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THE VALIDITY OF *CHINEMYS MEGALOCEPHALA* (TESTUDINES: BATAGURINAE).—Except for its mention on faunal lists (Wermuth and Mertens, 1977; Iverson, 1986; Ermi, 1986), very little has been published on

the Chinese big-headed turtle *Chinemys megalocephalo* since its description by Fang in 1934. It was originally diagnosed as distinct from *C. reevesii* (Gray, 1831) on the basis of structures associated with its enlarged head (e.g., broader, more massive skull, expanded alveolar surfaces, and hypertrophied head musculature).

*Chinemys megalocephalo* was known only from the type series and type locality (near Nanking) until 1985, when Yu and Jifan reported additional specimens from the Huang-Pu River in Shanghai and Wuhan (Yangtze river basin), and Guangxi (apparently the Si River basin). They also compared the three recognized *Chinemys* species morphologically, and supported the validity of *C. megalocephalo*, but again based only on skull/head morphology.

In recent years two morphotypes of megacephalic *Chinemys* have been imported from Asia via the pet trade. One presumably represents *C. megalocephalo*, but the taxonomic status of the other “dumbhead” morph has never been discussed.

Because megacephaly is commonly a geographically variable character in turtles, and because recent pet trade specimens of supposed *C. megalocephalo* resembled *C. reevesii* in all other aspects of morphology, we questioned the validity of *C. megalocephalo*. This paper reports the results of a morphometric comparison of the latter taxon with the other two recognized species of *Chinemys*: *reevesii* and *kwangtungensis*.

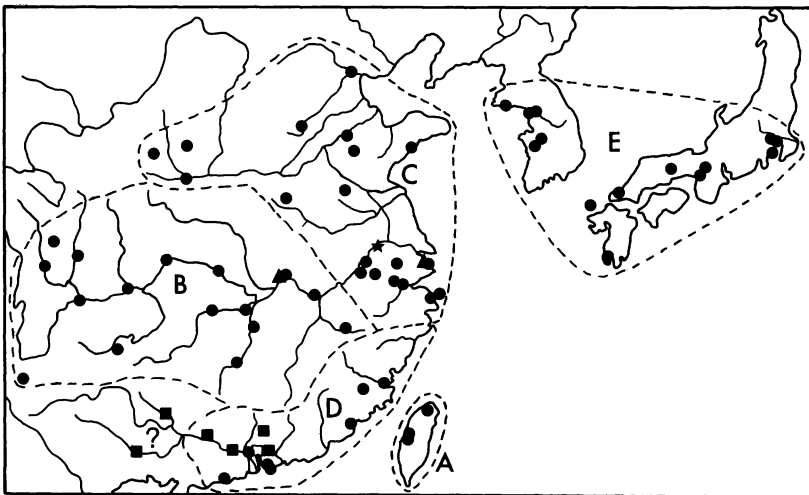


Fig. 1. Range of *Chinemys reevesii* (solid circles) in eastern Asia showing approximate sample areas (A–E) used in analyses. Star indicates type locality of *C. megalocephalo*; two triangles and question mark, additional localities of “big-headed” *Chinemys* reported by Yu and Jifan (1985). Squares are localities for *C. kwangtungensis*; open square is FMNH 15902.

