Herpetologica, 47(4), 1991, 407–420

A NEW BOX TURTLE OF THE GENUS *CUORA* (TESTUDINES: EMYDIDAE) WITH TAXONOMIC NOTES AND A KEY TO THE SPECIES

WILLIAM P. McCORD[1] AND JOHN B. IVERSON[2]

[1]*East Fishkill Animal Hospital, Hopewell Junction, NY 12533, USA*
[2]*Department of Biology, Earlham College, Richmond, IN 47374, USA*

ABSTRACT: A new species of Asian box turtle, *Cuora pallidicephala* (Emydidae: Bataguridae), is described from north central Yunnan Province, China. Comparisons are made with other members of the genus *Cuora* (including *Cistoclemmys*). *Cuora chriskarannarum* is placed in the synonymy of *Cuora pani*; *C. aurocapitata* may be a subspecies of *C. pani*; and *C. evelynae* is relegated to a subspecies of *C. flavomarginata*. A key to the species of *Cuora* is provided.

Key words: *Cistoclemmys*; *Cuora*; China; Systematics; Taxonomy; Emydidae; Testudines

BECAUSE of the recent increase in interest in Asian turtles by the Chinese (Buskirk, 1989; Luo and Zong, 1988; Zong and Pan, 1989), and the availability of Chinese material to Americans through the efforts of Mr. Oscar Shiu of Hong Kong (e.g., Ernst, 1988*b*; Ernst and Lovich, 1990; Ernst and McCord, 1987; Iverson et al., 1989; Iverson and McCord, 1989; Pritchard and McCord, 1991), the taxonomy of Chinese turtles has received more attention in the past 6 yr than at any equivalent time since the 1830's (e.g., Gray 1831*a*,*b*, 1834). This work has revealed that the diversity of turtles in China and southeast Asia is far greater than previously realized.

The Asian box turtles of the genus *Cuora* (including *Cistoclemmys*: Ernst and Barbour, 1989; Zong and Pan, 1989; but see Hirayama, 1984) have received the most attention, with the description of *C. pani* by Song in 1984, *C. aurocapitata* by Luo and Zong in 1988, *C. mccordi* by Ernst in 1988*a*, *C. chriskarannarum* by Ernst in 1988*b*, the synonymy of *C. hainanensis* (Li, 1958; Hu et al., 1975) with *C. galbinifrons* by Zong and Pan in 1989 (see also Buskirk, 1989), and the recognition of the Ryukyu Islands population of *Cuora flavomarginata* as a separate species (*C. evelynae*) by Ernst and Lovich in 1990. Although the first three aforementioned species apparently represent valid taxa, *C. chriskarannarum* is a synonym of *C. pani* (de Bruin, 1988; Philippen, in Stubbs, 1989; Pritchard, 1990), Ernst's redescription of *C. pani* actually redescribes *C. aurocapitata* (Pritchard, 1990), and *C. evelynae* is perhaps a subspecies of *C. flavomarginata* (see below).

Another very distinctive species of *Cuora* has recently been collected in China's Yunnan Province and is herein described. The species is allocated to the genus *Cuora* (sensu lato: McDowell, 1964; Ernst and Barbour, 1989) because it exhibits (1) a plastron with a transverse hinge anterior to the abdominal scutes and much reduction of the plastral buttresses (Boulenger, 1889); (2) anterior hexagonal neurals that are posteriorly short-sided; (3) a weakly tricarinate carapace, with a weakly to unserrated rear margin; (4) a first vertebral scute that nearly contacts the second marginal scutes; and (5) narrow triturating surfaces, lacking ridges.

METHODS

Representative specimens (see Appendix I) of all known species of *Cuora* from public and private collections were measured by JBI. Standard characters (Iverson, 1977) included at least carapace length (CL), maximum carapace width (MCW), carapace height at level of hinge (CH), maximum plastron length (MPL), maximum length of plastral forelobe (MFL), maximum length of plastral hindlobe (MHL), midline length of plastral hindlobe (HL), plastron width at level of junc-

TABLE 1.—Morphometric characters useful in distinguishing *Cuora pallidicephala* from other species of the genus: $\bar{x} \pm 1$ SD (range). Only adult or subadult specimens are included.

Species	Sex	*n*	MCL (mm)	CH/CL (×100)	MPL/CL (×100)	MGL/IAB (×100)	IF/IAN (×100)	IF/IAB (×100)
amboinensis	M	2	167.0 ± 9.8 (160–174)	42 (42–42)	92.3 ± 2.1 (91–94)	80.0 ± 2.8 (78–82)	31.3 ± 11.5 (23–39)	30.7 ± 8.3 (25–37)
	F	6	146.1 ± 27.0 (112–172)	45.6 ± 2.4 (42–48)	95.3 ± 2.5 (92–99)	65.9 ± 4.7 (58–72)	29.3 ± 10.1 (14–41)	26.3 ± 7.2 (16–34)
aurocapitata	M	7	101.1 ± 8.5 (91–119)	33.6 ± 1.9 (31–37)	93.9 ± 1.7 (91–96)	68.1 ± 4.0 (64–75)	50.7 ± 17.5 (28–80)	46.7 ± 12.3 (29–66)
	F	15	139.8 ± 12.3 (119–164)	38.3 ± 3.4 (34–43)	99.9 ± 1.9 (97–103)	61.1 ± 7.2 (50–72)	40.6 ± 7.8 (29–56)	41.4 ± 7.5 (29–56)
flavomarginata	M	13	142.0 ± 20.3 (120–189)	44.4 ± 2.7 (38–48)	96.8 ± 1.5 (95–100)	65.9 ± 7.1 (56–81)	26.8 ± 7.6 (18–46)	26.8 ± 8.0 (15–43)
	F	24	149.8 ± 16.5 (126–185)	47.3 ± 3.1 (40–53)	101.0 ± 2.7 (96–105)	60.0 ± 5.5 (50–70)	24.3 ± 7.7 (16–52)	23.2 ± 8.0 (14–51)
galbinifrons	M	3	159.2 ± 25.4 (131–180)	47.3 ± 0.8 (46–48)	97.8 ± 1.5 (96–99)	68.5 ± 11.4 (55–76)	30.3 ± 5.8 (25–36)	29.0 ± 6.4 (22–34)
	F	12	169.2 ± 20.6 (124–195)	47.5 ± 3.2 (42–55)	101.2 ± 2.4 (98–107)	66.8 ± 4.8 (59–75)	26.6 ± 11.6 (15–52)	25.0 ± 9.3 (14–43)
mccordi	M	7	117.6 ± 7.3 (107–131)	39.9 ± 2.0 (38–44)	94.3 ± 2.0 (92–99)	67.8 ± 4.2 (60–73)	36.5 ± 4.2 (30–42)	32.5 ± 5.1 (27–42)
	F	8	137.1 ± 9.2 (121–149)	44.5 ± 2.3 (41–48)	99.5 ± 1.5 (98–102)	64.3 ± 4.0 (57–71)	42.1 ± 4.4 (37–48)	37.7 ± 4.6 (33–46)
pallidicephala	M	3	165.8 ± 0.8 (165–166)	38.5 ± 0.0 (38–39)	91.7 ± 2.7 (89–95)	89.6 ± 7.6 (83–98)	59.5 ± 0.1 (50–67)	58.1 ± 8.5 (48–64)
	F	1	161.3	42.2	100.6	78.6	65.4	61.0
pani	M	6	116.8 ± 13.6 (103–143)	33.4 ± 2.6 (31–38)	97.0 ± 3.4 (93–103)	60.4 ± 4.4 (53–65)	38.0 ± 6.2 (32–48)	36.1 ± 5.3 (31–46)
	F	16	135.9 ± 14.0 (111–156)	37.5 ± 3.9 (32–45)	102.8 ± 1.9 (99–107)	56.7 ± 3.9 (51–64)	36.6 ± 9.4 (22–55)	36.7 ± 7.3 (25–49)
trifasciata	M	16	141.1 ± 18.1 (113–172)	35.8 ± 2.7 (30–41)	94.4 ± 2.2 (91–100)	68.0 ± 9.4 (49–82)	52.9 ± 12.5 (35–70)	43.5 ± 8.9 (28–55)
	F	19	164.9 ± 21.1 (126–203)	40.2 ± 3.5 (36–50)	98.9 ± 2.4 (93–103)	63.2 ± 7.1 (49–74)	49.9 ± 7.8 (38–66)	42.1 ± 6.7 (27–57)
yunnanensis	M	3	103.7 ± 19.7 (85–125)	33.6 ± 0.8 (32–35)	94.2 ± 1.4 (93–95)	86.1 ± 3.0 (83–89)	69.2 ± 7.1 (63–77)	59.5 ± 6.2 (53–66)
	F	1	138.0	41.4	95.5	88.2	96.8	89.8

