Size and Shape Description of Oviductal Eggs of *Draco obscurus formosus* (Squamata: Agamidae)

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Abstract.-Oviductal eggs were obtained by an abdominal dissection from a gravid *Draco obscurus formosus* which was captured near the northern limits of this species distribution during the Malaysian Heritage and Scientific Expedition to Belum, Temengor Forest Reserve, Ulu Perak, Peninsular Malaysia in 1993 and 1994. Egg size, shape, the species-specific egg bicone coefficient , clutch mass, and clutch volume are described. This is the first report that describes the egg and clutch characters of this species.

Key words.- Reptilia, Squamata, Agamidae, *Draco obscurus formosus*, Peninsular Malaysia, egg shape, bicone coefficent.

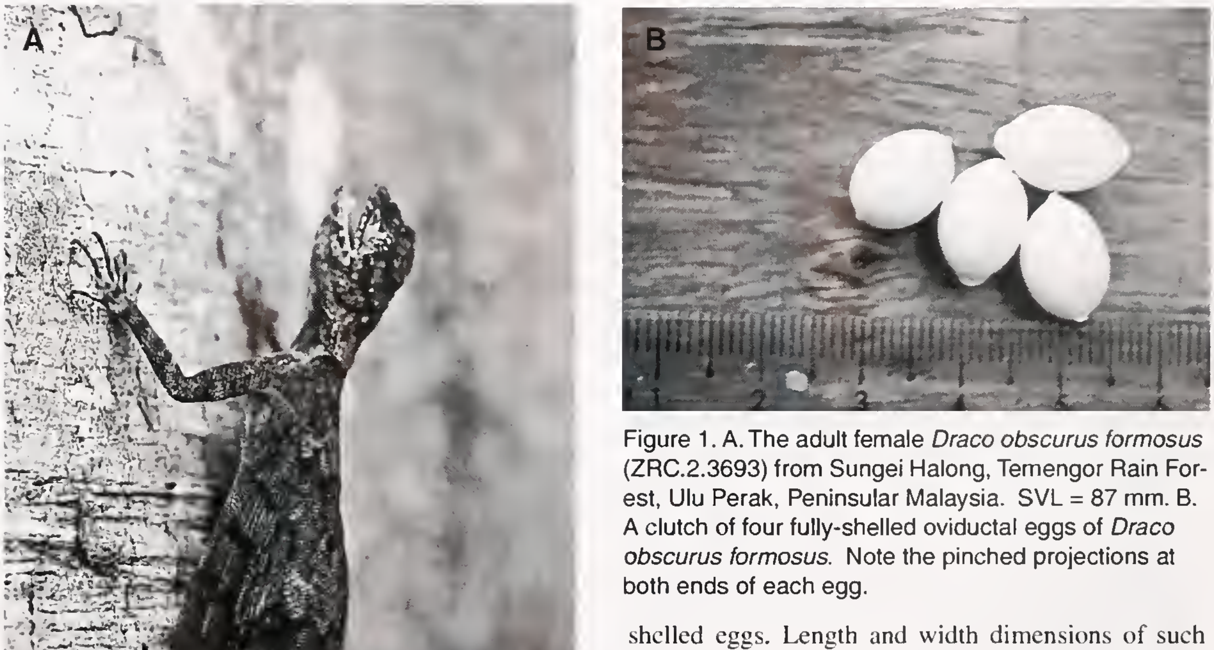

Figure 1. A. The adult female *Draco obscurus formosus* (ZRC.2.3693) from Sungei Halong, Temengor Rain Forest, Ulu Perak, Peninsular Malaysia. SVL = 87 mm. B. A clutch of four fully-shelled oviductal eggs of *Draco obscurus formosus*. Note the pinched projections at both ends of each egg.

Introduction

Size and shape characteristics of eggs, as well as the ecological implications of egg parameters, have been extensively studied in birds (e.g., Preston, 1968, 1969, 1974; Paganelli et al., 1974; Hoyt, 1979; Smart, 1991) but rare in reptiles (Iverson & Ewert, 1991; Maritz and Douglas, 1994). One reason for this neglect lies in the fact that most squamate reptiles lay soft, flexible-shelled eggs. Length and width dimensions of such eggs change as they absorb or lose water through the soft parchment shell to produce changes in their size, shape, volume, and surface area. Consequently, soft-shelled eggs have to be measured in their oviducts or soon after they are oviposited. This is in contrast to rigid-shelled eggs of crocodilians, geckos, birds, and some chelonians which can be measured at any time after being laid.

