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A NEW SPECIES OF *OCADIA* (TESTUDINES: BATAGURINAE) FROM SOUTHWESTERN CHINA

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Abstract.—A new species of batagurine turtle, *Ocadia glyphistoma,* purportedly from southwestern Guangxi Province, China, differs from *Ocadia sinensis* by having fewer broad neck stripes, bold dark markings on the ventral surfaces of the hind limbs, a distinctive medial notch in the tomium of the upper jaw, a broader carapace and plastron, a longer plastral forelobe, relatively shorter interpectoral, interabdominal, and interanal seams, and a relatively longer interhumeral seam. It differs from *Ocadia philippeni* by having bold dark markings on ventral surfaces of the hind limbs, no obvious wash of ventral pink to orange pigment, a distinctive medial notch in the tomium of the upper jaw, a broader shell, a relatively shorter plastron and bridge, and relatively shorter interpectoral, interabdominal, and interanal seams.

McCord & Iverson (1992) recently described a distinctive species of batagurine turtle (*Ocadia philippeni*) from Hainan Island, China, and compared that form with its only recognized congener, *Ocadia sinensis*. But during 1990 and 1991, Mr. Oscar Shiu of Hong Kong sent McCord a series of another distinct stripe-necked batagurine turtle from southwestern China with clear affinities to both *O. sinensis* and *O. philippeni* (Fig. 1). Univariate analysis of variance (Table 1) and discriminant function analysis (Fig. 2) demonstrated that these new turtles were similar, but morphometrically distinct from the latter two species, and so they are described herein as the third species of the genus *Ocadia* even though skeletal material is not yet available for definitive generic placement (e.g., McDowell 1964, Hirayama 1984, Gaffney & Meylan 1988). A study of the mitochondrial genome of all Asian batagurines is underway by J. W. Bickham, Iverson, and McCord to test this allocation.

Materials and Methods

Preserved material was borrowed from the American Museum of Natural History (AMNH), the 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 at the University of Florida (UF), and the United States National Museum (USNM), and living material was available in McCord's private collection (WPM). Methods of measurement and analysis follow McCord and Iverson (1991). Character abbreviations are in Table 1. All measurements are in mm.

Specimens examined included: *Ocadia philippeni*: China, Hainan Island (UF 80765–66 [holotye and paratype]; WPM 1–7, alive). *Ocadia sinensis*: "Laos" (UF 80817–19 [3 specs]; WPM 1, alive), Viet-

nam (BMNH 1903.7.2.1; MCZ 21051), Taiwan (FMNH 121230–32, 127172–73, 127175–78, 127180, 195492, 199750–51), China, Hainan Island (AMNH 30173, 30176–78, 30183–84, 30186–91, 30193, 30195–96; FMNH 6613 [formerly AMNH 30194]; MCZ 20687; MVZ 23940; UF 80816 [1 skeleton]), China, mainland (BMNH 1947.3.5.26 [holotype]; MVZ 23943; WPM 1–2, alive), and No Data (BMNH 1947.3.4.24, cotype of *Emys Bennettii*). *Ocadia glyphistoma*: China (UF 84818 [holotype]; WPM 1–9, alive).

Results and Discussion

Ocadia glyphistoma, new species
Guangxi stripe-necked turtle
Fig. 1

Holotype.—UF #84818, an adult male, preserved in alcohol; reported to have been collected near the Vietnam border southwest of Nanning, Guangxi Province, China, but purchased from local people near Nanning by Mr. Oscar Shiu, in the spring of 1991.