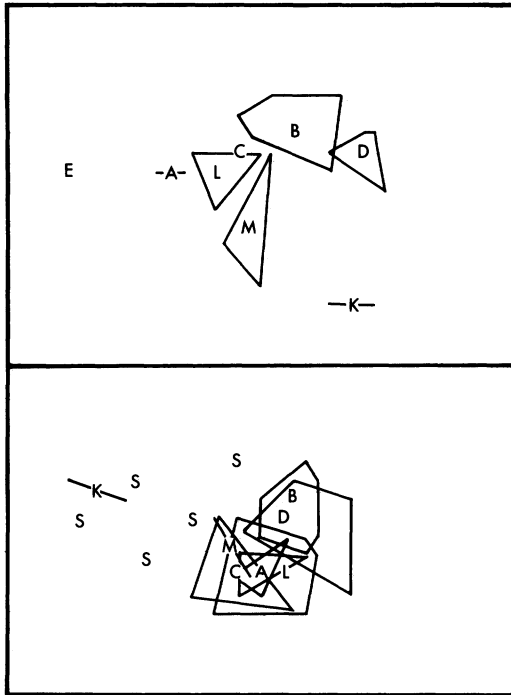


Fig. 2. Plot on the first two canonical axes of the population means for samples of male (top; total  $n = 31$ ) and females (bottom;  $n = 57$ ) of *Chinemys reevesii* (A–E), *C. megalcephala* types (M), live *C. megalcephala* (L) and *C. kwangtungensis* (K) produced by discriminant analysis based on nine character ratios. Population mean for sample E is the same as for sample A for the females. Specimens of megalcephalic (“dumbhead”) *Chinemys* (S;  $n = 5$ ; see text) were classified a posteriori in analysis. First axis accounts for 50.9 and 45.6% of total variation; second, 26.1 and 23.7%. Lines connect most dispersed values about each population mean.

*Methods.*—Institutional abbreviations are as listed in Leviton et al., 1985. Morphometric data from adult *C. reevesii* ( $> 120$  mm carapace length [CL]) previously analyzed by Lovich et al. (1985) were standardized by division by CL and submitted to discriminant and cluster analyses with data from Fang (1934) for the nine types of *C. megalcephala*, data from 16 live pet trade specimens of *C. megalcephala* in the private collection of W. P. McCord, data from three live pet trade (McCord collection) and one preserved (FMNH 15902, supposedly from Canton) female “dumbhead” *Chinemys*, and data from four specimens of *C. kwangtungensis* (UF 64342 and three live specimens in the John B. Iverson col-

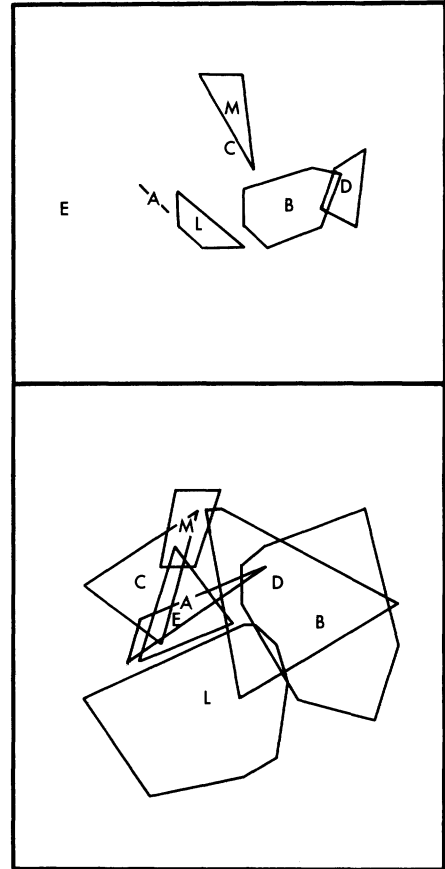


Fig. 3. Plots on the first two canonical axes of population means for the same samples of male (top;  $n = 29$ ) and female (bottom;  $n = 55$ ) *Chinemys* in Figure 2 (excluding *C. kwangtungensis* and “dumbhead” *Chinemys*) produced by discriminant analysis based on nine character ratios. First axis accounts for 62.7 and 44.2% of total variation for males and females, respectively; second, 19.4 and 27.7%. Lines connect most dispersed values about each population mean.

lection). Characters include CL, carapace width (CW), maximum plastron length (PL), maximum width of the posterior plastral lobe (PPW), gular scute length (GL), interhumeral seam length (IH), interpectoral length (IP), interabdominal length (IAB), interfemoral length (IF), and interanal length (IAN), and were all measured in mm. Sample areas for the discriminant analyses are delimited in Figure 1. Because of sexual dimorphism, analyses (all with the SPSS-X statistical package) were performed on males and females separately. Data were standardized by division by CL prior to analysis.

