

# BIAWAK

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# On the Cover: *Varanus dumerilii*

The captive-bred *Varanus dumerilii* depicted on the cover and inset of this issue were hatched on 12 June 2014 in the collection of Ben Aller (USA). Five live offspring from an original clutch of 10 eggs emerged after 163 days of incubation; two eggs from the clutch proved to be non-viable, and three contained dead, fully-developed embryos. The offspring resulting from this breeding represent a fifth generation of captive-bred *V. dumerilii*, and the twenty second clutch of *V. dumerilii* eggs hatched by Ben Aller to date. Photographs courtesy of **Chad Lane**.









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# BIAWAK

*Journal of Varanid Biology and Husbandry*

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**INTERNATIONAL VARANID INTEREST GROUP**  
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The International Varanid Interest Group is a volunteer-based organization established to advance varanid research, conservation, and husbandry, and to promote scientific literacy among varanid enthusiasts. Membership to the IVIG is free, and open to anyone with an interest in monitor lizards and the advancement of varanid research. Membership includes subscription to *Biawak*, an international research journal of varanid biology and husbandry, and is available online through the IVIG website.

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Captive-bred *Varanus griseus griseus* hatching in Denmark, 2010. Photographed by **Kenneth Jensen**.

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# ORGANIZATIONAL NEWS

## IVIG Steadily Continues to Grow and Diversify

The International Varanid Interest Group has seen continued increases in both its membership and the international breadth of its distribution. The period between June 2013 and May 2014 saw the addition of 101 new members, bringing IVIG membership to a total of 917 individuals from 54 countries (Fig. 1). New member countries include the United Arab Emirates, Lithuania, and Argentina.

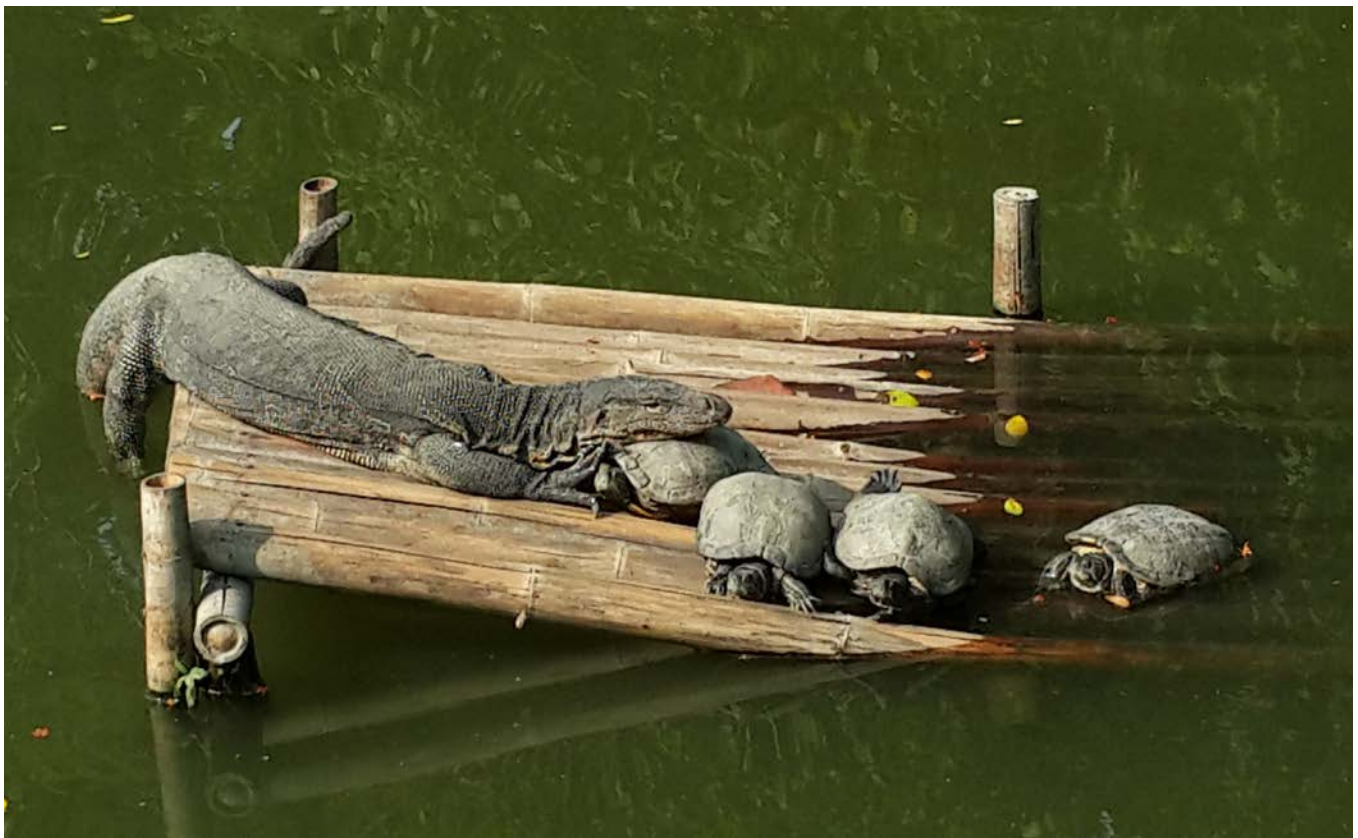
Now in its eighth year of publication, *Biawak* will continue to be released biannually, with new issues appearing in June and December of each year.