Diagnosis.—A medium-sized species of *Ocadia* (Table 2) most similar to *O. philippeni*, with a wide, basically tricarinate carapace having a prominent middorsal keel and weak lateral keels; an unhinged plastron; a medial notch in the tomium of the upper jaw (unnotched in other *Ocadia*); usually four yellow, black-bordered lateral head and neck stripes separated by narrow brown stripes (at least eight black-bordered, narrow, cream to yellow stripes in *O. sinensis*); the ventral surfaces of shell and skin not washed with pink, orange, or salmon (so colored in *O. philippeni*); the ventral surfaces of thighs boldly marked with dark pigment (no such dark markings in O. *sinensis* or O. *philippeni*); a relatively long plastral forelobe (maximum length averages 41% of carapace length [CL] in female and 37% in male *O. glyphistoma*, 42% and 39% in *O. philippeni*, and 38% and 36% in *O. sinensis*); a relatively long interhumeral seam (seam length averages 8.8% of CL in female and 8.5% in male *O. glyphistoma*, 8.6% and 6.2% in *O. philippeni*, and 5.6% and 5.3% in *O. sinensis*); a relatively short interpectoral seam (length averages 18% of CL in female and 17.5% in male *O. glyphistoma*, 21% and 20% in *O. philippeni*, and 21% and 20% in *O. sinensis*); a relatively short interabdominal seam (length averages 21% of CL in female and 22% in male *O. glyphistoma*, 25% and 23% in *O. philippeni*, and 26% and 23.5% in *O. sinensis*); and a relatively short interanal seam (length averages 9.6% of CL in female and 8.5% in male *O. glyphistoma*, 11.2% and 12.4% in *O. philippeni*, and 10.6% and 10.1% in *O. sinensis*) [see also Table 2 and Fig. 3].

Description (based on two adult females, five adult males, one subadult female and two subadult males, including the holotype).—Carapace length to at least 199 mm in males and at least 180 mm in females, elliptical, moderately tricarinate with a prominent medial keel and weak lateral keels, moderately domed (maximum shell height/CL = 0.338 to 0.435; mean = 0.41 for females, 0.38 for males), widest at marginal M7 or M8 (maximum carapace width/CL = 0.74 to 0.80 for females and 0.68 to 0.75 for males; means = 0.77 and 0.72, respectively), with a slightly serrated posterior margin, and with moderately obvious growth annuli (least obvious in old individuals). M1, 7, 8, and 9 largest (along carapace margin), approximately coequal in length; M11 smallest; M9 tallest; M9–11 distinctly flared. Cervical scute small, usually longer than wide, wider posteriorly than anteriorly, and indented medially along the posterior margin. Vertebrals V2–5 wider than long; V1 usually wider than long, but not contacting seam between M1 and M2; V5 usually not even close to contacting M10. Prominent medial keel most pronounced on V3 and V4; lateral keels weak (usually) to absent, but if present, most pronounced on costal C3. Carapace dark brown to nearly black, with seams more darkly marked; ca-