tion of humero-pectoral seam and plastral margin (PW1), plastron width at level of junction of abdomino-femoral seam and plastral margin (PW3), plastron width of level of junction of femoro-anal seam and plastral margin (PW4), maximum ventral width across gulars (GW), maximum length of right gular (MGL), and length of right interhumeral (IH), interpectoral (IP), interabdominal (IAB), interfemoral (IF), and interanal (IAN) seams. Sample sizes are given in Table 1.

All characters were standardized for body size by regressing each variable against carapace length and using the residuals in all statistical procedures (after Atchley et al., 1975, 1976). This avoided the concern about the statistical validity of using ratios; however, as noted by Berry (1978) for *Kinosternon*, the multivariate results obtained in our analyses were virtually identical whether ratios or residuals were used. Because of sexual dimorphism, males and females were analyzed separately. The effect of ontogenetic variation was reduced by analyzing only adults and subadults.

Discriminant function analysis of the residuals of all 16 variables (MCW, CH, MPL, MFL, MHL, HL, PW1, PW3, PW4, GW, MGL, IH, IP, IAB, IF, and IAN) was performed with the SPSS-X statistical program (SPSS Inc., 1983). Ten samples were compared in the overall analysis, including the new species and each of the nine previously recognized species of *Cuora*: *C. amboinensis*, *C. aurocapitata*, *C. evelynae*, *C. flavomarginata*, *C. galbinifrons*, *C. mccordi*, *C. pani*, *C. trifasciata*, and *C. yunnanensis*. ANOVA and pairwise species comparisons for each variable were made with Fisher's Least Significant Difference test with the STATVIEW™ statistical package (Feldman et al., 1987) on a MacIntosh™ computer. Parametric tests were employed despite the fact that some samples were small because (1) examination of variances (Table 1) suggested that they were homogeneous across samples (e.g., variances were relatively uniform and not positively correlated with means) and (2) examination of residual plots revealed no obvious deviance from normality. In any case, statistical analyses were used primarily to identify very distinctive samples and to suggest taxonomically useful characters and only secondarily to demonstrate statistically significant differences.

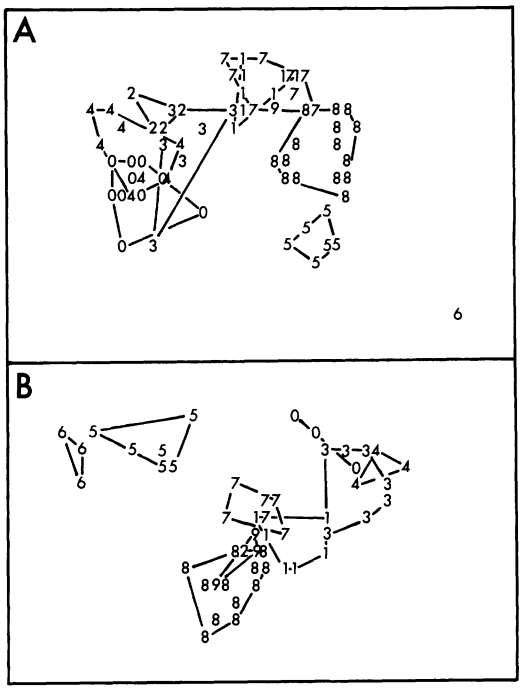


FIG. 1.—Plot of the first two canonical axes for (A) female and (B) male *Cuora* based on discriminant function analysis of standardized residuals for 16 characters (see text). Polygons connect most dispersed individuals of each sample. First axis accounts for 48.5% and 44.8% of the variation, respectively; second, 19.5% and 22.1%, respectively. Symbols are 1 = *aurocapitata*; 2 = *amboinensis*; 3 = *flavomarginata*; 4 = *galbinifrons*; 5 = *mccordi*; 6 = *pallidicephala*; 7 = *pani*; 8 = *trifasciata*; 9 = *yunnanensis*; and 0 = *evelynae*.

RESULTS

Discriminant analysis (Fig. 1) revealed that the new species and *C. mccordi* are morphometrically the most distinctive members of the genus. ANOVA of residuals further supported the distinctiveness of the new species. There was highly significant variation ($P < 0.003$) across all samples in all variables for both sexes, except for MGL in males ($P = 0.06$) and MFL in females ($P = 0.015$). The new species differed significantly for at least two characters (*mccordi*: range for all comparisons,