In addition to the informational resources available through the IVIG's website, <http://varanidae.org>, a discussion group entitled "*Biawak* - Quarterly



Fig. 1. Global distribution of IVIG membership.

*Journal of Varanid Biology and Husbandry*" has been established on the social networking website Facebook.com to further promote the exchange of ideas, news, and information relating to the biology and husbandry of varanid lizards. All IVIG members are encouraged to join and participate.



*Varanus salvator macromaculatus*. Dusit Zoo, Bangkok, Thailand. Photographed by **Barrett Agent**.



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# NEWS NOTES

## Man Sentenced for Killing Monitor

A magistrate in the city of Bicholim, North Goa District has sentenced a man to six months of prison for killing a protected monitor (*Varanus* sp., presumably *V. bengalensis*) and possessing two others. The man was charged with injuring a Schedule I protected species under India's 1972 Wildlife Protection Act.

Source: *The Times of India*; 2 May 2014

## Ranger Injured by Komodo Dragon

A forest ranger on the island of Rinca was seriously injured from being bitten on his left leg by a Komodo dragon (*Varanus komodoensis*). The ranger, identified as 'Tarzan', was feeding deer in Jagawana Loh Baru Post on the southern portion of the island when the dragon,

described as a medium-sized male, grabbed his leg. After five minutes, the dragon released the ranger who had tried unsuccessfully to fend it off with a bucket. He was eventually taken to a hospital on Bali to treat his injuries, which included a severed vein and tendon. It was stated that the ranger had worked in the park for nearly three decades without incident.

Source: *Jakarta Globe*; 21 April 2014

## Desert Monitor Rediscovered in Southeastern Turkey

The desert monitor (*Varanus griseus*) has been rediscovered in Şanlıurfa Province in southeastern Turkey. The observation was made by the Harran University Scientific Research Commission and the Scientific and Technological Research Council of Turkey (TÜBİTAK) as part of a survey on the herptofauna of this region near the Syrian border. Previously, the species had not been observed in the region since 2002



*Varanus pilbarensis*. Port Hedland, WA. Photographed by **Jordan Vos**.

when the remains of one killed by local villagers were discovered.

*Source: Hurriyet Daily News; 19 May 2014*

## Sea Turtle Nests Protected From Monitors

Two environmental groups – WWF Australia and the Burnett Mary Regional Group – are installing predator exclusion devices to protect the nests of loggerhead turtles (*Caretta caretta*) from foraging monitor lizards along Wreck Rock Beach near Agnes Water, Queensland. The devices consist of metal grills which possess openings large enough for hatchling turtles to move through. Thirty of the cages will be installed to protect from predators, particularly monitors which are said to be responsible for up to 90% of nest mortality in the area.

*Source: Gladstone Observer; 22 January 2014*

## Deaths of Zoo Komodo Dragons Reported

The Akron Zoo (US) announced the death of one of its Komodo dragons (*Varanus komodoensis*), a male named

TNT. Officials stated that the animal had suffered from a chronic degenerative condition of the spine which has led to long-term digestive issues including GI shutdown. The dragon had hatched in 1998 at the Miami Metro Zoo. At the Gladys Porter Zoo (US), a fifteen year-old male dragon has also died. The dragon, named Jahat, had been showing continuing signs of advanced age, according to zoo officials. A preliminary necropsy pointed to heart failure as being the cause of death.