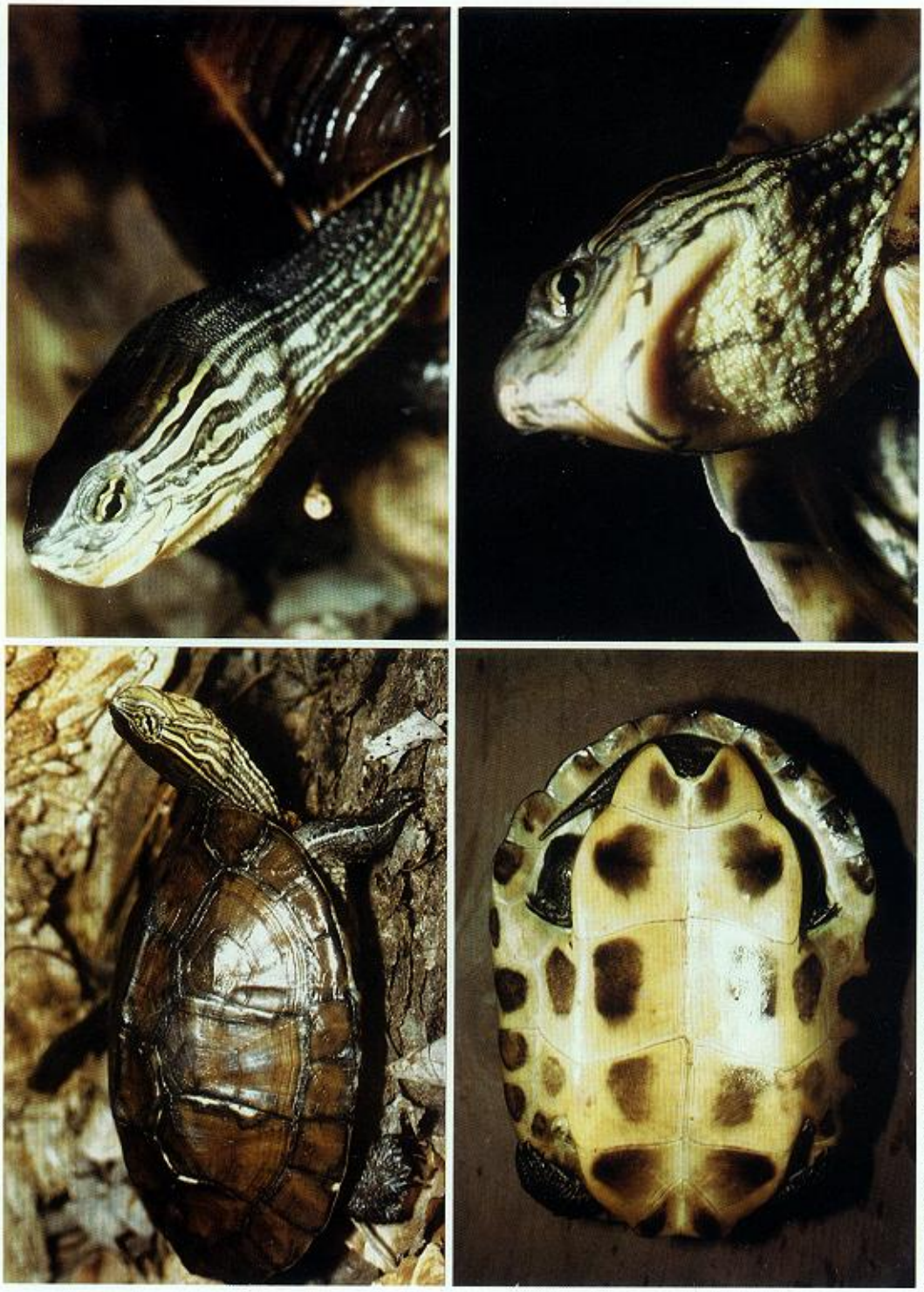

Fig. 1. (color). Head and plastral patterns of *Ocadia glyphistoma* (compare with color figures of *O. sinensis* and *O. philippeni* in McCord and Iverson, 1992). Carapace length of male in upper left is 118 mm; that of male in lower left is 180 mm; and that of female on right is 180 mm.

Table 1.—Results of univariate analysis of variance of residuals of 16 characters versus carapace length for three species of *Ocadia* (sexes analyzed separately). Differences are coded by first letter of species name; i.e., "s-g" indicates a significant difference between *sinensis* and *glyphistoma* for that character for the indicated sex. Methods of character measurement are in McCord and Iverson (1991).

Character	Males		Females	
	F	Differences	*F*	Differences
Maximum carapace width (CW)	3.72*	s-g; p-s	2.64	—
Maximum carapace height (CH)	1.46	—	0.01	—
Maximum plastron length (PL)	0.90	—	2.95	—
Maximum forelobe length (FL)	4.82*	p-g; p-s	9.03**	p-s
Maximum hindlobe length (HL)	0.82	—	4.01*	s-g; p-s
Plastral width (PW1)	2.30	—	1.62	—
Plastral width (PW3)	9.38***	p-g; p-s	4.24*	p-s
Plastral width (PW4)	10.34***	p-g; p-s	2.03	—
Bridge length (BL)	1.90	—	3.30*	p-g
Gular width (GW)	0.69	—	0.22	—
Gular length (GL)	4.44*	p-g; p-s	0.60	—
Interhumeral seam length (IH)	8.19**	p-g; s-g	4.95*	p-s
Interpectoral seam length (IP)	5.67**	p-g; s-g	2.77	s-g
Interabdominal seam length (IAB)	1.49	—	8.41**	p-g; s-g
Interfemoral seam length (IF)	11.31***	p-g; p-s	1.16	—
Interanal seam length (IAN)	17.08***	all	1.44	—

* $0.01 < P < 0.05$.
** $0.001 < P < 0.01$.
*** $P < 0.001$.

rinae usually not distinctly colored. A black notch on ventral posterolateral portion of each marginal, sometimes covering more than one-half of some marginals.

