The Herpetological Bulletin 168, 2024: 8–11
SHORT NOTE
https://doi.org/10.33256/hb168.811

Active forest nesting site, mating and cannibalistic oophagy behaviour in the Asian water monitor *Varanus salvator*

JACK HENRY GIBBON[1*], JIAZHEN LIM[2], MACARENA GONZÁLEZ-ABARZÚA[2], PABLO OROZCO-TER WENGEL[3], TOMMY TSAN-YUK LAM[2] & BENOIT GOOSSENS[1,3,4]

[1]Danau Girang Field Centre, c/o Sabah Wildlife Department, Wisma MUIS, Block B 5th Floor, 88100 Kota Kinabalu, Sabah, Malaysia
[2]State Key Laboratory of Emerging Infectious Diseases, School of Public Health, The University of Hong Kong, HongKong, China
[3]Organisms and Environment Division, Cardiff School of Biosciences, Cardiff University, Sir Martin Evans Building, Museum Avenue, Cardiff CF10 3AX, UK
[4]Sabah Wildlife Department, Wisma MUIS, Block B 5th Floor, 88100 Kota Kinabalu, Sabah, Malaysia

[*]Corresponding author e-mail: jackgibbon1109@gmail.com

INTRODUCTION

The Asian water monitor *Varanus salvator* is the second largest species of lizard (Briggs-Gonzalez et al., 2022), with a distribution encompassing most of south-east Asia. Unlike most varanids they are semi-aquatic, inhabiting the banks of streams, river deltas and coastal regions (Gleeson, 1981; Wikramanayake & Dryden, 1993; Guerrero-Sanchez, 2019). They are generalist carnivores, typically consuming the most abundant or accessible food source (Yu et al., 2022), taken as live prey (Gaulke 1991; Uyeda, 2009) or by opportunistic scavenging (Traeholt, 1994a; 1994b; Briggs-Gonzalez, 2022). Thus, their diet is highly varied, eating insects, spiders, myriapods, bony fish, crustaceans, gastropods, amphibians, reptiles and their eggs, birds and their eggs, mammals, fruit (Rashid, 2004; Rahman et al., 2017; Yu et al., 2022), rotten carcasses (Rahman et al., 2017), human food waste (Traeholt, 1993; Uyeda, 2009; Rusli et al., 2020), human corpses (Gunawardena, 2016), and even juveniles of their own species (Gaulke, 1991; Shine et al., 1996). Although common in anthropogenic landscapes, their wary behaviour around humans (Cota, 2011) has resulted in gaps in knowledge regarding vulnerable behaviours such as mating and nesting. Only two studies have described mating, and exclusively in urban landscapes (Cota, 2011; Trivalairat & Srikosamatara, 2022). Additionally, while burrows have an important role in the social life of most varanid species (Traeholt, 1995), only one active nesting site, dug into a termite mound in a sanctuary (Biswas & Kar, 1981), has ever been described in the literature. This report contains the first descriptions of an active nesting burrow and of mating behaviour in a natural setting, and also contains the first known instance of cannibalistic oophagy in *V. salvator*.

MATERIALS & METHODS

These observations originate from an unpublished study investigating the use of underground burrows and tree hollows in the life history of the Asian water monitor in the Lower Kinabatangan Wildlife Sanctuary (LKWS) in Sabah, Malaysian Borneo. This research was facilitated by a separate unpublished study, which established a network of video camera traps recording one-minute videos to monitor Sunda pangolins. The camera model used was a Recon Force Elite HP4 trail camera (Browning Arms Company), with passive infrared sensors (PIRs) measuring thermal contrast between the target and background to trigger automatically (Swann et al., 2011; Welbourne, 2014). A burrow of interest was discovered (5° 418'120" N, 118° 034'443" E) in an area of seasonally inundated secondary forest, within 20–25m of the Kinabatangan River (Fig. 1). The burrow was identified as a monitor lizard burrow through the placement of a camera trap. Two more cameras were placed outside the burrow on 29 March 2023, as the behaviour exhibited at this burrow was not comparable to that observed at any other site.

