	2.86	3.02	0–7	57	43
3	12	2.67	1.44	0–4	100	0
4	114	1.52	1.30	0–4	100	0
5	28	2.71	1.05	0–5	96	4
6	21	2.62	2.13	0–3	100	0

characters (CL, V1L, and IH). These relationships may indicate that Taiwan was initially colonized by animals from southeastern China (Region 6), and that Japanese and Korean *C. reevesii* are derived from populations in the Yantze Basin of China (Region 4). The direction and location of the Kuroshio Current could easily explain these patterns of dispersal. Nikolskii (1915) suggested that ocean currents were responsible for transporting *C. reevesii* to locations as far away as Bering Island, U.S.S.R. which is more than 3000 km north of southern Japan. The lack of similarities between Region 5 and any others is not easily explained. However, Sowerby (1925) and Pope (1935) considered this area to be largely extralimital, so specimens from there may represent a confusing man-made mixture from several other regions.

The extent of pigmentation, which many have used to differentiate between *C. reevesii* and the other taxa, is generally related to age and sex. Larger specimens, particularly males, tend to be darker than those in smaller size classes. This observation is in contrast with that of Liu and Hu (1939–40), who suggested that plastral pigmentation decreases with age. Others have reported that melanism is confined to males (Liu and Hu, 1939–40; Sachsse, 1975), but our sample contained eight melanistic females with well defined secondary sexual characters.

The high degree of variation within populations of *C. reevesii*, but not between them has also been observed for patterns in *Terrapene c. carolina* (Ernst and Barbour, 1972), and *Rhinoclemmys annulata* (Ernst, 1978); and for morphology in *Sternotherus odoratus* (Reynolds and Seidel, 1983). Several mechanisms were proposed by Reynolds and Seidel to explain this phenomenon: 1) gene flow due to aquatic dispersal between populations; 2) stream capture, which has been used to explain the relationships of other turtles including: trionychids (Webb, 1962), and *Sternotherus minor* (Iverson, 1977); 3) overland movement; and 4) similar selective regimes throughout the range.

An important explanation for low interpopulational variation in *C. reevesii* may be that of human influence. This species has been an important source of food and folk medicines for the Chinese since at least 2737 B.C. (Moll, 1982). Because of this they have been transported widely to markets within and outside their natural range (Sowerby, 1925; Pope, 1935). Sowerby (1925) noted that animals for sale in northern China had been captured in regions to the south. Accidental introductions and the resultant mixing of gene pools may have been frequent. The extensive network of irrigation systems built by the Chinese may also have facilitated gene flow between populations. Thus, human disturbances may have obscured any true geographic variation that existed previously in *C. reevesii*.

Specimens examined (256). Museum acronyms follow those of Duellman et al. (1978). George Mason University (=GMU). China (219): Anhui (28):

AMNH 31093, 31095-100, 31102, 31105-11, 31113-14, 31116, 31120, 31519-20, FMNH 6580-86. Chusan Island (4): CAS 8613-14, 8621-22. Fujian (26): AMNH 34193-97, 34208-11, 34219-29, 35181-84, CAS 74514, USNM 65426. Hong Kong (5): USNM 46941-45. Hubei (10): MCZ 160266-75. Hunan (5): AMNH 17415, 17417-18, 23581, FMNH 6587. Jiansu (13): AMNH 20539, CAS 16530-37, 16539-40, FMNH 21985, MCZ 38952. Jiansui (6): AMNH 35117-22. Nanking (11): CAS 71948, UMMZ 71272-81. Shangdon (5): AMNH 29630, 29632-35. Shanghai (26): CAS 14589-96, MCZ 6770, UMMZ 69380-84, USNM 31721, 65417-25, 72847-48. Sichuan (37): AMNH 23481 (*G. grangeri*: Holotype), 35239 (*G. grangeri* paratype), 62651-52, USNM 67447, 69911, 76622-27, 80106-07, 80695-97, 80940-41, 82656-73. Tianjin (30): CAS 41739-68. Zhejiang (13): CAS 8618-19, UMMZ 64996-65000, 65021-25. Japan (19): Awaji Island (1): CAS 16394. Honshu Island (13): AMNH 67028-29, CAS 16039-40, CM 43810, FMNH 17192, FSM 22307-08, 49432-33, 49441-42, GMU 1515-18, USNM 55756, 72332. Ikishiama Island (5): CAS 14597, 26120-22, 26124. Korea (3): CAS 31437, USNM 14512, 21181. Philippines (4): MCZ 16062-65. Taiwan (8): CM 62075, FMNH 121227-29, 121763-65, 169255. U.S.S.R. (1): Bering Island (1): USNM 21249.

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