Maximum plastron length shorter than carapace length (PL/CL = 0.95–0.98 in females; 0.87 to 0.95 in males). Plastron slightly upturned anteriorly, with no hinge present. Plastral forelobe width (PW1) at level of junction of humeropectoral seam and lateral plastral margin relatively wide (PW1/CL = 0.38 to 0.44 in females and 0.36 to 0.42 in males; means = 0.42 and 0.38, respectively). Anterior width of plastral hindlobe (PW3: at lateral junction of abdominofemoral seam) relatively wide (PW3/CL = 0.45 to 0.47 in females and 0.40 to 0.43 in males; means = 0.46 and 0.42, respectively). Plastral hindlobe with relatively deep anal notch. Bridge moderately long (BL/CL = 0.37 to 0.39 in females and 0.33 to 0.37 in males; means = 0.38 and 0.35, respectively); single large axillary and inguinal scutes on each bridge. Average plastral formula (see also Table 2 and Fig. 1 for diagnostic ratios): interabdominal seam (IAB) > interpectoral seam (IF) ≥ interfemoral seam (IP) ≫ gular length (GL) ≫ interanal seam (IH) ≥ interhumeral seam (IAN). Plastron dark yellow-cream (Fig. 1), with a large (covering up to half of scute), black blotch on each scute (primarily on older portion of scute). A smaller black blotch also occurring on bridge area of pectoral and abdominal scutes, and on axillary (usually) and inguinal scutes.

Head narrow; upper jaw unhooked, but with medial notch; triturating surfaces of medium width. Very small tubercles evident between angle of jaw and tympanum. Dorsum of head uniform dark olive-brown. Four (or sometimes five) narrow longitudinal black-bordered yellow stripes on side of head, separated by narrow brown or olive stripes; all four originating at orbit, upper two passing above tympanum, third from

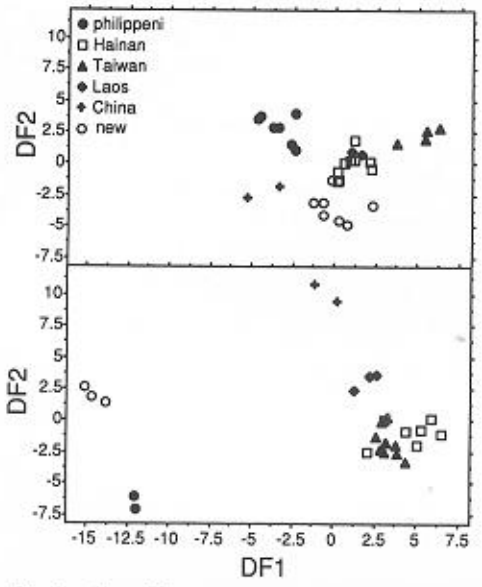

Fig. 2. Plot of first two canonical axes for specimens of *Ocadia* based on discriminant function analysis of the residuals of 16 characters (listed in Table 1; method as in McCord and Iverson, 1991) for males (top) and females. First and second axes account for 42.7% and 30.5% of variation, respectively, for males, and 66.0% and 20.2% for females. Geographic locations represent populations of *O. sinensis*.

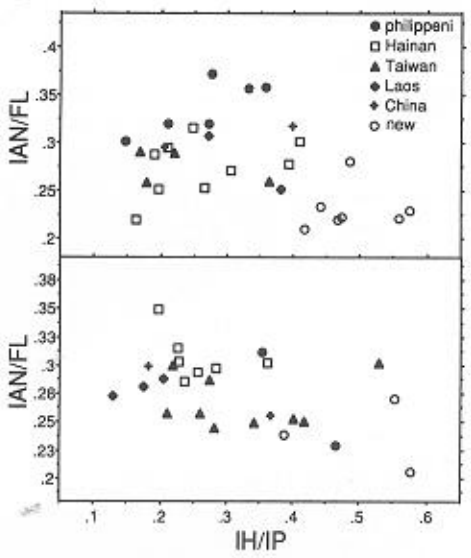

Fig. 3. Bivariate plot of relationships among males (top) and females of species of the genus *Ocadia* based on the characters IH/IP (interhumeral seam length/interpectoral seam length) and IAN/FL (interanal seam length/maximum plastral forelobe length). Geographic locations represent populations of *O. sinensis*.