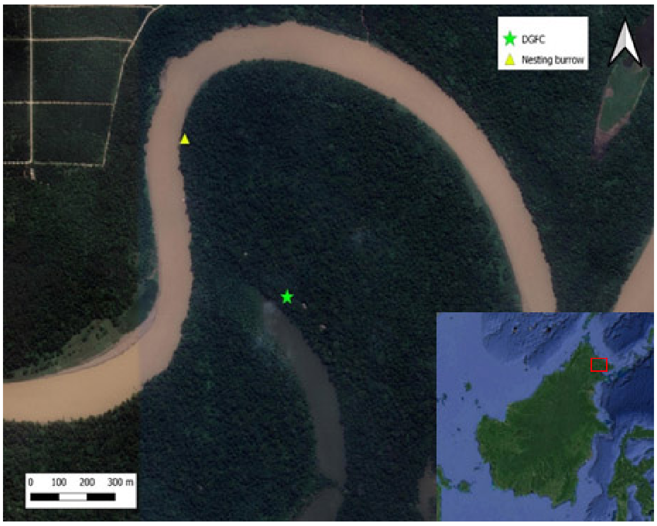

Figure 1. The location of the monitor lizard nesting burrow, close to the Danau Girang Field Centre (DGFC), the inset map shows the location of the study site within Borneo, Malaysia

OBSERVATIONS & DISCUSSION

Unusual behaviour was observed from 21–23 April 2023, when a monitor lizard filled in the burrow entirely (see Fig. 2) by scraping soil into the hole with its front legs; as

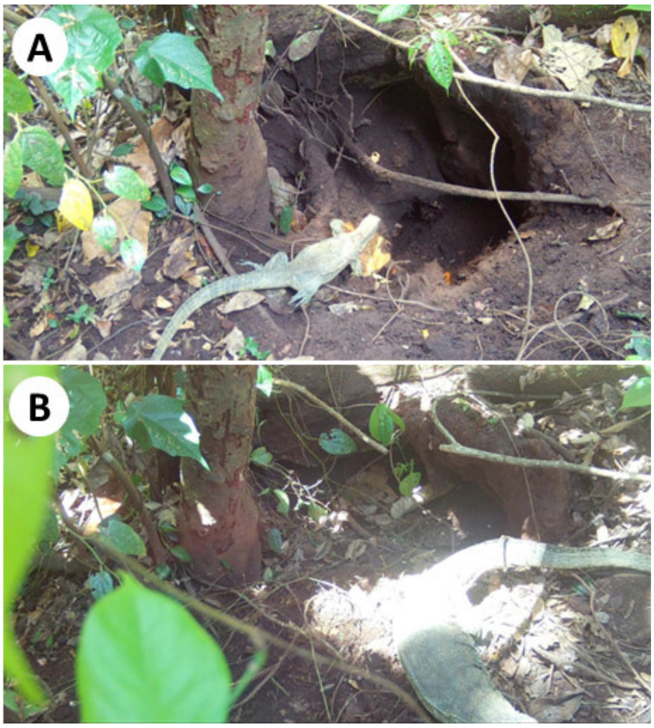

Figure 2. Camera trap images of *Varanus salvator* and its burrow- **A.** 21 April 2023 at about 11:00 h showing the monitor lizard burrow just before it was filled in. The exact time cannot be given due to a camera malfunction, **B.** 23 April 2023 from 12:45 h showing the burrow after it was filled in by a monitor lizard.