Iverson and Ewert (1991) applied Preston's (1968) formulation to describe reptile eggs firstly. This formulation was developed to describe the shape of avian eggs and assumed that an egg was axis-symmetric and the revolved egg outline on the x-axis gives its volume of revolution. Recently, Maritz and Douglas (1994)

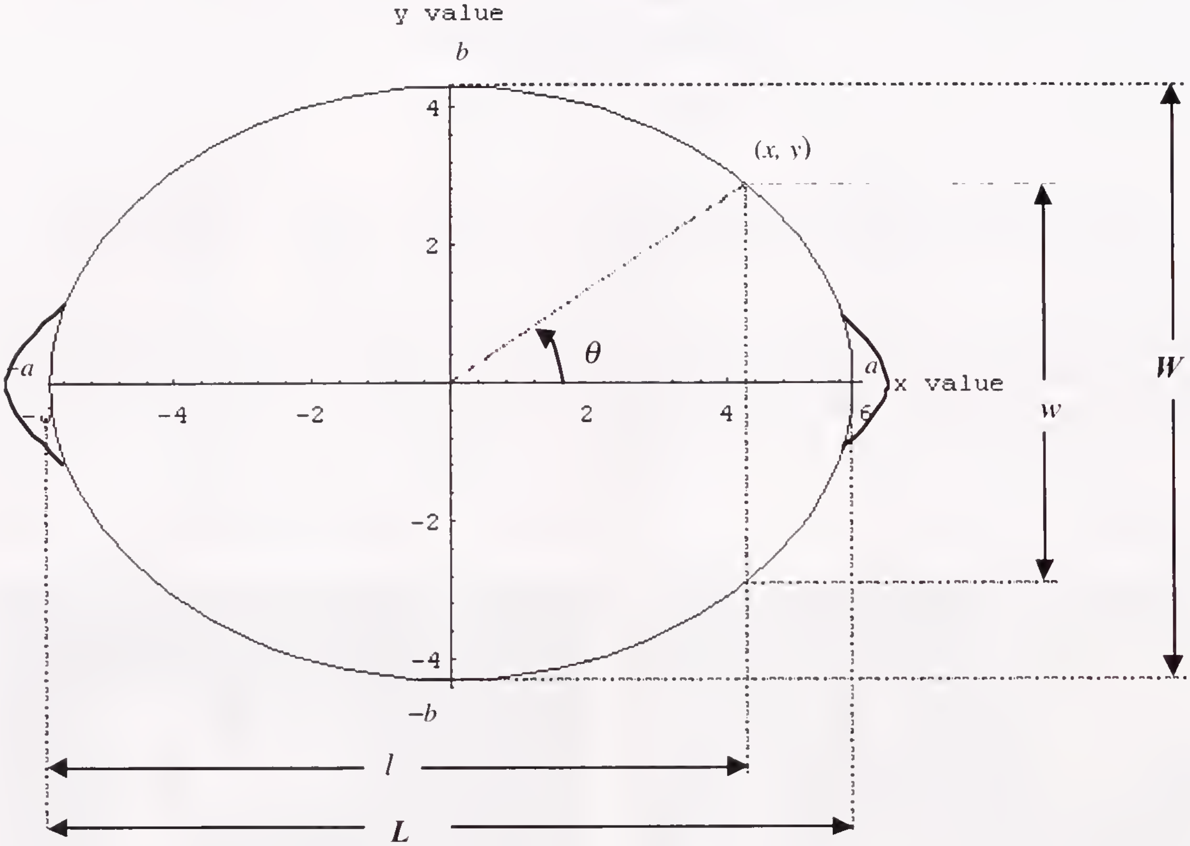

Figure 2. The coordinates and linear dimensions used to describe the shape of *Draco obscurus formosus* eggs; the outline of the egg shape, excluding the pinched ends, is generated by Mathematica software program. See text for details.

employed the Preston formulation to demonstrate the shape of reptile eggs from two linear measurements, egg length *L*, maximum width *W*, and the bicone coefficient c_2. The bicone coefficient is a species-specific parameter which measures bluntness at both ends of an egg; c_2 is negative for eggs with pointed ends, positive for eggs with blunt ends, and zero when the shape is a perfect ellipse.

During the Malaysian Heritage and Science Expedition to the Belum Temengor Forest Reserves in 1993 and 1994, a gravid female of *Draco o. formosus*, a subspecies endemic to southern Peninsular Thailand and Peninsular Malaysia (Boulenger, 1903, 1908; Musters, 1983) was collected (Diong et al. 1995). This presented an opportunity to collect oviductal eggs for size and shape quantization for this subspecies.

Material and Methods

Material examined

One gravid female (Fig. 1a) was collected on 9 Dec 1994 from a trunk of a large tree along Sungei [river] Halong, about 2 km upstream of Camp Halong (5° 24´N, 101° 18´E), Temengor Rain Forest Reserve, Ulu Perak, Malaysia, during the Belum Scientific Expedition (Diong et. al. 1995). Specimen was measured and dissected the day after collection. Head and body shape, as well as mass of body and egg were measured to the nearest 0.01 mm and 0.01 g by digital calipers (Mitutoyo) and electronic balance (Ohaus), respectively. Voucher specimen was deposited in the Zoological Reference Collection, School of Biological Sciences, National University of Singapore.

