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Predation on *Gonocephalus liogaster* (Günther, 1872) (Agamidae) by *Ptyas carinata* (Günther, 1858) (Colubridae) in Sarawak, Borneo

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Gonocephalus liogaster (Günther, 1872) is a large, forest-dwelling lizard, inhabiting lowland rainforests and peat swamp forests of Sundaland (Das, 2006). They are often found perching on tree trunks during the day and sleep clinging onto slender tree branches, their heads directed towards the trunk at night. This sleeping behaviour is commonly seen in many arboreal lizards to enhance detecting and subsequently avoiding nocturnal predators (Mohanty et al., 2016). Despite these strategies, lizards are often mentioned as prey of snakes. Within the genus, *G. chamaeleontinus* (Laurenti, 1768) has been reported as prey of the cat snake, *Boiga drapiezii* (Boie, 1827) (Cegalerba and Szwemberg, n.d.) in Sumatra, Indonesia.

The keeled rat snake, *Ptyas carinata* (Günther, 1858) is one of the largest non-venomous snakes in Borneo, reaching a maximum length of 4 m. This agile, diurnal snake is mainly terrestrial, inhabiting lowland forests and plantations. Despite its wide distribution, it is uncommon on Borneo (Stuebing et al., 2014); they are known to feed on large frogs and small mammals, especially rats (David and Vogel, 1996; Konopik et al., 2014).

The following observations were made during a field study on the comparative ecology of lizards of the genus *Gonocephalus* at Kubah National Park, Sarawak, Borneo (Park Headquarters at 01.6124°N, 110.1966°E, WGS84, elevation 141 m), including *G. liogaster* (Fig. 1), *G. bornensis*, *G. doriae* and *G. grandis*. An adult female *G. liogaster* measuring 110 mm snout-vent-length (SVL) and 258 mm total length (TL), weighing 50 g, was fitted

Figure 1. An adult female *Gonocephalus liogaster* fitted with a radio transmitter (Holohil BD-2), at Kubah National Park, Sarawak. Photo by WJW.

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Figure 2. Microhabitats associated with radio signals related to predation on *Gonocephalus liogaster* by *Ptyas carinata* in Sarawak, Borneo. (A) Within the root mass of an uprooted tree, showing the caudal region of the snake; (B) Inside a rock fissure along a stream bank, also showing the caudal region of the snake; and (C) the excreted transmitter hanging on a vine associated with saplings. Photos by WJW.

with a temperature-sensitive radio transmitter (Holohil BD-2; weight 1.8 g, frequency 150.150). Visuals of the transmitter-bearing lizards were obtained starting on 18 October 2019. On 29 November 2019 at 10:46 h, radio signals from the transmitter associated with the lizard were picked up 87 m away (01.61128°N, 110.1952°E, elevation 117 m), northeast from the previous location, where it was found one-day prior. The signals originated from a root mass of an uprooted tree, ca. 3 m off the tarred Summit Trail, where an adult (ca. 2.5 m) *P. carinata* was observed (Fig. 2A). The species was identified by the distinct caudal pattern of pale spots and a reticulated pattern (Stuebing et al., 2014). The body of the snake was lodged deep within the root mass and it appeared undeterred by the disturbance associated with the discovery. On 2 December 2019, at 11:15 h, the radio signal was 109 m (01.61051°N, 110.1958°E, elevation 172 m), southeast from the previous location, and came from a deep fissure of a rocky stream bank (Fig. 2B), under dense undergrowth. In this instance, the snake was observed to move deeper within the rocks when disturbed. On 6 December 2020, at 10:33 h, radio signals were from a site 89 m (01.61128°N, 110.1961°E, elevation 159 m), north-northeast from the previous point. However, there were no visuals of the snake, and the transmitter was found hanging ca. 1.4 m above ground on a vine (Fig. 2C). The location had a thick layer of leaf litter with minimal undergrowth. The transmitter had traces of faeces stuck on the harness, further confirming that the *G. liogaster* suffered predation by *P. carinata* and the transmitter believed to be excreted by the snake. While the anterior harness,

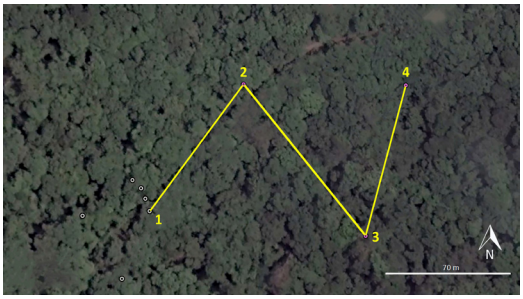

Figure 3. Significant encounter points of the incident involving predation by *Ptyas carinata* on *Gonocephalus liogaster* with a radio transmitter in Kubah National Park. Symbols: Points in white indicate localities associated with *G. liogaster* (21 October 2019–27 November 2019); points in pink indicate localities associated with *P. carinata* (29 November 2019–6 December 2019). Numbers indicate subsequent encounters in chronological order (from 1 to 4); yellow line represents minimum displacement between consecutive encounters. (base map from Google Earth 2020)

which was attached to the pelvic girdle of the lizard, was broken, the transmitter itself was not damaged during the passage through the gut of the snake.

Assuming that the observed *Ptyas carinata* preyed on the *Gonocephalus liogaster* after the first sighting of the snake (on 27 November 2019, 18:32 h) and defecated on the same day the transmitter was found, a maximum throughput period of ca. 8.5 can be assumed. The predator displaced 285 m during this period and the mean displacement per day was 33.53 m. The mean elevation of snake locations was 170.8 ± 9.0 m. The time elapsed from ingestion to defecation (gut passage time, PT) for this individual falls within the range of other terrestrial colubrid snakes, which typically varies from 3.5–11.6 days (Skoczylas, 1978; Lillywhite et al., 2002). Because the individual of *P. carinata* was estimated to be ca. 2.5 m in total length, and weigh ca. 3 kg, the *G. liogaster* would be consider an average-sized meal for the snake, considering past records of *P. carinata* feeding on large frogs and small mammals. PT values are generally influenced by many factors, including the texture and quality of food, meal size, feeding frequency, temperature, activity, gut morphology, as well as nutritional and physiological status of the animal (Lillywhite et al., 2002). However, since tracking was not conducted daily, the displacement and mean displacement per day may conceivably be underestimated, whereas the PT value may be overestimated.

These positional data may be the first to be recorded for this snake species, as no studies have been conducted on its movements, and add to the knowledge of its biology, including diet and microhabitat use, in addition to adding to the list of predators of *Gonocephalus*.

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