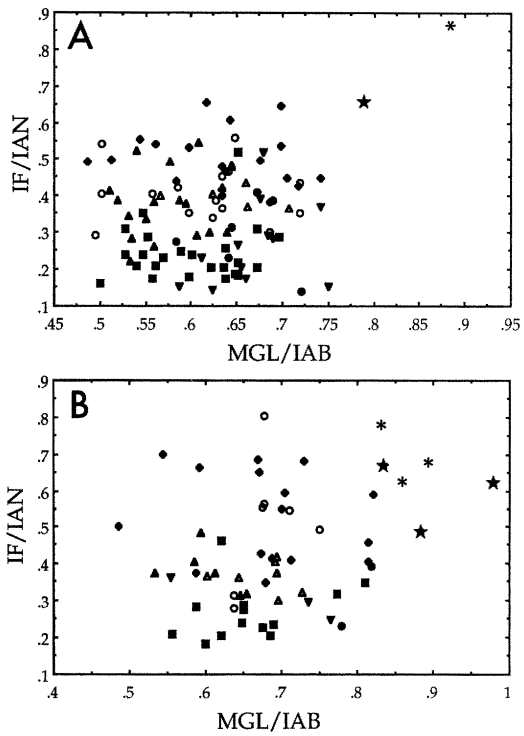


FIG. 2.—(A) Bivariate plot of the relationships among 102 females of the species of the genus *Cuora* based on the characters maximum gular length/interabdominal length (MGL/IAB) and interfemoral length/interanal length (IF/IAN). Species codes are solid dots = *amboinensis*; open dots = *aurocapitata*; solid squares = *flavomarginata* (including *evelynae*); inverted solid triangles = *galbinifrons*; open triangles = *mccordi*; stars = *pallidicephala*; solid triangles = *pani*; solid diamonds = *trifasciata*; and snowflakes = *yunnanensis*. (B) Bivariate plot of the relationships among 60 males of the species of the genus *Cuora* based on the characters maximum gular length/interabdominal length (MGL/IAB) and interfemoral length/interanal length (IF/IAN). Species coded as above.

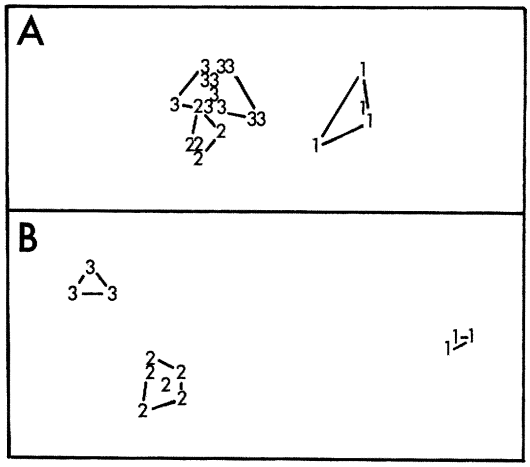


FIG. 3.—Plot of the first two canonical axes for (A) female and (B) male *Cuora flavomarginata* from mainland China (1) and Taiwan (2) and *C. evelynae* (3) from the Ryukyu Islands based on discriminant function analysis of standardized residuals for 16 characters (see text). Polygons connect most dispersed individuals of each sample. First axis accounts for 90.5% and 93.9% of variation, respectively; second, 9.5% and 6.1%, respectively.

2–8 of 16 total characters) from any other population of females and for at least six characters (from *yunnanensis*: range for all comparisons, 6–10 of 16 total) from any other population of males. Combination of the raw variables into ratios for which the new species was most distinct (Fig. 2A,B) also demonstrated its distinctiveness.

The discriminant analysis also indicated that there is considerable overlap between *C. evelynae* and *C. flavomarginata*. Because those two forms are very similar (Ernst and Lovich, 1990) and include three allopatric populations that each have been named (*C. f. sinensis* Hsu, 1930, on the mainland; the nominae subspecies on Taiwan, and *C. evelynae* Ernst and Lovich, 1990, in the Ryukyu Islands), the data standardization and discriminant analysis were repeated for those taxa from those three locations (Fig. 3). That analysis revealed (1) that the mainland population is by far the most distinctive of the three, (2) that no variable varied significantly across the female samples, and (3) that only MCW ($P = 0.03$) and IAB ($P = 0.003$) varied significantly across the male samples. In addition, ANOVA of those two characters showed that the mainland population was significantly different from the other two populations, but that the Ryukyu population was not.

DISCUSSION

Although the original purpose of this report was not to examine variation within species, our analyses suggested that the Chinese mainland subspecies of *C. flavomarginata* (*C. f. sinensis* Hsu, 1930) was more different from the nominate form on Taiwan than was the recently described *C.*

evelynae Ernst and Lovich (1990) from the Ryukyu Islands. Ernst and Lovich's analysis is inconclusive because (1) they included juveniles in their analysis without consideration of allometric variation, (2) they did not analyze males and females separately, despite sexual dimorphism in several characters, and (3) they analyzed raw measurement data (i.e., without standardization for body size differences among samples). Examination of their Table 1 and their discriminant function analysis suggests that the Ryukyu population is distinctive in having larger yellow carapace blotches than the other two populations, and that it may be distinctive in the size of the interabdominal seam, but that no other of their characters seems to distinguish significantly the Ryukyu sample from the other two samples. However, our ANOVA demonstrates that IAB in the Ryukyu sample was not significantly different from the other two samples. In addition, our discriminant analysis (Fig. 3) clearly indicated the greater distinctiveness of the mainland population than the Ryukyu population. We conclude that the Ryukyu sample apparently differs significantly from the mainland and Taiwan samples only in the size of its yellow carapace blotches, and that the mainland sample is weakly but significantly different from the other two. We therefore believe that the elevation of the Ryukyu population to species status by Ernst and Lovich (1990) is unwarranted, and until a more complete analysis of variation among those three populations is undertaken, we recommend the relegation of *C. evelynae* to a subspecies of *C. flavomarginata*.

Although we have not seen the actual holotype or allotype of *Cuora pani*, we have examined color photographs of them provided by M. Song to H. D. Philippen and J. R. Buskirk and others taken by R. de Bruin, as well as the pictures published in Song (1984). We have also examined the holotype and paratype of *Cuora chriskarannarum* as well as the "other material" referred to in the description of that species. We agree with de Bruin (1988), Philippen (in Stubbs, 1989), and Pritchard (1990) that the two forms are indistinguishable, and thus, *Cuora chriskarannarum* Ernst and McCord should be relegated to the synonymy of *Cuora pani* Song.

We have also examined the material that Ernst (1988*b*) redescribed as *C. pani*, as well as pictures of the type of *Cuora aurocapitata* provided in the original description (Luo and Zong, 1988) and color photographs of the latter provided by Zong to H. D. Philippen. We concur with Buskirk (1989) and Pritchard (1990) that Ernst's (1988*b*) concept of *C. pani* was actually based on *C. aurocapitata*.

Our studies of the original literature and the results of our morphological comparisons (especially Fig. 1A) suggests that *Cuora pani* Song and *C. aurocapitata* Luo and Zong are very similar and differ primarily in color pattern. We have even seen specimens of *C. aurocapitata* with intermediate plastral patterns (e.g., UF 78128 = JI-89-173). These two taxa may, thus, be only subspecifically distinct (with *C. pani* tending to have a wider carapace, a longer plastron, a longer plastral hindlobe, and a wider PW4 than *C. aurocapitata*). However, any synonymy should await more extensive study of geographic variation in the two forms.

Other taxonomic and biogeographic problems within this complex still remain. First, the types of *C. pani* were said to have been collected in Shaanxi Province in central China, whereas those of *C. chriskarannarum* were said to have been collected in eastern Yunnan Province (Fig. 4). These localities are separated by nearly 1200 km. Whether *C. pani* (including *chriskarannarum*) actually has a range that extensive, or whether one (or both) of the recorded localities is in error remains to be determined. In fact, the ranges of most of the species of the genus are as yet poorly defined (Fig. 4).