**Results.**—Discriminant analysis (Fig. 2) of samples of the three previously recognized species of *C. (reevesii, kwangtungensis, and megaloccephala)* revealed that *C. kwangtungensis* is a distinctive species characterized by a shorter GL (9–11% of CL vs 12–18% in *reevesii* and *megaloccephala*; means, 9.9 and 14.8%, respectively), a wider CW (68–76% of CL vs 60–72%; means, 71.3 and 66.7%, respectively), and a shorter IP (13–18% of CL vs 13–22%; means, 16.0 and 18.5%, respectively), in addition to the qualitative differences provided by Yu and Jifan (1985). Furthermore, a posteriori classification of the “dumbhead” specimens in that analysis (Fig. 2; bottom) suggests that they are large, female, megacephalic *C. kwangtungensis*. The one “dumbhead” turtle with data (FMNH 15902) is from Canton, which lies in the lower Si river basin, the only drainage from which *C. kwangtungensis* is known (though *C. reevesii* occurs there as well; Iverson, 1986). Because the Guangxi record of “megaloccephala” reported by Yu and Jifan (1985) lies in that same basin, it is possible that it also represents a megacephalic *kwangtungensis*. The availability of more specimens of all size classes of the latter species will be necessary to confirm this hypothesis.

Discriminant analysis was next performed using only samples of *C. reevesii* and *C. megaloccephala* (Fig. 3). The results indicate that specimens of the latter taxon fall well within the variation exhibited among samples of *C. reevesii*. They also suggest the existence of significant geographic variation among samples of *reevesii* (especially in males), contrary to the results of Lovich et al.’s earlier (1985) study. In decreasing order of significance, the characters IP/CL, IAN/CL, PPW/CL, and IG/CL in males, and IP/CL, IAB/CL, IF/CL, and PPW/CL in females all varied significantly among *reevesii* samples (Wilkes-Lambda F values all  $P < 0.05$ ). This discrepancy is probably because the earlier study analyzed morphological data unstandardized either by ratio or regression analysis. A multivariate analysis of geographic variation in scute proportions in adult *C. reevesii* is thus badly needed.

Cluster analysis of ungrouped specimens of *C. reevesii* and *C. megaloccephala* produced dendrograms by three agglomeration methods (average linkage, centroid, or median) that all suggested that *C. megaloccephala* is not significantly distinguishable from *C. reevesii* based on the nine character ratios analyzed here (Fig. 4).