*Sources: Wkyc.com; 18 February 2014 (Akron); Brownsville Herald; 21 April 2014 (Gladys Porter)*

## Komodo Dragons Return to the Bronx Zoo

After an absence of a half century, Komodo dragons (*Varanus komodoensis*) are again on display at New York's Bronx Zoo (US). Three dragons born nearly four years ago at the Los Angeles Zoo (US) – two females and a male – mark the first time since 1959 that the zoo has exhibited the species. The dragons' new exhibit is part of a larger exhibit entitled "Amazing Monitor", which features several other monitor lizard species including the spiny-tailed monitor (*V. acanthurus*) and blue tree monitor (*V. macraei*).

*Source: New York Times; 23 May 2014*



*Varanus niloticus*. Queen Elizabeth National Park, Uganda. Photographed by **Michael Pitt**.



## Komodo Dragon on Display at Calgary Zoo

The Calgary Zoo (CA) has recently unveiled a new exhibit in its Eurasia section displaying a Komodo dragon (*Varanus komodoensis*). At 28 years in age, “Loka”, the oldest female dragon in captivity and the only dragon at the zoo, will soon be joined by four, six-month-old juveniles from the Colchester Zoo (UK), though displayed separately.

Source: CTVnews.ca; 29 May 2014

## New Species of Monitor Lizard Described

A new species of monitor lizard belonging to the *Varanus* subgenus *Odatia* has recently been described from the southern Pilbara region of Western Australia. The new rock-dwelling species, *Varanus hamersleyensis* is closely related to, but genetically distinct from *V. pilbarensis*, differing in dorsal coloration and pattern.

Source: Maryan, B., P.M. Oliver, A.J. Fitch & M. O’Connell. 2014. Molecular and morphological assessment of *Varanus pilbarensis* (Squamata: Varanidae), with a description of a new species from the southern Pilbara, Western Australia. *Zootaxa* 3768(2): 139-158.

## 400 Water Monitors Relocated from Samut Sakhon Province, Thailand

More than 400 *Varanus salvator macromaculatus* were captured and removed from Samut Sakhon Province, Thailand after local residents complained that the monitors were preying on fish, crabs, and shrimp on their farms. Officials from the Department of National Parks, Wildlife and Plant Conservation division removed animals from Yeesan, Praek Nam Daeng, Klong Khone and Bang Jakreng subdistricts, and, protected under the 1992 Wildlife Conservation and Protection Act, all

animals were relocated to Khao Son Wildlife Breeding Center in Jom Beung District, Ratchaburi Province.

Source: <http://bangkok.coconuts.co>; 29 May 2014

## Report from the Fifth Annual Meeting of the “AG Warane und Krustenechsen”

Komodo dragons and Gondwanaland were the highlights of the sixth annual meeting of the DGHT’s “AG Warane und Krustenechsen” (Monitor Lizard and *Heloderma* Working Group of the German Herpetological Society) which took place on 17-18 May 2014 at Leipzig Zoo in Eastern Germany. In addition to listening to some interesting talks about monitor lizards as usual, this year’s attendees of the meeting were given a special guided tour through the Leipzig Zoo’s new Gondwanaland exhibit (opened in 2011).

Day one began with a welcome address by Thomas Hörenberg (Stuttgart) and André Koch (Bonn), which were followed by some general remarks about news from the scientific community. The first talk by Markus Patschke (University of Bochum) detailed his Master’s project on the systematics and integrative taxonomy of the *V. timorensis* species group. In addition to discussing the phylogenetic relations of the different members, the underestimated diversity of these dwarf monitors was illustrated with numerous photographs from the wild. Next, André Koch (Zoological Research Museum



Meeting participants touring Gondwanaland.



Male *Varanus komodoensis* at Gondwanaland, Leipzig Zoo.



Female *V. komodoensis* at Gondwanaland, Leipzig Zoo.

Alexander Koenig, Bonn) introduced the results of Yannick Bucklitsch's Master's thesis about the scale microstructure of monitor lizards. This project included samples of 40 different species from all recognized subgenera. Beyond answering systematic questions, the microstructure of monitor skin can be used to help customs identify reptile leather products such as bags and watches. Before lunch, all participants met in front of the old Aquarium building for a group photo and tour. The historical building houses several amphibian and reptile species including two monitor lizard species, *V. jobiensis* and *V. prasinus*. Of particular interest, Leipzig Zoo was the first facility to successfully breed *V. jobiensis* in captivity.

