

Additional records of intrageneric predation and cannibalism in monitor lizards (Squamata: Varanidae)

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Monitor lizards (genus *Varanus*) are the only extant members of the Family Varanidae. They show a uniformity of structure and currently comprise 88 species (Uetz et al., 2024). They are generally large-bodied, vary in total adult body length from 21–321 cm (*V. sparnus* and *V. komodoensis*, respectively), and weigh 0.017–100 kg (Randow, 1932; King and Green, 1999; Dick and Clemente, 2016). Monitors are carnivorous scavengers and opportunistic predators that feed on annelids, insects, crustaceans, mammals (including even echidnas and bats), fish, reptiles, amphibians, and birds (Overton, 1987; Losos and Greene, 1988; Bennett, 1998; Pianka et al., 2004; Zdunek, 2023). There are field observations of cannibalism in several species, including *V. bengalensis* (Auffenberg, 1994; King and Green, 1999; Karunarathna et al., 2017; Sirimanna et al. 2020), *V. giganteus* (King et al., 1989), *V. gouldii* (Shine, 1986; Mitchell, 1986), *V. griseus* (Mitchell, 1986; Tsellarius and Tsellarius, 1997; King and Green, 1999), *V. komodoensis* (Auffenberg, 1981; Mitchell, 1986), *V. panoptes* (Rhind et al., 2013), *V. rosenbergi* (King and Green, 1979), *V. salvator* (Shine et al., 1996; scavenging – Amarasinghe et al., 2009; Uyeda et al., 2013; Karunarathna et al., 2015; cannibalistic oophagy – Gibbon et al., 2024), *V. timorensis* (Arida et al., 2023), and *V. tsukamotoi* (Vogt, 2010). Peters (1973) suggested that cannibalism in *V. storri* may explain the absence of juveniles. In monitor lizards from the Philippines, now called *V. marmoratus* after revisions in the taxonomy of the *V. salvator* complex, cannibalism is rather

uncommon (Gaulke, 1989; 1991; Welton et al., 2014). During observations in Natal, Africa, Charlton (1973) documented a case of cannibalism in *V. niloticus*, but only in captivity. Cannibalism has also been reported in captive *V. acanthurus*, *V. exanthematicus*, and *V. glebopalma* (Horn and Schürer, 1978; Bennett, 1998, 2000).

Cannibalism is the process of consuming part or the entire body of individuals of the same species at any stage of their life cycle (Elgar and Crespi, 1992). It is a common and widespread phenomenon among animals and plays an important role in the ecology and evolution of many species. For example, *V. komodoensis* and *V. doreanus* juveniles are arboreal, probably to avoid food competition and cannibalism by the adults (Auffenberg 1981; Pianka et al., 2004). The benefits of cannibalism are various and include additional nutrient intake, elimination of reproductive and resource-based competition, and/or control of territory (Polis, 1981). In Sri Lanka, Jolley and Meek (2007), reported aquatic territorial conflict/combat between two *V. s. salvator*. Violent confrontations between conspecific monitor lizards are rare outside the context of ritual combat or over resources, such as food and shelter (Horn et al., 1994; Tsellarius and Tsellarius, 1997). Here, we present a few rare observations of intrageneric predation in varanids along with several cases of cannibalism.

***Varanus salvator* vs. *V. bengalensis*.** On 21 October 2022 at 07:20 h, we observed an interaction between two monitors near a freshwater tank in Weerawila (6.2960°N, 81.2364°E, elevation 32 m) in the southern dry zone of Sri Lanka. At the time of the observation, we were approximately 20 m from the lizards during their interaction. The surrounding area was a suburban habitat, which included a fishing pier (Hambantota District), level ground (without rocks), short grass, and small bushes (ca. 30 cm high). Photographs were taken using a Nikon D4 camera with a 200–500 mm telephoto lens to not disturb the animals during the observation. The ambient temperature was approximately 32°C, the wind was moderate with a clear sky.