Finally, both the multivariate and univariate morphometric analyses, as well as subjective color pattern comparisons (Figs. 5–7) support the distinctiveness of the new species. Geographically, the two known localities for the new species lie within 100 km of those for *C. yunnanensis* (Fig. 4), and those two forms differ from all other *Cuora* in having a relatively long inter-

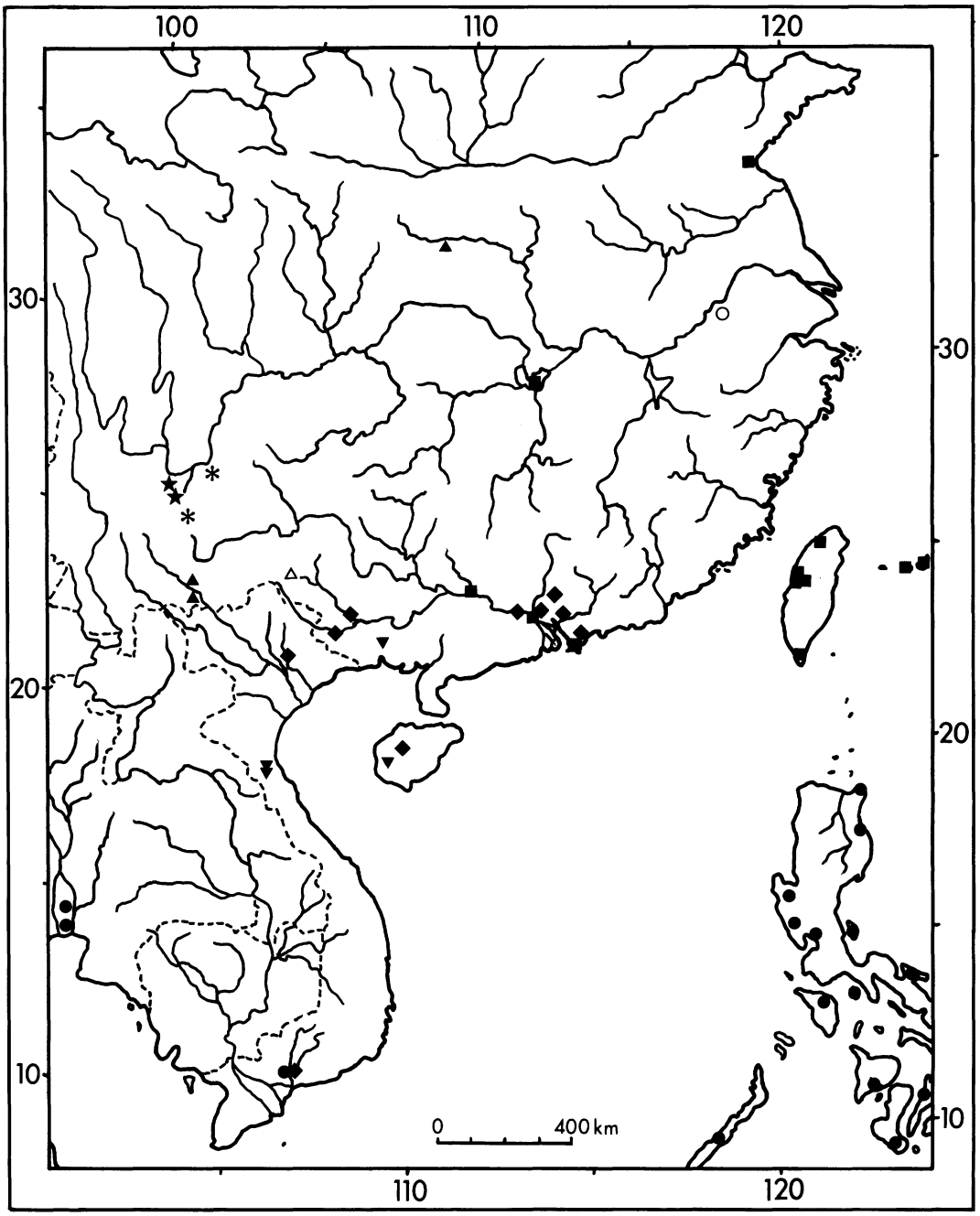


FIG. 4.—Distributions of the species of the genus *Cuora* in Asia. Species coded as in Fig. 2.

→

FIG. 5.—Comparison of the species of the genus *Cuora* recognized in this paper: (A) *amboinensis* (male, CL = 136 mm); (B) *aurocapitata* (male, CL = 119 mm); (C) *flavomarginata* (female, CL = 147 mm); (D) *galbinifrons* (female, CL = 172 mm); (E) *mccordi* (female, CL = 121 mm); (F) *pallidicephala* (male, CL = 166); (G) *pani* (female, CL = 127 mm); (H) *trifasciata* (female, CL = 182 mm); and (I) *yunnanensis* (BMNH 1946.1.22.98, male, CL = 125 mm).


A
B
C
D
E
F
G
H
I

femoral seam and a relatively short interabdominal seam (Fig 2A,B). However, they differ in that *C. yunnanensis* has a boldly mottled chin and throat, and a dark, boldy striped head, and lacks a mostly black plastral pattern (Figs. 5–7; Ernst, 1988*b*), in addition to having a significantly narrower plastron (PW1, PW3, and PW4), a smaller body size, a shorter plastral hindlobe in females, and a longer plastron in males.

Extensive field work in Yunnan Province by Oscar Shiu and his contacts has resulted in the discovery of *Cuora mccordi* (but note that the type locality is given in Ernst, 1988*a*, as Paise, Guangxi Province, but should have been "in Yunnan Province, west of Paise, Guangxi Province"; Oscar Shiu, personal communication to W. M. McCord), the new species, and the additional records of *C. pani* listed in the description of *C. chriskarannarum* (Ernst and McCord, 1987). Surprisingly, however, *C. yunnanensis* has not been collected since its original description (Boulenger, 1906; see Ernst, 1988*b*).

Given the overwhelming evidence supporting the distinctiveness of the new Yunnan species, we name it *Cuora pallidicephala*, in reference to its pallid head markings relative to its congeners.

Cuora ***pallidicephala*** sp. nov.
Pale-headed Chinese box turtle
Figs. 5F, 6F, 7F

Holotype.—UF 77230, an adult male, preserved in alcohol; reported to have been collected at Wuting [= Wuding: 25°26′ N, 102°21′ W] or Yuanmow [25°41′ N, 101°54′ W], Yunnan Province, China; purchased from locals by Mr. Oscar Shiu, in August 1989.