After lunch, Leipzig Zoo's curator Fabian Schmidt shared his experiences with keeping Komodo dragons, starting with the planning of Gondwanaland, the

construction of the gigantic tropical hall and the importation of the dragons. Accompanied by many photographs of the dragons' 170 m<sup>2</sup> enclosure, Mr. Schmidt explained many aspects of *V. komodoensis* husbandry at Leipzig Zoo. In addition to proper climatic conditions, he noted the importance of correctly handling the large monitor lizards for security reasons. Mr. Schmidt's talk was followed by the general meeting of the working group's members, moderated by Thomas Hörenberg. Besides minor issues, the next meeting and its location were discussed, with members agreeing that annual meeting location should change since participants originate from all federal states of Germany.

After a coffee break, Tino Meyer (Altomünster) described his keeping experiences with *V. mertensi*, including details about the technical equipment and requirements of the large terrarium he constructed in the



Participants of the Fifth Annual Meeting of the "AG Warane und Kurstenechsen" at Leipzig Zoo.



cellar of his house. Attempts to maintain the *V. mertensi* with aquatic turtles were unsuccessful due to repeated disturbance by the monitors.

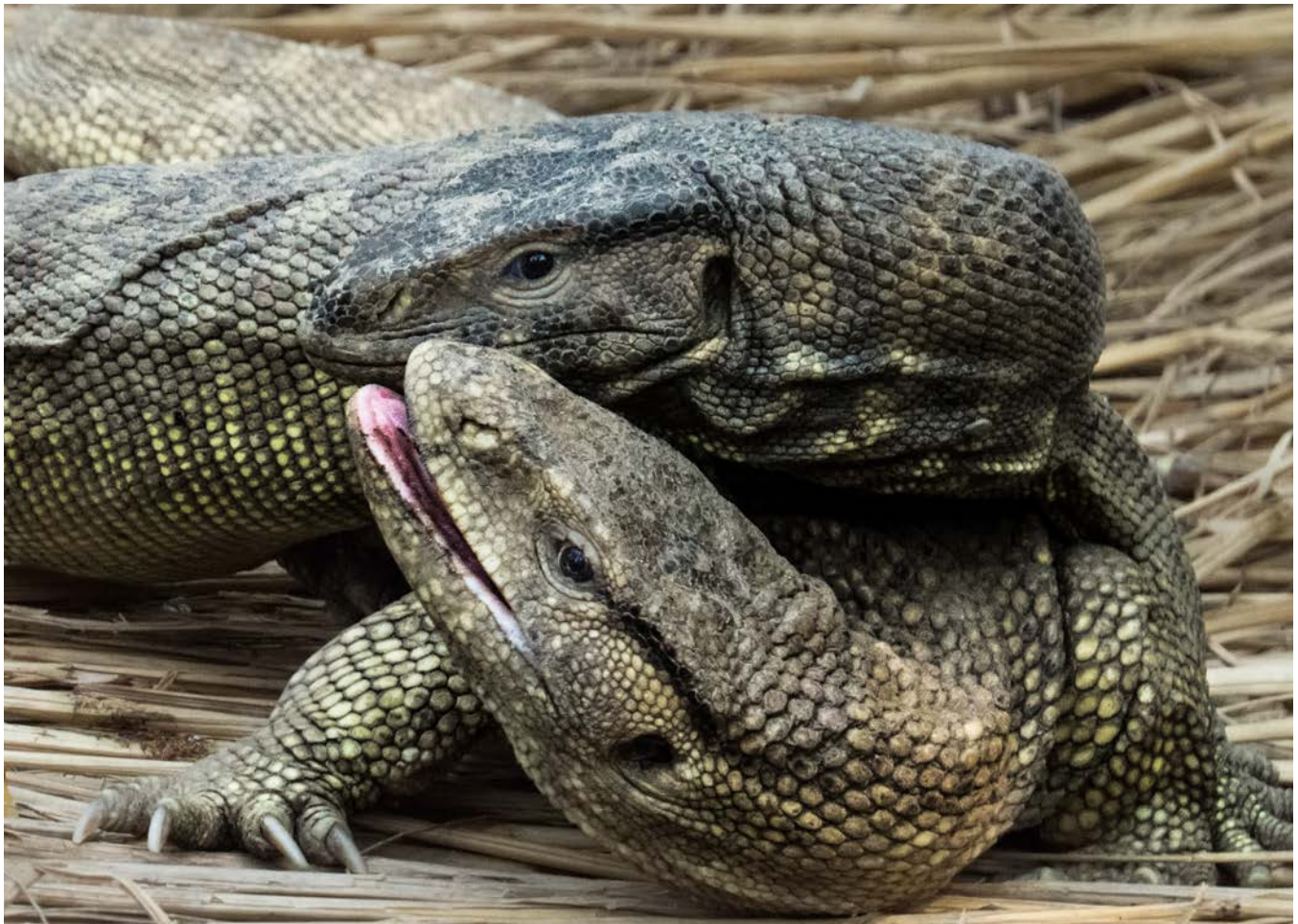
The final talk by André Koch (Museum Koenig) focused on the disputed new classification of monitor lizards proposed by Raymond Hoser, which caused much confusion due to the many new names which were erected unnecessarily and without providing any evidence. In addition, several other shortcomings of Hoser's publication were explained and discussed.