top passing through tympanum and sometimes broken anteriorly, and lower stripe passing below tympanum. All stripes extending posteriorly to base of neck. Anterior continuations of stripes from orbit to nares variably obvious. Chin yellow, with variable vague black mottling (sometimes forming circles), but with seven black-bordered yellow longitudinal stripes (often discontinuous) extending from level of tympanum to base of neck. Tomia yellow with variable thin black markings. Black horizontal line across eye (through pupil); iris yellow-green.

Anterior surface of antebrachium covered with large, imbricate scales, the largest of which are sickle to spade-shaped; largest scales on hindlimb at heel, but much smaller than largest forelimb scales. Upper parts of limbs and tail covered with fine scales. Exposed parts of forelimbs dark olive-gray to nearly black, with faded yellow or orange or cream stripes (often discontinuous) extending outward from base of limbs variable distances onto limb; stripes barely visible on dorsal surface of antebrachium, but very obvious on ventral aspect of limbs. Stripes on posterolateral margins of each limb always obvious and extending at least to heel. Recessed areas of axillary region and between neck and forelimbs boldly marked with alternating dark gray and yellow to faded orange stripes. Recessed areas of inguinal region mostly yellow, but with some vague faded, dark gray blotching. Tail moderately long, gray-black dorsally, with a pair of vague longitudinal dorsolateral dark brown stripes extending along full length of tail; gray-black ventrally, but flecked with yellow or cream, and with a pair of longitudinal ventrolateral cream to light brown stripes extending the full length of the tail.

Males with a slightly concave plastron; females with a flat plastron. Males with a longer tail than females; vent at level of pos-

Table 2.—Morphometric characters useful in discriminating among species of the genus *Ocadia*. Character abbreviations are interhumeral seam length (IH), interpectoral seam length (IP), interanal seam length (IAN), interabdominal seam length (IAB), and maximum plastral forelobe length (FL). Values are means followed by range in parentheses. Common alphabetic superscripts following ranges indicate species means for that character that are significantly different ($P < 0.05$) by Fisher's (protected) least significant difference test.

Sample	Sex	*n*	Carapace length (mm)	IH/IP	IAN/FL	FL/IP	FL/IAB
O. philippeni							
Hainan	M	7	169.0 (113–199)	0.31 (0.15–0.60)^{a}	0.32 (0.22–0.37)^{d}	1.92 (1.77–2.36)^{r}	1.73 (1.39–1.94)^{k}
	F	2	216.7 (214–219)	0.41 (0.35–0.46)	0.27 (0.23–0.31)	1.99 (1.99–1.99)^{h}	1.66 (1.55–1.81)^{j}
O. sinensis							
Hainan	M	9	125.3 (107–155)	0.27 (0.16–0.41)	0.27 (0.22–0.32)	1.81 (1.66–1.97)	1.51 (1.30–1.65)
	F	7	146.8 (114–220)	0.26 (0.20–0.36)	0.31 (0.29–0.35)	1.82 (1.68–2.04)	1.45 (1.29–1.63)
Taiwan	M	4	177.7 (155–200)	0.23 (0.17–0.37)	0.27 (0.26–0.29)	1.86 (1.74–1.94)	1.53 (1.43–1.70)
	F	9	201.0 (176–235)	0.33 (0.21–0.53)	0.27 (0.25–0.30)	1.88 (1.76–2.10)	1.45 (1.37–1.59)
China	M	2	133.5 (117–150)	0.30 (0.21–0.40)	0.31 (0.30–0.32)	1.82 (1.74–1.91)	1.56 (1.52–1.59)
	F	2	261.0 (251–271)	0.28 (0.18–0.37)	0.28 (0.26–0.30)	1.82 (1.73–1.91)	1.43 (1.30–1.57)
"Laos"	M	2	141.4 (136–147)	0.33 (0.27–0.38)	0.28 (0.25–0.31)	1.81 (1.74–1.88)	1.74 (1.53–1.95)
	F	3	223.1 (195–258)	0.17 (0.13–0.20)	0.28 (0.27–0.29)	1.74 (1.67–1.81)	1.45 (1.37–1.53)
Total	M	17	140.5 (107–200)	0.27 (0.16–0.41)^{b}	0.28 (0.22–0.32)^{d}	1.82 (1.66–1.97)^{g}	1.54 (1.30–1.95)^{jk}
	F	21	191.8 (114–271)	0.28 (0.13–0.53)^{c}	0.28 (0.25–0.35)^{e}	1.84 (1.67–2.10)^{i}	1.45 (1.29–1.63)^{j}
O. glyphistoma							
China	M	7	169.9 (102–245)	0.49 (0.42–0.57)^{ab}	0.23 (0.21–0.28)^{d}	2.11 (1.89–2.25)^{fg}	1.71 (1.52–1.90)^{ij}
	F	3	152.9 (121–180)	0.51 (0.39–0.58)^{c}	0.24 (0.21–0.27)^{e}	2.36 (2.03–2.85)^{hi}	1.95 (1.83–2.04)^{l}