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We observed two monitors that came to eat fish that had been discarded by fishermen. There did not seem to be any competition for food at the time, although we noticed that the two lizards did keep a close watch on each other. They were identified as a Sri Lankan Water Monitor, *Varanus salvator salvator* Laurenti, 1768 (VSS), and a Bengal Monitor, *V. bengalensis* Daudin, 1802 (VB), based on the physical characters presented by Auliya and Koch (2020). The total length of the VSS was estimated at 200 cm, and the total length of the VB at 120 cm. Based on body and tail characteristics, both lizards were most likely males (Bennett, 1998).

When the lizards eventually faced each other (at approximately 07:45 h), they simultaneously stood on their hind legs and began wrestling. Neither used their tail in the altercation and each continually attempted to bite their opponent on the neck, forelegs, and head. Although the larger VSS initiated the confrontation, the smaller VB continued to fight. After combating for 2 min, both monitors fell to the ground and the VSS tried to flip the VB on its back. During this time, the VB did not attempt to escape but continued to engage in the confrontation. At approximately 08:00 h, the VSS held the VB firmly by the back of the neck (Fig. 1) and crept under a small bush. At this time, the VB's body was motionless, although its tail twitched a few times. The VSS continued its hold on the neck of the VB tightly for at least four more minutes. At this point, we could confirm that the VB was dead and the VSS began to slowly swallow the VB headfirst. At approximately 08:25 h, the VSS had completely swallowed the VB and moved to the freshwater tank. The entire event lasted nearly 40 min.

***Varanus salvator macromaculatus* vs. *Varanus nebulosus*.** On 2 February 2023, at 14:43 h in Kranji Coastal Nature Park in Singapore (1.4408°N, 103.7357°E, elevation 15 m), we came upon an attempted predation scene. A Southeast Asian Water Monitor, *Varanus salvator macromaculatus* (Deraniyagala, 1944), was observed shaking its head violently side-to-side under dry leaves. When it lifted its head, we observed another, smaller lizard in its mouth (Fig. 2A). Initially, we thought it was another *V. s. macromaculatus* and that this was an act of cannibalism, but upon closer inspection, the smaller monitor was identified as a Clouded Monitor, *Varanus nebulosus* (Gray, 1831; Fig. 2B). The *Varanus s. macromaculatus* was approximately 50–60 cm in total length (a subadult) and the *V. nebulosus* was approximately 15–20 cm long (possibly a recent hatchling). The entire observation had lasted nearly 5 min when the *V. s. macromaculatus* ran into the forest edge with its prey in its mouth. We lost track of both lizards in the forest and do not know what ultimately occurred after the initial observation.

Cannibalism in *Varanus salvator macromaculatus*. At 14:00 h on 11 March 2017, while walking through Sungei Buloh Wetland Reserve in Singapore (1.4449°N, 103.7243°E, elevation 7 m), we witnessed an act of cannibalism between two *V. s. macromaculatus*. The scene was accompanied by the sound of a struggle from the side of the path, where we observed a larger Water Monitor holding a conspecific in its jaws and shaking it violently (Fig. 3A). After several rounds of being shaken, the smaller individual stopped moving and appeared dead. The larger predator, alarmed by the presence of observers, snuck away with its prey some 20 m into the bush and swallowed it whole (Fig. 3B).