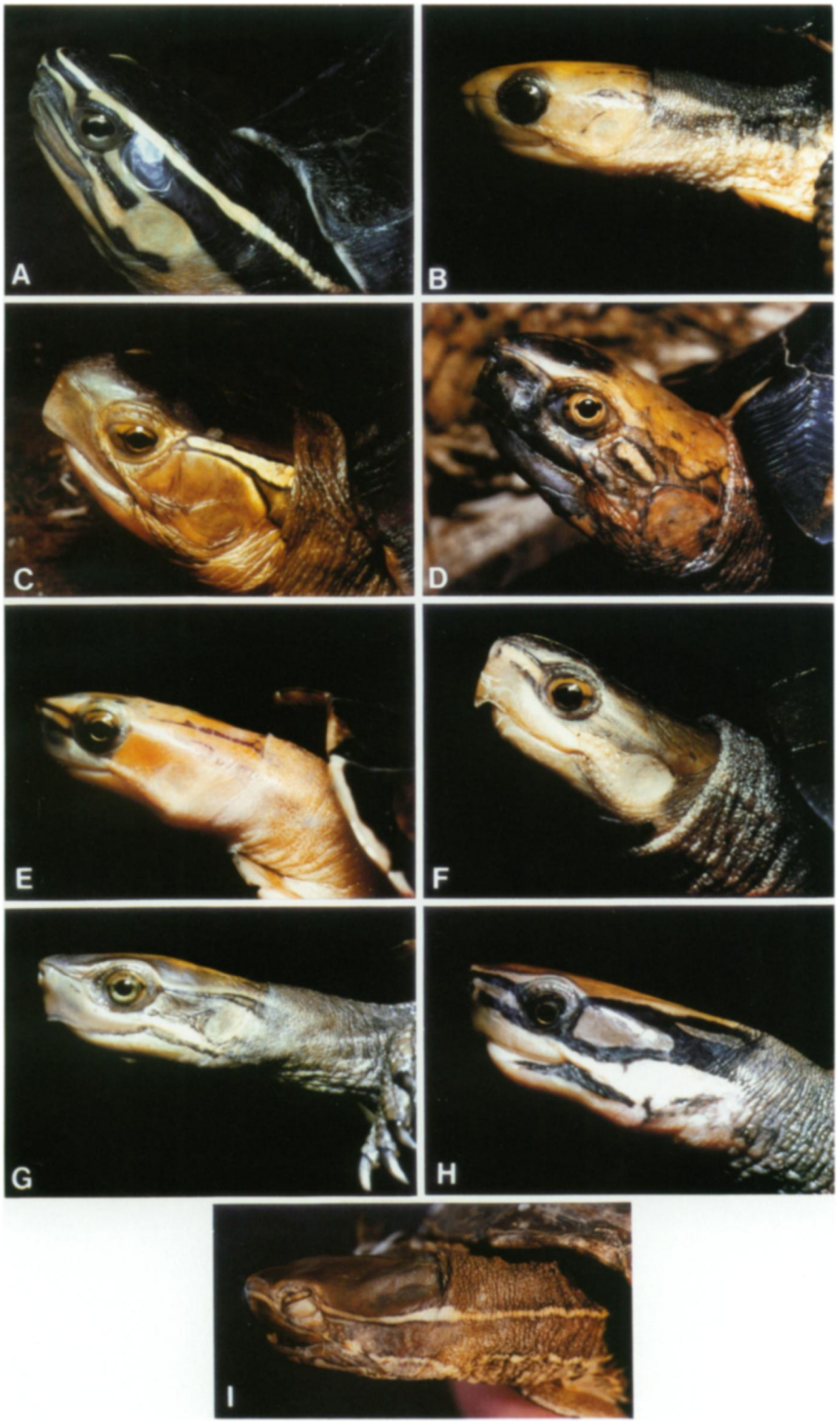
Paratype.—UF 77253 an adult male, preserved in alcohol; same data as holotype.

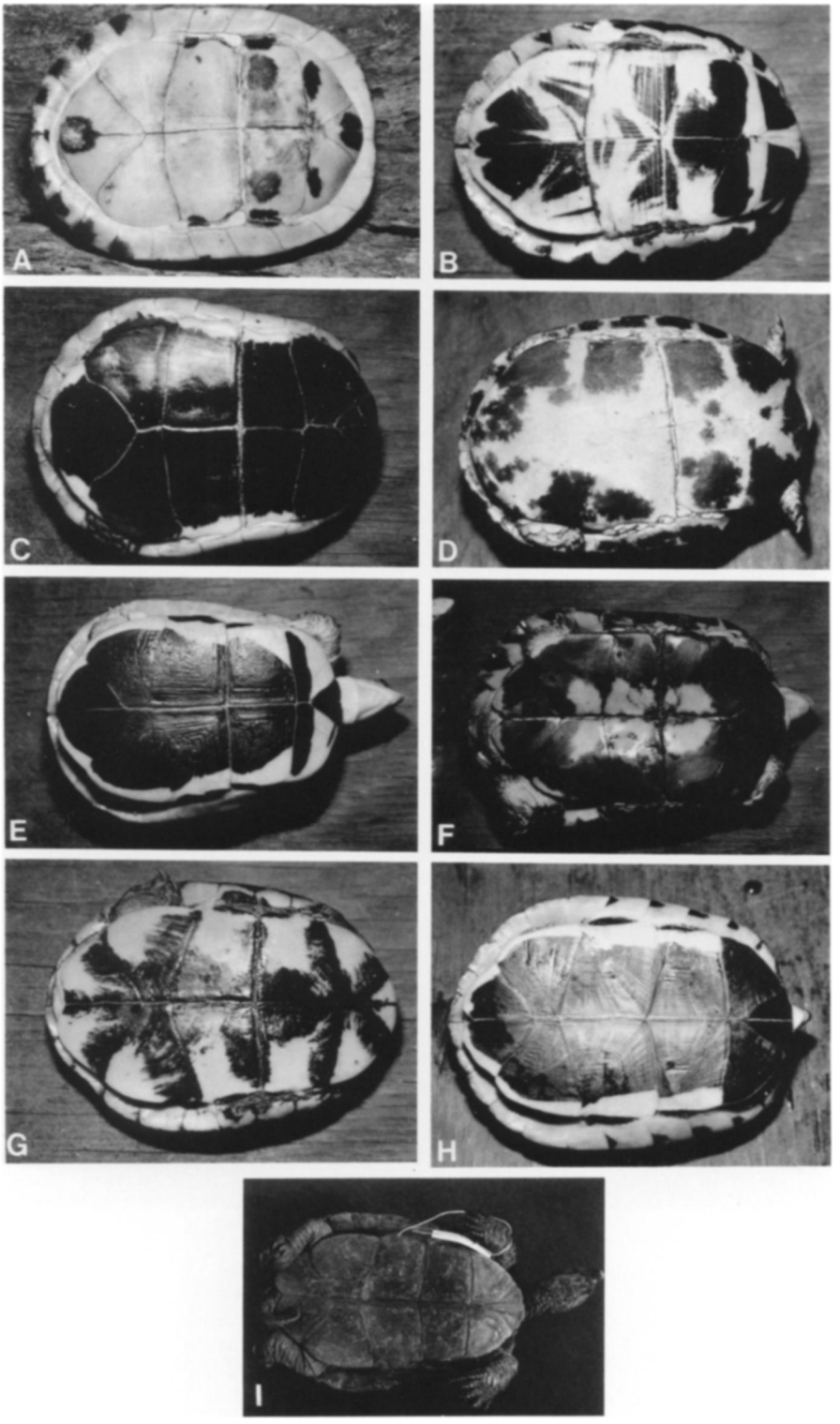
Diagnosis.—A moderately domed species of *Cuora* [low domed in *C. aurocapitata, C. pani, C. trifasciata,* and *C. yunnanensis*; high domed in *C. flavomarginata* (including *C. evelynae*), *C. galbinifrons, C. mccordi,* and most *C. amboinensis*] with a brownish yellow head and a narrow black-bordered yellow line passing from the nostrils through the eye to the dorsal margin of the tympanum [distinctly different in all others (Fig. 7)]; a weakly tricarinate black carapace (at least in adults) [some shade of brown in all but *C. amboinensis,* some *C. flavomarginata,* and some *C. galbinifrons* (Fig. 6)]; a black plastron with a central, yellow oblong figure on the pectorals, abdominals, and femorals, and the lateral margins of the humerals and femorals and the posterior margins of the anals marked with yellow [black blotched to uniform black to unmarked in other species (Fig. 7), but none has a distinctive black-bordered central yellow figure]; a relatively wide plastral hindlobe [relatively narrower in *C. amboinensis, C. aurocapitata, C. pani, C. trifasciata,* and *C. yunnanensis*]; relatively long gular and interfemoral seams [relatively short gulars in *C. aurocapitata, C. mccordi, C. pani,* and *C. trifasciata,* and relatively short interfemorals in all other species but *C. yunnanensis*]; and relatively short interabdominal and interanal seams [relatively long interabdominals in all other species but *C. yunnanensis,* and relatively long interanals in all other species but *C. trifasciata* and *C. yunnanensis*].

