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NOTES ON *Harpesaurus borneensis* (MERTENS 1924), A LIVE BEARING AGAMID LIZARD FROM THE LOWLANDS OF BORNEO

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The agamid genus *Harpesaurus* is poorly understood, partially due to their scarcity in collections. Two taxa have been described from Borneo, originally assigned to two different genera: *Harpesaurus* [*Hylagama*] *borneensis* and *Harpesaurus thescelorhinos*. Today *thescelorhinos* is generally considered a junior synonym to *borneensis*. We here report on three additional specimens collected in Sarawak in 2005. While the two new females had some scale characters distinctly different from the two females previously known, we consider all known specimens from Borneo conspecific. Most notably, the two new females were soon to give live birth. This constitutes the first known example of live birth in agamid lizards from a tropical lowland area. We discuss why this unusual reproductive mode may have evolved in this particular taxon.

Keywords: Agamidae, Borneo, *Harpesaurus*, live birth, lizard, oviparity, ovoviviparity, viviparity.

INTRODUCTION

The South-East Asian agamid genus *Harpesaurus* Boulenger 1885 consists of a handful of poorly known species. The most striking feature of the genus is the presence, either in males only or in both sexes, of one or two prominent rostral appendages. Depending on the source, between four (Moody, 1980) and six (Böhme, 1989) species have been assigned to this genus, none of which have been collected more than a few times (Böhme, 1989). Judging from their rarity in collections as well as a scarcity of literature records, all seem to be uncommon and/or have restricted distributions within the islands of Sumatra, Java, and Borneo (assuming a more inclusive taxonomy, recognizing six species).

Part of the taxonomic discrepancy can be attributed to a Bornean form referred to as both *Hylagama borneensis* Mertens 1924 (based solely on the holotype, an adult female; SMNS 4596) and *Harpesaurus thescelorhinos* King 1978. The latter seems to be known from the two type specimens only — an adult male (holotype, FMNH 131540) and an adult female (paratype, FMNH 138196). Moody (1980) considered the two forms to be conspecific and assigned them to the genus *Hylagama* (as *H. borneensis*). Manthey and Grossman (1997) also considered *thescelorhinos* to be a junior synonym to *borneensis*, but grouped them with *Harpesaurus*. We here follow the latter nomenclature, and report on three specimens collected during herpetological surveys in north-central Sarawak for the Planted Forest Project (Grand Perfect Sdn Bhd, Sarawak, Malaysia; see Stuebing, 2007).

MATERIAL AND RESULTS

On 25 April 2005 at 22:50, a juvenile specimen (SVL = 35 mm, tail = 55 mm) (FMNH 269005) was found at the base of the limestone outcrop Batu Lebik at Bukit Sarang (2°39′11.5″ N 113°3′54″ E), south of Bintulu, Sarawak. It was sleeping with the head pointing upward, and perched on the tip of a thin, dead vine ~3.6 m above ground. The capture location was not closely associated with any stream or standing water. The specimen was brought to the camp and kept in a cage for 1.5 days before it was preserved. While sleeping and/or undisturbed, the color was a dull olive green with brown diagonal markings. When stressed by handling the olive parts turned dull brown. During the time in captivity it

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Fig. 1. Detail of fetuses just dissected out of FMNH 269004.

was seen eating a small, green insect larva. When disturbed, it waggled back and forth along its longitudinal axis, similar to the locomotion typical of chameleons. It was not able to run very fast but made short leaps between twigs. Although rather stiff to the touch, the tail curled into a loose upward loop when the lizard was prodded on the nose [for a photo, see Manthey (2010)], similar to some *Phrynocephalus* species. Due to its stout horn-like rostral appendage (though short, since it was a juvenile specimen) we assume it to be a male.

Another specimen (FMNH 269004) was found at 23:50 on 11 May 2005, some 5 m from standing water at the base of the limestone outcrop Batu Anyi, a few hundred meters from where the above mentioned juvenile was collected. It was a gravid female (SVL = 59 mm, tail = 100 mm). It has a group of pointed, erected scales above the rostral. Protruding from the center of these scales is a single flagellum-like scale [see photo in Manthey (2010)]. This scale is considerably shorter than that of the male *thescelorhinos* holotype. The specimen was drab brownish with diagonal rows of small dark spots when found sleeping, hanging at the tip of a thin vine, 2.1 m above ground, head facing up. The color did not change notably before it was euthanized the following day. Like the juvenile male, the tail had some muscular control but was not used as a "fifth limb." Also this specimen showed a waggling locomotion when disturbed, and coiled the tail upwards in a loose spiral when prodded on the nose [see photo in Manthey (2010)]. After euthanizing the specimen for preservation, we dissected it in order to take data on clutch size. To our surprise, it did not contain eggs but two almost fully developed fetuses (FMNH 270651 and 270652). They were surrounded by a thin, transparent membrane, and a small amount of egg yolk remained to be absorbed before they were due. The fetuses were large in comparison to the female (SVL = 26 mm, tail = 43 mm; SVL = 26 mm, tail = 41 mm) (Figs. 1 and 2).

Fig. 2. Female FMNH 269004 with her two fetuses (and field tag).

Yet another adult female (SVL = 57 mm, damaged tail = 57 mm) (FMNH 269092) was collected on 8 October 2005 at 19:27 in the Tubau area (3°5′9.6″ N 103°37′44.4″ E). It was found sleeping 1.5 m above ground on a shrub, head facing up, one meter from a rocky stream. The secondary forest at the site constituted a 10 m wide river buffer in the planted forest zone. Like the above-mentioned female, it had a single, short, horn-like scale protruding from a group of erected and pointed scales on the snout. It showed a dull olive green coloration while at rest and appeared passive and non-aggressive during the day. Like the previous specimens we collected, its tail cured upwards in a loose spiral when the lizard was stressed. When dissected this female too was found to contain two fetuses close to full development.