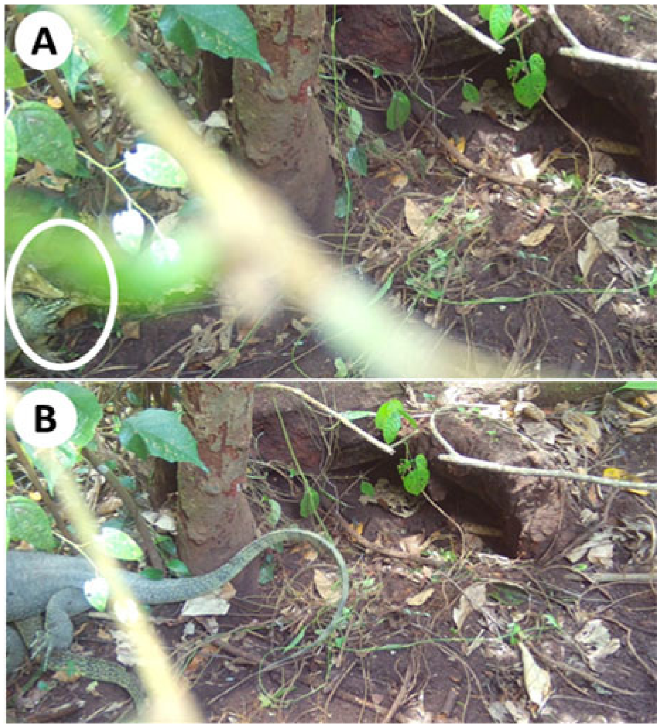

Figure 3. Camera trap images of the mating behaviour of *Varanus salvator* - **A.** 23 April 2023 from 19:16 h showing the male biting onto the neck of the female in a mating display (circled), **B.** Another image from shortly afterwards showing the male mounting the female.