terior carapace margin in males; anterior to it in females.

Etymology.—From the Greek *glyphis* (carved or notched) and *stoma* (mouth), in reference to the species' distinctively notched upper jaw.

Other material.—Two adult females, four adult males, one subadult female, and two subadult males (all from type locality, but not designated as paratypes); specimens all alive in the collection of William P. McCord (WPM 1-9), and to be deposited on their death in the UF collection.

Distribution.—Known only from the region of the type locality. The precise locality could not be determined since the turtles were collected by local people.

Remarks.—Our studies of the genus *Ocadia* have clarified the provenance of the type material of *O. sinensis* and *O. bennettii,* as well as their taxonomic relationship. Based on the original description and illustrations of *Emys bennettii* Gray (1844, 1855) and on Iverson's examination of one of the cotypes (BMNH 1947.3.4.24), we concur with Günther (1864:27) that *Emys bennettii* is synonymous with *Ocadia sinensis.* In addition, discriminant function analysis performed with that cotype as an unknown suggested that it originated on Taiwan and not on Hainan Island or the Chinese mainland (see range map in Iverson 1992). Measurements from the holotype of *O. sinensis* (BMNH 1947.3.5.26) were also analyzed and the specimen was confirmed to have originated on the Chinese mainland.

We can also clarify somewhat the distribution of the genus *Ocadia* in Vietnam and adjacent China. Based on the descriptions of Siebenrock (1903), Bourret (1941; with illustrations), and Petzold (1963), *O. sinensis* is known from at least as far west as the Red River basin in Vietnam. Although we have not examined the specimens on which those descriptions were apparently based (e.g., Rijksmuseum van Natuurlijke Histoire of Leiden 4750, and Zoologisches Institut und Museum of Hamburg R00414 and R00416), the illustrations in Bourret (1941) are clearly of *O. sinensis.* In addition, MCZ 21051 from Phuc Son, Vietnam, and BMNH 1903.7.2.1 from "Annam" are also *O. sinensis.* Furthermore, given that Bourret (1941) called this species the most common emydid in the Tonkin (Red) delta region, and that Felix (1965) also found it to be common in the area west of Hanoi, its occurrence in at least the Red River basin in Vietnam seems unquestionable. However, this suggests that the range of *O. glyphistoma* in southwestern Guangxi Province, China, lies wholly within the range of *O. sinensis,* and that the two species may be broadly sympatric. Indeed, *O. sinensis* has been reported to occur only 40 km north of Nanning, Guangxi (at Wuming) by Lin (1984, in Buskirk, 1989). Unfortunately, until more museum material for this genus from southwestern China and adjacent Vietnam is available, the precise distributions of the individual species will remain uncertain.

Acknowledgments

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