Description (based on one female and three male adult specimens, including the types).—Carapace length (CL) to at least 166 mm in males and at least 162 mm in females, elliptical, moderately domed (shell height at level of hinge/CL = 0.385–0.422; $\bar{x}$ = 0.394), widest near the junction of marginals (M) 8 and 9 (maximum carapace width: CW/CL = 0.642–0.740; $\bar{x}$ = 0.689), with straight sides, and a smooth to slightly serrated posterior margin. Carapace surface smooth, without obvious growth annuli. M1 widest, M4–6 smallest; M8–12 slightly flared. Nuchal scute small (posterior width/maximum CW = 0.052–

→

FIG. 6.—Comparison of head patterns of males of the species of the genus *Cuora* recognized in this paper: (A) *amboinensis*; (B) *aurocapitata*; (C) *flavomarginata*; (D) *galbinifrons*; (E) *mccordi*; (F) *pallidicephala*; (G) *pani*; (H) *trifasciata*; and (I) *yunnanensis*.


A
B
C
D
E
F
G
H
I


A
B
C
D
E
F
G
H
I

0.065; $\bar{x}$ = 0.059), rectangular, and longer than wide. All vertebrals (V) wider than long; V1 contacting (or nearly so) seam between M1 and M2; V5 not contacting M10. Low medial keel most pronounced on V1, V4 and V5.

Maximum plastron length equal to or shorter than carapace length (PL/CL = 1.0 in single female; 0.89–0.95 in males), slightly upturned anteriorly, with moveable hinge between pectoral and abdominal scutes. Anterior plastral lobe (AL) shorter than posterior lobe (AL/maximum plastron length = 0.416–0.439; $\bar{x}$ = 0.426). Plastral forelobe width at level of junction of humero-pectoral seam and lateral plastral margin 126.9% (range 123.5–129.4) of plastral forelobe length. Width of plastral hindlobe (at lateral junction of abdominal-femoral seam) 102.7% (100.2–105.0) of maximum length of plastral hindlobe. Plastral hindlobe (HL) with shallow anal notch (medial length of HL/maximum HL length = 0.907–0.952; $\bar{x}$ = 0.924). Bridge moderately long (bridge length/CL = 0.27–0.31; $\bar{x}$ = 0.29); axillaries reduced or absent; one small inguinal scute. Average plastral formula: interpectoral seam (IP) ≥ interabdominal seam (IAB) ≥ interanal seam (IAN) > intergular seam (IG) >> interfemoral seam (IF) >> interhumeral seam (IH). Intergular seam/IAB = 0.79–0.98; $\bar{x}$ = 0.87. IF/IAN = 0.50–0.67; $\bar{x}$ = 0.61. IG/IP = 0.77–0.97; $\bar{x}$ = 0.87. Interanal seam present and complete. Head narrow; upper jaw slightly to strongly hooked; tubercles dorsal to angle of jaw and anterior to tympanum very pronounced.

Anterior surface of antebrachium covered with large, imbricate scales, the largest four of which are sickle-shaped; largest scales on hindlimb at heel, but much smaller than largest forelimb scales. Upper parts of limbs and tail finely scaled. Males with a slightly concave plastron; females with a flat plastron. Males with larger, thicker tails than females; vent posterior to carapace margin in males, anterior to it in females.

Coloration.—Color nearly uniform black, but with occasional eroded areas of brown to yellow. Generally a black triangular area on ventral anterolateral margin of M1–4 and M8–12, although sometimes entire ventral surface washed with black; M5–7 mostly black ventrally. Plastron mostly black, with central oblong yellow figure on medial areas of pectoral, abdominal, and femoral scutes, and margins of pectorals, femorals, and anals marked with yellow; bridge mostly black, except for small yellow blotch at junction of hinge and bridge. Dorsum of head uniform olive green. Black-bordered narrow yellow line originates at nostrils, passes to orbit, and continues posteriorly from orbit where it fades completely near the dorsal rim of the tympanum. Tomia, tympanum, chin, and ventral neck surface uniform yellow. Iris yellow to olive green. Exposed parts of forelimbs dark olive green laterally, but washed with salmon medially; exposed parts of hindlimbs dark olive dorsally and yellow ventrally, with some salmon wash on bottom lateral aspect of feet. Recessed areas of skin yellow, except for salmon wash at base of neck and onto dorsum of forelegs. Tail yellow ventrally, and nearly black dorsally, with indistinct lighter dorsolateral lines on each side.

Other material.—One male and one female (both topotypic) alive in the collection of William P. McCord (WPM); to be deposited on death in the UF collection.

Distribution.—Known only from the two type localities, although which of the four available specimens came from which

←

FIG. 7.—Comparison of plastral patterns of the species of the genus *Cuora* recognized in this paper: (A) *amboinensis* (male, CL = 160 mm); (B) *aurocapitata* (female, CL = 120 mm); (C) *flavomarginata* (male, CL = 141 mm); (D) *galbinifrons* (female, CL = 172 mm); (E) *mccordi* (female, CL = 121); (F) *pallidicephala* (male, CL = 166); (G) *pani* (male, CL = 111 mm); (H) *trifasciata* (female, CL = 145 mm); and (I) *yunnanensis* (BMNH 1946.1.22.98, male, CL = 125 mm).

of the two localities is uncertain. Said to have been collected from near highland streams.