We have examined the female holotype of *Hylagama borneensis* as well as the male holotype and female paratype of *Harpesaurus thescelorhinos* to compare them with the two female specimens collected by us. The only apparent difference between the four females is that both the *thescelorhinos* paratype and the *borneensis* holotype lack the pronounced rostral appendage seen in the two new specimens. Not only do the *thescelorhinos* paratype and *borneensis* holotype lack the single horn-like scale, but they also lack the group of pointed scales that form a raised hump, from which the horn protrudes. What Mertens (1924) referred to as a ~1.5 mm high "höcker" (hump) on the nose, consisting of numerous pointed scales, is not nearly as evident as the cluster of erected scales in the new females. The four females appear identical in other respects, e.g., the shape, size, and placement of cranial humps above and behind the eyes, and the tail tip being slightly curved up. We therefore consider them conspecific and the presence or absence of the rostral appendage in females a variable trait. Interestingly, the rostral horn in the male holotype of *thescelorhinos* is only half of the length depicted in the drawing by King (1978); when folded backwards it reaches only to the center of the eye. The group of

pointed scales at its base forms a somewhat larger hump than seen in the females we collected.

Mertens' (1924) holotype of *borneensis* contained two eggs. Today there is only the hard yolk of one half egg (without any shell), but it is not clear whether the eggs were at one time calcified or merely membrane-like. Given that the gravid females we collected were obviously about to give live birth, it is unclear from Mertens' description whether the reproductive mode differs between populations, or if the specimen he examined would have retained the eggs and eventually given live birth.

DISCUSSION

Live birth (ovoviviparity or viviparity) is generally a life history trait seen in reptiles of high latitudes or high altitudes (Shine, 1985, 1995), where females help incubating their clutch by optimizing their behavior. Also arid conditions may select for females to retain eggs for longer, the evolutionary end point of which is live birth (Andrews and Mathies, 2000). While live birth has evolved at least 100 times in squamate reptiles (Blackburn, 1999), there are to our knowledge only live bearing species in two agamid genera. Of the 40+ species of *Phrynocephalus* found across Asia, five Chinese species, found primarily in the Tibetan plateau at elevations >2200 m a.s.l., give live birth (Barabanov and Ananjeva, 2007). The other exception is *Cophotis ceylanica* of Sri Lanka. It lives in gardens and forests 1300 – 2200 m a.s.l., and gives live birth to 2 – 8 young (Manthey and Schuster, 1992; Manthey, personal observation).

The area in Sarawak from which most specimens of *H. borneensis* are known (we include the synonym *H. thescelorhinos* here) can be characterized as tropical evergreen lowland rain forest. Save from the two eggs noted by Mertens (1924) in the *H. borneensis* holotype, discussed above, there seems to be no information available on the reproductive strategies of any other *Harpesaurus* species. What might have caused this species to evolve towards live birth here in the equatorial lowlands — an area that never experiences cold temperatures and would thus seem optimal for oviparity? Our hypothesis is as follows.

The Bukit Sarang area is, like much of the lowlands of Sarawak, periodically subjected to heavy rain. As a consequence, the water level in the headwaters of a stream emerging at Bukit Sarang can differ more than two meters over a period of a few days (personal observation). Swiftlet nest collectors working at the site make daily records on precipitation, and claim that the rainfall is rather unpredictable with regards to season. After heavy and prolonged rain, much of the forest surrounding the limestone hills is flooded with more than a foot of water. It may then take days or more for the water to recede.

Most agamids, including highly arboreal species such as *Draco* spp., lay their eggs in the soil of the forest floor. It is likely that any eggs deposited in the ground perish when the forest floor is flooded for several days. Still, there are agamids in the area that — at least normally — lay their eggs in the ground. Many of them, such as *Bronchocela cristatella* and *Gonocephalus bornensis*, are common and widespread across the region. In such species, gene flow is likely to prevent any major local adaptations such as a switch from oviparity to live birth [ovoviviparity or viviparity (cf. Storfer and Sih, 1998)]. This may particularly be so if intermediate stages between the two strategies, i.e., oviposition at a late embryonic stage, lead to reduced offspring fitness (Shine and Thompson, 2006; see also Andrews and Mathies, 2000).

While the scarcity of records means that there is very little distributional information available for any *Harpesaurus* species, it seems as if *H. borneensis* is distributed primarily in the lowlands of north-central Sarawak [see King (1978) and our data; locality for Mertens (1924) is stated as "Central-Borneo" and thus unclear]. Posit that historically, the core of its distribution has been within low-lying areas prone to flooding, similar to Bukit Sarang. If so, there may have been a rather uniform selection pressure for live birth throughout much of its range, with little or no gene flow from more well drained regions where oviparity might otherwise be the optimal strategy. Alternatively, if they have had a wider but patchy distribution, the reproductive mode may differ between populations. Such inter-population variation is known for a few lizards (Qualls et al., 1996; Smith and Shine, 1997; Odierna et al., 2001). [We notice here that while the Tubau specimen (FMNH 269092) was collected at an altitude of ~30 m a.s.l., this area is well drained and most of the surrounding areas are within 200 – 300 m a.s.l.] We therefore suggest that (local) adaptation to unpredictable floods is what may have caused a lizard from this equatorial lowland site to evolve towards viviparity, making it the first agamid in South-East Asia known to give live birth.

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