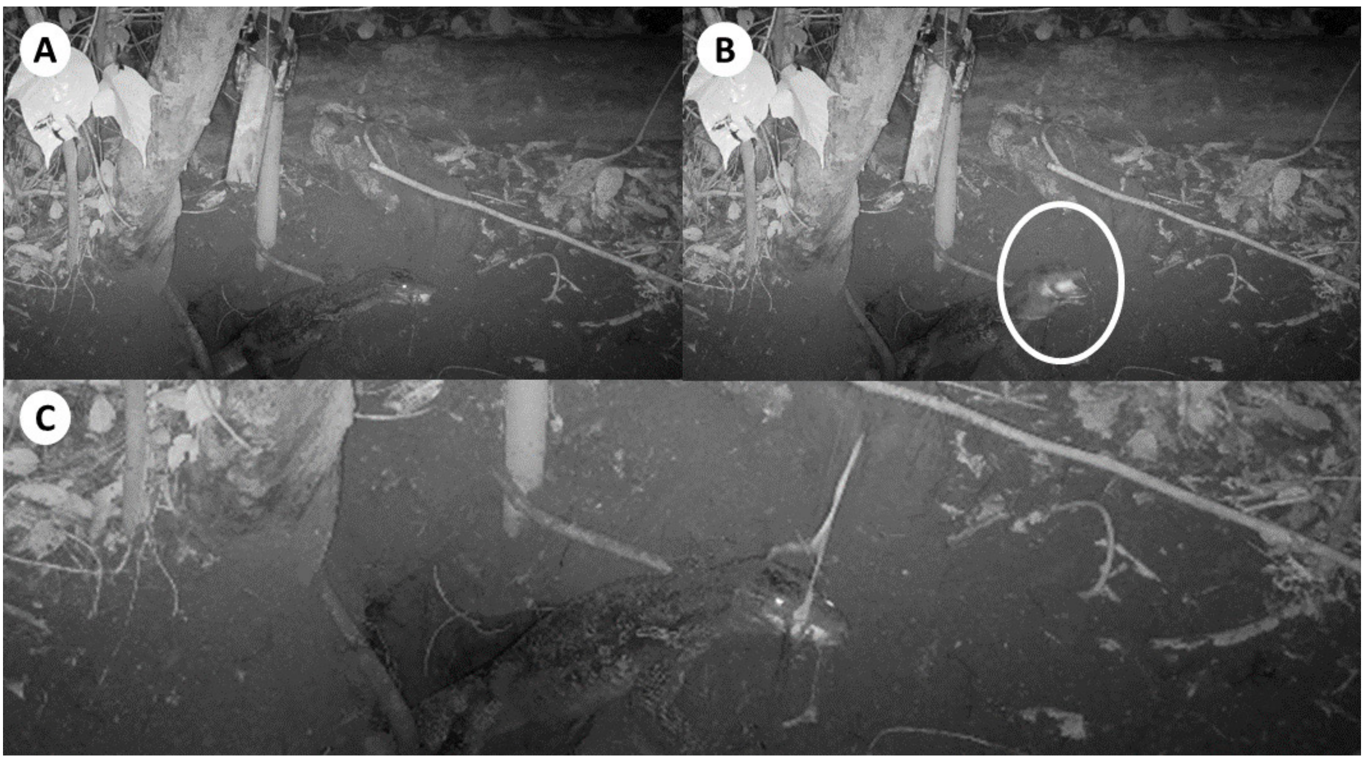

Figure 4. A series of still images taken on 30 June 2023 from 20:29 h showing a monitor lizard raiding the burrow - **A.** The monitor lizard carrying an egg out of the burrow, **B.** the monitor lizard swallowing an egg by holding its head upwards and stretching and nodding the neck (circled), **C.** the monitor lizard biting an egg and popping the yolk out of the shell.

revealed later this was associated with egg laying but egg-laying was not caught on camera. Over the following week what appeared to be the same individual, based on size and behaviour, returned to the burrow multiple times each day. This is challenging to confirm, as in this species identification of individuals in images captured by camera traps is often not possible. This lizard exhibited frequent alert behaviours, including standing still and raising the head and neck to increase perception, likely the nest guarding behaviour previously reported in *V. salvator* (Anonymous, 1978; Biswas & Kar, 1981; Somma, 2003). Scraping of the head and neck on nearby trees and logs was also a frequent behaviour, though this was not unique to this burrow. Furthermore, during this period there was an incident of mating (Fig. 3) that appears to involve the same individual. This coincided with the first heavy rains of the hot season, which may trigger hormonal changes in both males and females (Cota, 2011), yet it is unclear why mating behaviour occurred so soon after egg laying. We suggest that this may be nest guarding behaviour, with the female mating with the male as a distraction to prevent it from cannibalising the nest. The presence of eggs was confirmed on 30 June 2023 at approximately 20:30 h, when a monitor lizard raided the nest and consumed at least one egg (Fig. 4); the total clutch size is unknown. Oophagy has been shown to be a common feeding strategy in *V. salvator* (Cota, 2011), with the eggs of snakes, crocodiles, turtles, lizards and birds constituting between 5% (Rahman et al., 2017) and 37% (Rusli et al., 2020) of their diet. Cannibalism is seen less frequently, with some unpublished records of large adults eating smaller *V. salvator* adults (Gaulke, 1991; Shine et al., 1996) and no observed instances of cannibalistic oophagy.

Camera trapping has not been widely adopted for use on reptiles, with 3% of camera trapping studies targeting reptile species (Meek, 2015), although cameras have successfully recorded species over 100 g (Welbourne, 2014), including the Asian water monitor (Naim et al., 2012). Cameras enable the gathering of long-term, high-resolution datasets, something unprecedented in reptile ecology (Richardson et al., 2018). This is particularly true for vulnerable behaviours such as mating and nesting, as active searches do not facilitate observation of natural behaviour. However, there are drawbacks, for instance the inability to mark individuals, making it unclear whether behaviours are representative of the population or the result of individual specific variation. One solution may be to use software such as I3S (den Hartog & Reijns, 2008), which identifies intraspecific spot patterning on the dorsal surface to recognise individuals. I3S has been used in the sympatric lizard *V. giganteus* (Moore et al., 2020), though has not been trialled for the Asian water monitor. Additionally, the low body temperature of *V. salvator*, which stays close to ambient temperatures, results in a low gradient between the target and the background (Welbourne, 2014), meaning they are less likely to trigger cameras when passing through the detection zone (Rovero et al., 2010).