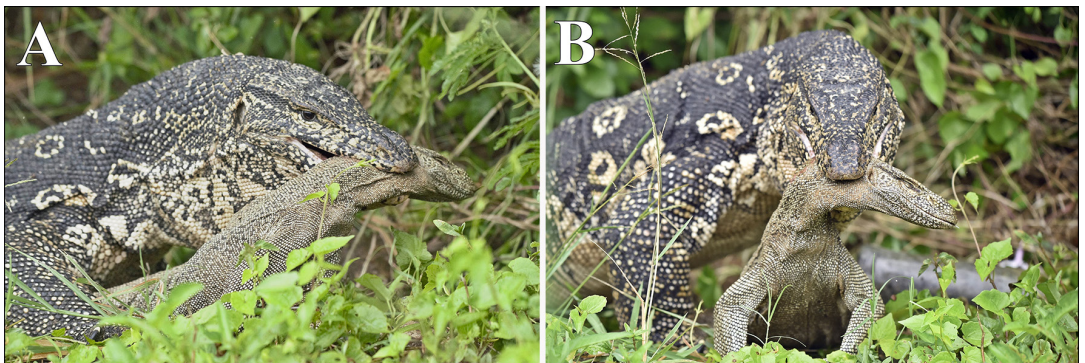


Figure 1. (A) *Varanus salvator salvator* grips *V. bengalensis* tightly by the neck, clenching its jaws. (B) The predator lifts the dead prey to swallow it. Photos by Geemal Harold.

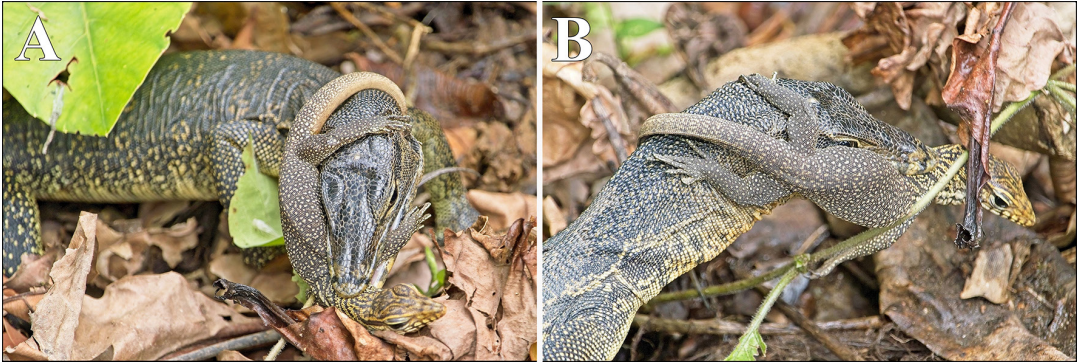


Figure 2. (A) *Varanus salvator macromaculatus* holds a juvenile *V. nebulosus* by the neck. (B) The juvenile *V. nebulosus* was identified by its characteristic dorsal pattern and the position of its nostrils. Photos by Max U.



Figure 3. An adult *Varanus salvator macromaculatus* grasps a conspecific's neck, lifts it off the ground, and shakes it violently (A), then devours it whole (B). Photos by Daniel Wee.

Cannibalism in *Varanus salvator bivittatus*. On 7 October 2024 at 10:22 h at the entrance to a hotel in Jimbaran, southern Bali, Indonesia (8.7785°S, 115.1672°E), we came upon an attempted predation scene on a concrete bank next to a water reservoir. A subadult (approximately 40–50 cm in total length) Two-striped Water Monitor, *Varanus salvator bivittatus* (Kuhl, 1820), was observed with another smaller lizard in its mouth (Fig. 4A). It was another, juvenile specimen of *V. s. bivittatus* (approximately 15–20 cm in total length) trying to free itself from the jaws of the former. Attempts to bite the aggressor in its mouth were ineffective (Fig. 4B). The whole observation lasted < 5 min, when the larger individual, with its prey in its mouth, entered the water and drifted away.