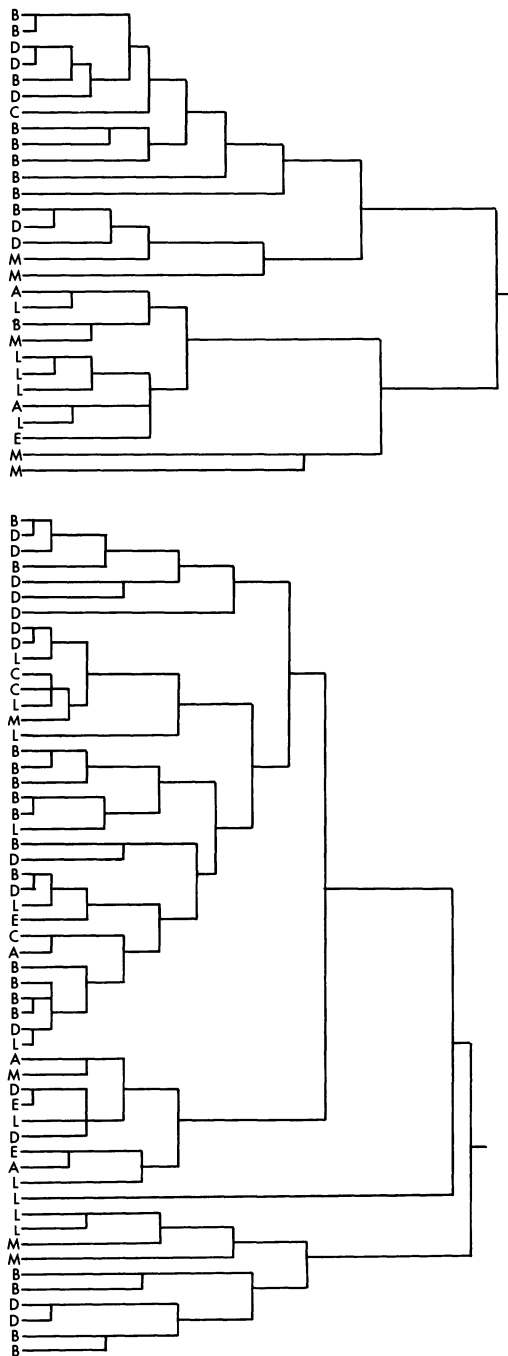


Fig. 4. Dendrogram of male (top) and female (bottom) *Chinemys reevesii* and *C. megaloccephala* produced by cluster analysis (average linkage method) based on nine character ratios. Operational taxonomic units are coded by sample: *C. reevesii* (A–E), *C. megaloccephala* types (M), and live *C. megaloccephala* (L).

*Conclusions.*—Megacephaly (the presence of an enlarged, broadened head, with expansive alveolar surfaces and hypertrophied jaw musculature) is reasonably common among turtles. It is known at least among the chelids *Emydura australis*, *E. krefftii*, *E. macquarrii* (Cogger, 1975), *E. victoriae* (Legler, pers. comm.), and the subgenus *Batrachemys* of the genus *Phrynops* (Pritchard, 1979); the pelomedusid *Peltocephalus* (Pritchard, 1979); the cheloniid *Caretta caretta*; the emydines *Graptemys barbouri*, *G. geographica*, *G. pseudogeographica kohnii*, *G. pulchra*, *Malaclemys terapin* (Conant, 1975) and *Trachemys scripta* (Pritchard and Trebbau, 1984); the batagurines *Malayemys subtrijuga* and *Chinemys megaloccephala* (Pritchard, 1979) and apparently *C. kwangtungensis* (this paper); the kinosternids *Kinosternon dunni* (Pritchard, 1979), *K. hirtipes* (Iverson, 1981), *K. subrubrum* (some North Carolina populations, Iverson, unpubl.), *K. odoratum* (Iverson, unpubl.), *K. minor* (Berry, 1975), *K. depressum*, *K. carinatum*, *Claudius angustatus*, *Staurotypus triporcatus*, and *S. salvinii* (Pritchard, 1979); the platysternid *Platysternon* (Pritchard, 1979); and the trionychids *Amyda cartilaginea*, *Apalone ferox*, *A. spiniferus*, *Dogania subplana* and *Trionyx triunguis* (Dalrymple, 1977; Meylan, 1987).

Because megacephaly is typically correlated with diet (e.g., mollusks, or rarely, large fruits), it is most common in aquatic, carnivorous taxa that characteristically feed on the bottom (e.g., kinosternids and trionychids), and it is rare among herbivorous turtles that inhabit open water or are terrestrial (e.g., emydines, batagurines, testudinids). Whether it is primarily an evolutionary or a developmental response for any given species is difficult to determine. The variability of its expression in many taxa (e.g., *Emydura*, *Graptemys*, some *Kinosternon*, trionychids) suggests an important developmental component in at least those taxa (Dalrymple, 1977); however, its constancy in other taxa (e.g., *Caretta*, *Claudius*, *Peltocephalus*, *Platysternon*) suggests a mainly genetic basis in those.

The inability to distinguish *Chinemys megaloccephala* and *C. reevesii* morphometrically, except for the enlarged head of the former, and the fact that big-headed specimens are apparently known from several sites in China (Yu and Jifan, 1985), all within the range of *C. reevesii*, suggests that *C. megaloccephala* is but a local variant of *C. reevesii*, adapted or acclimated to a diet of mollusks. *Chinemys megaloccephala* Fang should therefore be synonymized with *C. reevesii* (Gray).