In conclusion, camera traps have enabled us to observe vulnerable behaviour in natural habitat, something not possible with other techniques. The findings shed light on underexplored behaviours in *V. salvator*, however definitive inferences cannot be made from a handful of observations, so it is clear that more long-term research is needed.

ACKNOWLEDGEMENTS

This research would not have been possible without the hard work of the research staff, field assistants and volunteers at Danau Girang Field Centre who assisted in searching for burrows and placing camera traps. This research was partly supported by Hong Kong University Grants Committee RGC's Collaborative Research Fund (C7144-20GF). Thanks also goes to R. Davies for his helpful advice proofreading this short communication.

REFERENCES

Anonymous. (1978). *Varanus salvator* breeding at Madras Snake Park. *Hamadryad* 3(2): 4.

Biswas, S. & Kar, S. (1981). Some observations on nesting habits and biology of *Varanus salvator* (Laurenti) of Bhitarkanika Sanctuary, Orissa. *The Journal of the Bombay Natural History Society* 78: 303–308.

Briggs-Gonzalez, V., Evans, P., Klovanish, C. & Mazzotti, F.J. (2022). A species bioprofile for the Asian water monitor (*Varanus salvator*). *Southeastern Naturalist* 21(3): 187–210. Doi: 10.1656/058.021.0302.

den Hartog, J. & Reijns, R. (2008). I3S Manta manual: interactive individual identification system - Classic version 4.0.2. http://reijns.com/wp-content/uploads/2020/01/I3S%20Classic.pdf. Accessed on 3 March 2023.

Gaulke, M. (1991). On the diet of the water monitor, *Varanus salvator*, in the Philippines. *Mertensiella* 2: 143–153.

Gleeson, T.T. (1981). Preferred body temperature, aerobic scope, and activity capacity in the monitor lizard, *Varanus salvator*. *Physiological Zoology* 54(4): 423–429. Doi: 10.1086/physzool.54.4.30155835.

Guerrero-Sanchez, S. (2019). Ecology and health of the Asian water monitor lizard (*Varanus salvator*) in the fragmented landscape of the Kinabatangan Floodplain, Sabah, Malaysia. PhD thesis. Cardiff University. 142 pages. Available at: https://orca.cardiff.ac.uk/id/eprint/126151/1/Guerrero-Sanchez_PhD_Thesis_FinalVersion.pdf. Accessed on 23 February 2023.

Gunawardena, S.A. (2016). Forensic significance of monitor lizard scavenging activity on human corpses. *Biawak* 10(2): 45–47.

Meek, P.D., Ballard, G. & Fleming, P.J.S. (2015). The pitfalls of wildlife camera trapping as a survey tool in Australia. *Australian Mammalogy* 37(1): 13–22. Doi: 10.1071/AM14023.

Moore, H.A., Champney, J.L., Dunlop, J.A., Valentine, L.E. & Nimmo, D.G. (2020). Spot on: using camera traps to individually monitor one of the world's largest lizards. *Wildlife Research* 47(4): 326–337. Doi: 10.1071/WR19159.

Naim, M., Advento, A.D., Sudharto, Ps, Jennings, A.P., Veron, G., Verwilghen, A. & Caliman, J. (2012). The presence and distribution of small carnivores in oil palm plantation and their role in controlling rat damage: preliminary results from a camera trapping study. 4th IOPRI-MPOB International Seminar: Existing and Emerging Pests and Diseases of Oil Palm. Bandung, Indonesia, 13–14 December. Advances in Research and Management. https://agritrop.cirad.fr/568280/1/document_568280.pdf. Accessed on 23 February 2023.