Etymology.—The name *pallidicephala* is a combination of the Latin *pallidus*, meaning pale or pallid, and the Greek *kephale*, meaning head.

Acknowledgments.—This species would not have been collected without the efforts of O. Shiu of Hong Kong. Curators and technicians at the American Museum of Natural History (AMNH), the Natural History Museum (British Museum of Natural History; BMNH), the California Academy of Sciences (CAS), the Field Museum of Natural History (FMNH), the Museum of Comparative Zoology at Harvard (MCZ), the Museum of Vertebrate Zoology at Berkeley (MVZ), the Florida Museum of Natural History (UF), and the United States National Museum (USNM) facilitated specimen loans. M.-T. Song, Y. Zong, J. R. Buskirk, C. H. Ernst and H. D. Philippen provided photographs, data, and/or other pertinent information. The comments of J. R. Buskirk, C. H. Ernst, and J. E. Lovich on an early draft of the manuscript are greatly appreciated. All photographs are by Iverson, with the able assistance of R. Smith. Support for Iverson was provided by the Earlham College Professional Development Fund, the Joseph Moore Museum of Natural History, and his family.

Key to the Species of the Genus *Cuora*

1a. Plastron without a posterior anal notch 2
b. Plastron with a distinct posterior anal notch 4
2a. Carapace usually with lower 70 to 80% of pleurals lightly colored (e.g., white, cream, or yellow); if lower part of pleurals mostly dark, then light color organized into anterolaterally directed starburst on each scute ..... *C. galbinifrons*
b. Carapace with lower 70 to 80% of pleurals uniformly darkly colored (e.g., brown or black) 3
3a. A single thinly black-bordered lemon-yellow temporal stripe extending back from posterodorsal margin of each orbit; tympanum light brown to orange, but never yellow ..... *C. flavomarginata*
b. Three yellow stripes on each side of head, one from tip of snout to dorsal margin of tympanum to neck and two from nostrils through orbit to neck; tympanum yellow or cream ..... *C. amboinensis*
4a. Carapace with three longitudinal black stripes; head with broad, black postorbital stripe enclosing an elongate brown or olive triangle behind the eye and a narrow brown or olive bar dorsal to, and extending posterior from, the tympanum ... *C. trifasciata*
b. Carapace without three longitudinal black stripes; head with yellow, orange, or brown stripes on each side 5
5a. Chin darkly mottled; head brown with two narrow light stripes extending posteriorly from orbit. *C. yunnanensis*
b. Chin without dark mottling; head yellow or olive 6
6a. Plastron mostly black, but with large central, yellow blotch; interfemoral seam length more than 53% of interpectoral seam length. *C. pallidicephala*
b. Plastron partly to mostly black, with dark pigment generally associated with the scute seams; interfemoral seamlength less than 53% of interpectoral seam length 7
7a. Plastron mostly black, with dark pigment not associated only with seams; carapace domed; head with orange temporal stripe ..... *C. mccordi*
b. Plastron partly black, with dark pigment concentrated near seams; carapace not domed; head with yellow, brown, or olive temporal stripe 8
8a. Dark pigment on plastron arranged in rectangular bars associated with the seams; carapace olive-brown with lighter brown vertebrals; head olive with darker brown and/or black markings ..... *C. pani*
b. Dark pigment on plastron associated with seams, but usually streaked rather than rectangular; carapace brown with reddish vertebrals; head lemon yellow ..... *C. aurocapitata*

Literature Cited

Atchley, W. R., C. T. Gaskins, and D. Anderson. 1975. Statistical properties of ratios of biological data. Am. Zool. 15:829.

———. 1976. Statistical properties of ratios. I. Empirical results. Syst. Zool. 25:137–148.

Berry, J. F. 1978. Variation in Systematics in the *Kinosternon scorpioides* and *K. leucostomum* Complexes (Reptilia: Testudines: Kinosternidae) of Mexico and Central America. Ph.D. Dissertation, University of Utah, Salt Lake City, Utah.

Boulenger, G. A. 1889. Catalogue of the Chelonians, Rhynchocephalians, and Crocodiles in the

British Museum (Natural History). Taylor and Francis, London.

———. 1906. Descriptions of new reptiles from Yunnan. Ann. Mag. Nat. Hist. 17:567–568.

BUSKIRK, J. R. 1989. New locality records for Chinese non-marine chelonians. Chinese Herpetol. Res. 2:65–68.

DE BRUIN, R. 1988. Twee nieuwe *Cuora*-soorten uit China. Lacerta 47:4–6.

ERNST, C. H. 1988*a*. Redescriptions of two Chinese *Cuora* (Reptilia: Testudines: Emydidae). Proc. Biol. Soc. Washington 101:155–161.

———. 1988*b*. *Cuora mccordi*, a new Chinese box turtle from Guangxi Province. Proc. Biol. Soc. Washington 101:466–470.

ERNST, C. H., AND R. W. BARBOUR. 1989. Turtles of the World. Smithsonian Institution Press, Washington, D.C.

ERNST, C. H., AND J. E. LOVICH. 1990. A new species of *Cuora* (Reptilia: Testudines: Emydidae) from the RyuKyu Islands. Proc. Biol. Soc. Washington 103:26–34.

ERNST, C. H., AND W. P. MCCORD. 1987. Two new turtles from southeast Asia. Proc. Biol. Soc. Washington 100:624–628.

FELDMAN, D. S., J. GAGNON, R. HOFMANN, AND J. SIMPSON. 1987. Statview II. Abacus Concepts, Berkeley, California.

GRAY, J. E. 1831*a*. Characters of a new genus of freshwater tortoise from China. Proc. Zool. Soc. London 1831:106–108.

———. 1831*b*. Synopsis Reptilium or Short Descriptions of the Species of Reptiles. Part I. Cataphracta, Tortoises, Crocodiles, and Enaliosaurians. Treüttel, Würtz Co., London, England.

———. 1834. Characters of several new species of freshwater tortoises (*Emys*) from India and China. Proc. Zool. Soc. London 1834:53–54.

HIRAYAMA, R. 1984. Cladistic analysis of batagurine turtles (Batagurinae: Emydidae: Testudinoidea); A preliminary result. Stud. Geol. Salmanticensia Vol. Esp. 1. Stud. Paleonchelonolog. I 1984:141–157.

HSU, H. E. 1930. Preliminary note on a new variety of *Cyclemys flavomarginata* from China. Contrib. Biol. Lab. Sci. Soc. China, Zool. Ser. 6(1):1–7.

HU, S., E. M. DJAO (= ZHAO), AND Z. HUANG. 1975. Three new species of reptiles from Hainan Island, Guangdong Province. Acta. Zool. Sinica 24:379–384.

IVERSON, J. B. 1977. Geographic variation in the musk turtle, *Sternotherus minor*. Copeia 1977:502–517.

———. 1981. Biosystematics of the *Kinosternon hirtipes* species group (Testudines: Kinosternidae). Tulane Stud. Zool. Bot. 23:1–74.