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**FOAM-GENERATING BEHAVIOR IN TADPOLES OF LEPTODACTYLUS MYSTACEUS.**—Foam nests produced by some frogs in the family Leptodactylidae presumably prevent desiccation of eggs and embryos (Heyer, 1969; Downie, 1984; Dobkin and Gettinger, 1985). Downie (1984) reported that tadpoles of *Leptodactylus fuscus* can generate foam independently of that produced by adult frogs at the time of egg deposition. No other tadpoles are known to generate foam. Observations on adult nesting behavior and tadpole behavior and development of another species in the *L. fuscus* group, *L. mystaceus*, revealed that foam production by tadpoles also occurs in this species.

We studied growth and survivorship of *L. mystaceus* tadpoles in two nests at a field site in Brazil. Experiments were designed to establish whether tadpoles of this species generate foam and to determine whether a critical number of tadpoles is required to do so.

Observations were made and experiments conducted from 18 Jan.–9 March, 1987, in Pará, Brazil, at a site 60 km E and 32 km S Altamira. This time period corresponded with the beginning of the rainy season; sporadic rains occurred prior to 12 Feb., with rainfall occurring frequently thereafter (Fig. 1). Temperature during this time remained fairly constant. The mean overnight low was  $23.0 \pm 0.7$  C (range, 21.7–25.0 C) and the mean daily high was  $32.2 \pm 1.9$  C (range, 26.1–34.4 C). The field site was located in undisturbed lowland rain forest along

the Rio Xingu, a large tributary of the Amazon River.

Observations were made in a small grassy field near an abandoned camp. A small pool 0.45 × 2.5 m, 2 cm deep, bordered one side of the field. Small boards, cardboard, and other debris were concentrated at one end of the field near a small thatched-roof pole shed. A large chorus of *L. mystaceus* called intermittently from secluded spots under debris and small shrubs in the area.

Two foam nests of *L. mystaceus* (hereafter referred to as Nest 1 and Nest 2) were located on 31 Jan. after a period of dense chorusing that began on 28 Jan. Nests are produced by the male and female in a mud basin constructed previously by the male (Fig. 2A). Characteristics of Nest 1 and Nest 2, respectively, were: 1) Nest 1 located under a small stump 30 cm in diameter, Nest 2 located under a piece of damp cardboard; (2) distance to water, 5.5 and 2.1 m; (3) depth of mud basin, 3.7 and 4.4 cm; (4) diameter of mud basin, 6 cm for both; (5) depth of foam, 1.5 and 0.5 cm; (6) pH of foam, measured with pH test paper, 5.0 and 5.8; (7) afternoon temperature of foam, 27.2 C and 28.9 C; and (8) probable date of egg deposition, 29 Jan. and 28 Jan. The tadpoles in Nest 1 were flooded from their nest by a heavy rain that occurred on 12 Feb. after a 22 d period of almost no rainfall (Fig. 1). Tadpoles in Nest 2 disappeared from the nest on 5 Feb.

To determine stage and size of tadpoles in the nests, a few were randomly selected and carefully removed from each nest at daily intervals for 4 d and then at intervals of 2–3 d. These tadpoles were immediately preserved in 10% formalin and were later staged (Gosner, 1960). TL of each tadpole was measured with digital calipers. Tadpoles in both nests had hatched prior to the initiation of our observations. In both nests, tadpoles reached a peak size at Stage 25 and decreased slightly in size after that (Table 1). There was no further growth of tadpoles while they were in the nest, but tadpoles continued to develop to Stage 27.

Experiments were conducted to determine: 1) if tadpoles removed from original nest foam and washed can generate new foam; and 2) if so, whether there is a critical number of tadpoles necessary to generate foam. Observations were also made on the foam-generating behavior of tadpoles during the experiments.

For Experiment 1, 22 tadpoles were collected from Nest 1 on 3 Feb. and transported to the