Cannibalism in *Varanus gouldii*. On 25 March 2023 at 10:59 h in Kakadu National Park, Northern Territory, Australia (12.9635°S, 132.5362°E, elevation 16 m),

camera traps recorded a scene of cannibalism between two Sand Goannas, *Varanus gouldii* (Gray, 1838). For the safety of the camera traps, we do not provide the exact location of this observation. The smaller individual attempted to defend himself by climbing on the back of the larger one (Fig. 5A). However, the latter grabbed the neck of its prey (Fig. 5B), improved its grip, and shook it vigorously (Fig. 5C). As a result, it swallowed the smaller individual whole (Fig. 5D). The recorded event lasted 15 min. This type of behaviour was previously documented in the Northern Territory by Shine (1986) via the stomach contents of the of another specimen, by John Fowler in the form of opportunistic scavenging in the 1990s (Fig. 6), and by Godwin et al. (2020) in a road-killed adult with a freshly swallowed juvenile. Outside the Northern Territory, this type of behaviour was previously only observed in captivity, where an adult male attacked a juvenile and devoured it (Johnson, 1976).



Figure 4. (A) A subadult *Varanus salvator bivittatus* holds a juvenile conspecific at midbody, despite (B) the juvenile biting it. Photos by Eric Knight.



Figure 5. A sequence of images documenting an interaction of cannibalism between two Sand Goannas (*Varanus gouldii*). Photos by Dave Loewensteiner.



Figure 6. A Sand Goanna (*Varanus gouldii*), killed on the road while in the process of consuming a juvenile of its species on the Main Darwin Highway, Katherine, Northern Territory, Australia. December, circa 1995. Photo by John Flower.

Discussion

Documented observations of intrageneric predation in Varanidae are rare. Previous studies have included a juvenile road-killed *V. bengalensis* scavenged by a *V. s. salvator* (Karunaratna et al. 2017); an adult Yellow-spotted Monitor, *V. panoptes* Storr, 1980, swallowing a *V. gouldii* whole (which was 11% of the predator's weight; Christian, 1995); an attempted predation of an adult Yellow Monitor, *V. flavescens* (Hardwicke & Gray, 1827), on a juvenile *V. bengalensis* (Chaudhuri and Chowdhury, 2018); the stomach contents of *V. giganteus* Gray, 1845 with half-digested *V. gouldii* (20% of the predator's overall body weight; Pianka, 1994); and a Line-tailed Pygmy Monitor, *V. caudolineatus* Boulenger, 1885 in the stomach contents of the Black-headed Monitor, *V. tristis* Schlegel, 1839 (Pianka, 1982). *Varanus gouldii* is known as a saurophagy specialist and has been reported to include *V. brevicauda* Boulenger, 1898, *V. caudolineatus*, and *V. gilleni* Lucas & Frost, 1895 in its diet (Pianka, 1994).

To the best of our knowledge, we present here the first documented direct observations of intrageneric

predation by an adult *V. s. salvator* on an adult *V. bengalensis* in Sri Lanka, and also attempted predation between *V. s. macromaculatus* and *V. nebulosus*, as well as cannibalism of *V. s. macromaculatus* in Singapore and *V. s. bivittatus* in Bali (Indonesia). The generalised diet of many monitor lizards, combined with their ability to swallow large prey, suggests that intrageneric predation and cannibalism may be more widespread than currently believed. Observations presented here have in common the predation technique and the fact that the prey is swallowed whole, in a very short time, similar to how *V. komodoensis* swallows large prey (D'Amore et al., 2011). In the case of robust prey, monitor lizards will violently shake the prey until it shows no signs of life (Loop, 1974), and the prey can then be swallowed without risk of injury. This type of large prey provides a high-energy food source, but this strategy comes with the risk of significant energy expenditure due to possible hunting failure (Green et al., 1991; Zdunek and Sullivan, 2023). Observations such as these, even as single events, broaden the scope of information about the natural history and ecology of monitor lizards and their predators and diet.

Interesting additional information is that the villagers around the Weerawila area in Sri Lanka believe that *V. s. salvator* and *V. bengalensis* attempt to mate, not fight. They consider the fighting behaviour as courtship and said that they have observed similar situations previously. In their opinion, this coupling creates new poisonous animals, and the villagers believe the meat of monitor lizards is unfit to eat. As a result, the local people do not kill or hunt them, which is beneficial for monitor lizards in this part of Sri Lanka.

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