Quantization of egg shape

Length (*L*) and maximum width (*W*) of each egg were measured to obtain elongation ($E = L/W$), bicone coefficient (c_2) and volume (*V*) using the method described by Maritz and Douglas (1994). The outline of the egg was described parametrically using the Preston formulation, as follows :

$$x = \left(\frac{L}{2}\right)\cos(\theta),$$

$$y = \left(\frac{W}{2}\right)\sin\theta(1 + c_2 cos^2\theta),$$

$$0° \leq \theta \leq 360°$$

Mathematica (1993) software programme was used to generate the shape described by the parametric equations. A 35 mm slide of the clutch of eggs was projected on to a white cardboard mounted on a wall and three lines parallel to the y axis (c.a. 2/3 W) were drawn to the outline of each egg (Fig. 2) to obtain measurements of l, w, L, and W from the projected image; this procedure was repeated for the other half of the egg so that the bicone for each egg was an average of six estimations. The bicone coefficient was determined with the formula, $c_2 = \frac{1}{\alpha}\left(\frac{r}{\sqrt{1-\alpha}} - 1\right)$, where $r = \frac{w}{W}$, $\alpha = \left[2\left(\frac{l}{L}\right) - 1\right]^2$, and was subsequently used to estimate egg volume, V (in cm^3), as follows: $V = \frac{\pi}{6000}LW^2\left(1 + \frac{2}{5}c_2 + \frac{3}{35}c_2^2\right)$. Clutch volume was defined as the sum of individual egg volume in the clutch.

Results

Size of female lizard

Body mass 10.02 g, snout-vent length (SVL) 87 mm; tail length (TL) 167 mm; head length (HL) 16.78 mm; jaw length (JL)16.86 mm, head width (HW) 10.59 mm; hind leg length (HLL) 270 mm; hind foot length (HFL) 170 mm; fore leg length (FLL) 270 mm; fore foot length (FFL) 9 mm.

Clutch size, egg size, and shape quantization of eggs

The clutch consisting of 4 oviductal eggs; 2 eggs in each oviduct; 2 yolked ova and 4 whitish ova in right ovary, 2 yolked ova and 5 whitish ova in left ovary; yolked ova, 5.07 - 5.15 mm in diameter, white undeveloped ova 1.50 - 1.72 mm in cross diameter. Eggs turgid, shelled with chalky-white parchment-like membrane. Egg shape ellipsoidal, ends blunt, but each with pinched cap at ends (Fig. 1b, 2). Pinched ends solid, thick, firm, flat and in same plane, less than half a semi-circle; outline of lip-like pinched structure asymmetric. Mean ± SD of L excluding pinched ends for 4 eggs 11.83 ± 0.53 mm (range: 10.94 - 12.30 mm); L including pinched ends 13.00 ± 0.26 mm (range: 12.14 - 13.40 mm); W 8.71 ± 0.20 mm (range: 8.40 - 8.91 mm); elongation L/W 1.36 ± 0.08 (range: 1.23 -1.41); mean egg bicone coefficient c_2 -0.021 ± 0.008 (range: -0.032 to - 0.010); egg volume 0.487 ± 0.022 cm^3 (range: 0.460 - 0.510); egg mass 0.497 ± 0.022 g (range: 0.470 - 0.520 g); density 1.0205 ± 0.0009 (range:1.0196 - 1.0217). Total clutch volume 1.86 cm^3; total clutch mass 1.99 g; relative clutch mass [clutch mass divided by female (clutch plus body) mass] in percent, 19.86; relative clutch mass [clutch mass divided by female (body only, exclusive of clutch) mass] in percent, 24.78

Discussion

The present specimen has TL/SVL ratio equaled to 1.92 which is a middle size compared to Musters' (1983) report of 1.89 – 1.99 for females of this species. Musters (1983) while reporting a mean SVL of 82 ± 7mm for four females of this lizard and a mean clutch size of 3.7 for three females of *Draco obscurus formosus*, made no reference to egg shape of this lizard. Hendrickson (1966) recorded a mean clutch size of 2 in *D. melanopogon* (n = 14) and a mean clutch size of 4 in *D. volans* (n = 20). This suggests that clutch sizes in *D. o. formosus* and *D. volans* may be similar, being larger than that in *D. melanopogan*. Among these gliding agamid lizards, clutch size is probably constrained by body size and clutch mass as a larger clutch mass is likely to reduce the horizontal displacement covered during gliding. In the present study, the total clutch mass accounted for almost 20 percent of female body mass.

The three *Draco* species, *D. obscurus formosus*, *D. melanopogan*, and *D. volans*, all have contrasting egg shapes. Causility of variation of egg shape in the genus are unknown. The eggs are distinctly pointed at both ends in *D. melanopogan* but are ellipsoidal, blunt, and smoothly rounded at both ends in *D. volans* (Hendrickson, 1966). Eggs of *D. obscurus formosus* is a nearly perfect ellipsoid as indicated by the species-specific bicone coefficient, c_2 -0.021, which is very close to c_2 = 0, the value for a perfect ellipse. Additionally, the eggs are much rounder, as indicated by its elongation factor of 1.36 which is smaller in eggs of *D. volans* (E = 1.6) and *D. melanopogon* (E = 2.06), as calculated from Hendrickson's (1966) L and W measurements of the eggs. The most unusual structure of *D. o. formosus* eggs is the flat projections pinched outwards from both ends. The significance of the crescent-shaped pinched ends is unknown, but they may function as reserves of parchment shell materials to allow the stretching and expansion of the egg during development.

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