IVERSON, J. B., C. H. ERNST, S. GOTTE, AND J. E. LOVICH. 1989. The validity of *Chinemys megalocephala* (Testudines: Batagurinae). Copeia 1989: 494–498.

IVERSON, J. B., AND W. P. MCCORD. 1989. The proper taxonomic allocations of *Emys nigricans* Gray, *Emys muticus* Cantor, and *Geoclemys kwangtungensis* Pope. Amphibia-Reptilia 10:23–33.

LI, Z. Y. 1958. Report on the investigation of reptiles of Hainan Island. Chinese J. Zool. 2:234–239.

LUO, B., AND Y. ZONG. 1988. A new species of *Cuora—Cuora aurocapitata*. Acta Herpetologica Sinica 3:13–15.

MCDOWELL, S. B. 1964. Partition of the genus *Clemmys* and related problems in the taxonomy of the aquatic Testudinidae. Proc. Zool. Soc. London 143:239–279.

PRITCHARD, P. C. H. 1990. Review of: Turtles of the World, by Carl H. Ernst and R. W. Barbour. Copeia 1990:602–607.

PRITCHARD, P. C. H., AND W. P. MCCORD. 1991. A new Emydid turtle from China. Herpetologica 47:139–147.

SONG, M.-T. 1984. A new species of the turtle genus *Cuora* (Testudoformes: Testudinidae). Acta Zootaxonomica Sinica 9:330–332.

SPSS, INC. 1983. SPSS^x User's Guide. McGraw-Hill, New York.

STUBBS, D. 1989. Tortoises and freshwater turtles: An action plan for their conservation. IUCN/SSC Tortoise and Freshwater Turtle Specialist Group, Canterbury, England.

ZONG, Y., AND L. PAN. 1989. Studies on the the genus *Cuora* of the Testudoformes. Current Herpetol. East Asia 1:198.

Accepted: 4 December 1990
Associate Editor: David Cannatella

APPENDIX I

Specimens Examined

See Acknowledgments for abbreviations. *C. amboinensis*: Indonesia (WPM 1, alive), Philippines (UF, two uncatalogued specimens; WPM, two live specimens), Viet Nam (WPM, four live specimens), and without data (UF, two uncatalogued specimens). *C. aurocapitata*: China (UF 78116–20, 78128–29, 78757; WPM, 17 live specimens). *C. flavomarginata*: Taiwan (BMNH 1947.3.5.68 [syntype]; CAS 18034–37; FMNH 82658, 121225–26, 127170–71, 127324, 199746–49), China [BMNH 1947.3.4.50 (syntype); JBI, one live specimen; UF, three uncatalogued specimens; WPM, four live specimens], Ryukyu Islands (*C. f. evelynae*; CAS 21015–22, 26102–109, 26801; MCZ 7997, 55838, 56064). *C. galbinifrons*: Viet Nam (UF 78564–68, 78570–73; WMP, five live specimens), China, Hainan Island (WPM, six live specimens). *C. mccordi*: China (USNM 281850; WPM, 15 live specimens). *C. pallidicephala*: China (UF 77230, 77253; WPM, two live specimens). *C. pani*: China [UF 78121–27; USNM 266162–63 (holotype and paratype of *chriskarannarum*); WPM, 16 live specimens]. *C. trifasciata*: China (AMNH 30139–40, 30142, 30146–50, 30152; CAS 11348; MCZ 20689, 120334; FMNH 6614–18, 6620–21; JBI, one uncatalogued specimen; WPM, seven live specimens), Laos (WPM, two live specimens), Burma (WPM, three live specimens), Viet Nam (MCZ 20689; WPM, four live specimens), no data (WPM, one live specimen). *C. yunnanensis*: China (BMNH 1946.1.22.97–99, 1946.1.23.1–3).

Note

Subsequent to the acceptance of this paper for publication, nine additional males and 13 additional females of *Cuora pallidicephala* from the type locality were obtained by WPM through Oscar Shui. Those specimens [UF 78752 (a skeleton), 78753-56 (in alcohol), and 17 others alive the WPM collection] confirm the distinctiveness of the species as well as the reliability of the characters considered diagnostic in the paper. The live specimens will eventually be deposited in the UF collection.

Herpetologica, 47(4), 1991, 420–429

A NEW SPECIES OF *PROCTOPORUS* (SQUAMATA: GYMNOPHTHALMIDAE) FROM ECUADOR

DAVID A. KIZIRIAN AND LUIS A. COLOMA

Museum of Natural History and Department of Systematics and Ecology, The University of Kansas, Lawrence, KS 66045-2454, USA

ABSTRACT: A new species of gymnophthalmid lizard, *Proctoporus cashcaensis*, is described from the Hoya de Chimbo in the Andean Cordillera Occidental of Ecuador. This species is distinguished from other species of *Proctoporus* by features of squamation and body proportions. Natural history data for the new taxon are presented.

Key words: Reptilia; Squamata; Gymnophthalmidae; *Proctoporus cashcaensis*; New species; Ecuador

THE genus *Proctoporus* Tschudi 1845 consists of 15 species occurring in the Andean Cordillera from Bolivia to Venezuela and on Trinidad. The existence of undescribed taxa referred to *Proctoporus* has been known for many years (e.g., Duellman, 1979; Hillis, 1985), yet it has been 35 yr since the most recent species description (Uzzell, 1958). The species of *Proctoporus* are characterized by having an elongate deeply forked tongue with scalelike imbricate plicae, well-developed limbs, rectangular or subhexagonal dorsal scale rows, large squarish juxtaposed platelike scales on the venter, few large platelike head scales, posterior sutures of parietal and interparietal scales not forming a straight line, nasal scales separated by rostral and frontonasal scales, midventral pregular scales not enlarged, femoral pores, moveable eyelids, transparent eye discs, ear openings, and normal-sized innermost digits. All *Proctoporus* (except three populations which may represent undescribed taxa) lack prefrontal scales. Other gymnophthalmids lack prefrontal scales (i.e., *Anotosaura vanzolinia*, *Colobodactylus*, *Pholidobolus annectens*, *Ph. macbrydei*, *Ph. montium*, *Ptychoglossus bicolor*, some species of *Bachia*, *Heterodactylus*, *Micrablepharus*, *Stenolepis*, some individuals of *Prionodactylus vertebralis*, and the holotype of *Ecpleopus fraseri*, a synonym of *Euspondylus maculatus*) but also possess characters not shared by *Proctoporus*. *Anotosaura vanzolinia*, *Bachia* and *Heterodactylus* exhibit reduction of limb elements and lack external ear openings. In *Colobodactylus*, and *Stenolepis*, the pollex is reduced or absent. *Micrablepharus* lacks a pollex and eyelids. In *Ptychoglossus*, the posterior sutures of the interparietal and parietal scales form a straight line, enlarged postparietal scales are absent, and oblique plicae are present on tongue. *Prionodactylus* and *Pholidobolus* have two median rows of enlarged pregular scales. *Euspondylus* usually possess prefrontals and smooth or feebly keeled dorsal scales. Therefore, the referral of the new taxon