Rahman, K.M.M., Rakhimov, I.I. & Khan, M.M.H. (2017). Activity budgets and dietary investigations of *Varanus salvator* (Reptilia: Varanidae) in Karamjal ecotourism spot of Bangladesh Sundarbans mangrove forest. *Basic and Applied Herpetology* 31: 45–56. Doi: 10.11160/bah.79.

Rashid, S.M.A. (2004). Population ecology and management of water monitors, *Varanus salvator* (Laurenti, 1768) at Sungei Buloh Wetland Reserve, Singapore. https://repository.nie.edu.sg/handle/10497/1663. Accessed on 22 February 2023.

Rovero, F., Tobler, M. & Sanderson, J. (2010). Camera trapping for inventorying terrestrial vertebrates. In *Volume 8 – Manual on field recording techniques and protocols for all taxa biodiversity inventories*. 100–128 pp. Eymann, J., Degreef, J., Häuser, Samyn, Y. & Van den Speigel, D. (Eds.). Belgium: ABC Taxa.

Rusli, M.U., Chen, G., Booth, D. & Lei, J. (2020). Diet preference and activity of Asian water monitor at Chagar Hutang turtle sanctuary. *Journal of Sustainability Science and Management* 15(6): 61–67. Doi: 10.46754/jssm.2020.08.006.

Shine, R., Harlow, P.S. & Keogh, J.S. (1996). Commercial harvesting of giant lizards: the biology of water monitors *Varanus salvator* in southern Sumatra. *Biological Conservation* 77(2–3): 125–134.

Somma, L.A. (2003). Parental Behaviour in Lepidosaurian and Testudinian Reptiles: A Literature Survey. Malabar, USA: Krieger Publishing Company. 174 pp.

Swann, D.E., Kawanishi, K. & Palmer, J. (2011). Evaluating types and features of camera traps in ecological studies: a guide for researchers. In *Camera traps in animal ecology: methods and analyses*. 27–433 pp. O'Connell, A.F., Nichols, J.D. & Karanth, K.U. (Eds.). Tokyo, Japan: Springer.

Traeholt, C. (1993). Notes of the feeding behaviour of the water monitor, *Varanus salvator*. *Malayan Nature Journal* 46: 229–241.

Traeholt, C. (1994a). Notes on the water monitor (*Varanus salvator*) as a scavenger. *Malayan Nature Journal* 47: 345–353.

Traeholt, C. (1994b). The food and feeding behaviour of the water monitor lizard, *Varanus salvator*, in Malaysia. *Malayan Nature Journal* 47: 331–343.

Traeholt, C. (1995). Notes on the burrows of the water monitor lizard, *Varanus salvator*. *Malayan Nature Journal* 49: 103–112.

Uyeda, L. (2009). Garbage appeal: relative abundance of water monitor lizards (*Varanus salvator*) correlates with the presence of human food leftovers on Tinjil Island, Indonesia. *Biawak* 3(1): 9–17.

Welbourne, D. (2014). Using camera traps to survey diurnal terrestrial reptiles: a proof of concept. In *Camera trapping – wildlife management and research*. 225–232 pp. Meek, P., Fleming, P., Ballard, G., Banks, P., Claridge, A., Sanderson, J. & Swann, D. (Eds.). Victoria, Australia: CSIRO Publishing.

Wikramanayake, E.D. & Dryden, G.L. (1993). Thermal ecology of habitat and microhabitat use by sympatric *Varanus bengalensis* and *V. salvator* in Sri Lanka. *Copeia* 193: 709–714.

Yu, X., Zanudin, A.B.T.M., Rusli, M.U., Booth, D.T. & Lei, J. (2022). Diet reflects opportunistic feeding habit of the Asian water monitor (*Varanus salvator*). *Animal Biology* 72(1): 27–37. Doi: 10.1163/15707563-bja10065.

Accepted: 18 December 2023