Day two of the meeting began at 0830 h. No talks were planned for the day; instead, the focus was a guided tour through the Gondwanaland exhibit hall at Leipzig Zoo. With its enormous size of about 17,000 m<sup>2</sup>, Gondwanaland dominates the urban image of the city. Under its roof, numerous animals from Asia, South America and Africa are displayed amongst scenery of tropical plants and rocks. At present, the male *V.*

*komodoensis* is housed individually in the spacious enclosure since both female specimens at the zoo are not yet large enough to withstand his approaches. Currently, Leipzig Zoo is the only German institution with Komodo dragons, with hopes that they will breed them in the future. Participants observed a feeding of the male dragon with a 4 kg meal. Afterwards, Gondwanaland was explored together with the curator who explained in detail many aspects of the exhibit.

The "AG Warane und Krustenechsen" donated some money for the Komodo dragons and thanks the Leipzig Zoo staff for their support and hospitality that resulted in a perfect meeting in a unique location. The advisory board would also like to thank all guest speakers and participants.

*Submitted by Thomas Hörenberg & André Koch*



*Varanus flavescens*. Madhyamgram, West Bengal, India. Photographed by **Rajarshi Dasgupta, Rajarshi Dasgupta Photography**.

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# ANNOUNCEMENT

## Interdisciplinary World Conference on Monitor Lizards 27-29 July 2015

**Suan Sunandha Palace Hotel  
Bangkok, Thailand**



**Hosted by the Faculty of Science and Technology  
Suan Sunandha Rajabhat University  
Dusit District, Bangkok, Thailand**



The interdisciplinary World Conference on Monitor Lizards will focus on the biology, ecology, natural history, and captive breeding of monitor lizards. Manuscripts and posters will be accepted starting in July 2014 and are to be submitted to: [monitor.conference.2015@gmail.com](mailto:monitor.conference.2015@gmail.com)

### **Optional Events Scheduled for 24, 26, 30-31 July 2015**

24 July	Day Trip to the Natural History Museum and National Science Museum, Thailand.
26 July	Day Trip to Dusit Zoo to see Bangkok's largest urban population of wild <i>Varanus salvator macromaculatus</i> .
30-31 July	2 day trip to Khao Yai National Park.

Conference Fee: Has not yet been determined, but will be cheaper than comparable international conferences. We are tentatively planning for a conference fee of \$200-\$250 USD. Included with the conference fee is conference attendance, lunch along with coffee breaks on the days of the conference and the welcome dinner on the first day of the conference. Also included with the conference fee is a copy of the conference proceedings to be published after the completion of the conference.

Optional events are extra and not included in the conference price. The price for these events is still being worked out at this time.

More specific information can be found in mid-July 2014 on the conference website which can be accessed through the following link: <http://www.sci.ssru.ac.th/>

Conference registration, submission of manuscripts and further inquiries can be sent to: [monitor.conference.2015@gmail.com](mailto:monitor.conference.2015@gmail.com), once the conference website is in operation. The amount of time per presentation given to participants will be dependent on the number of total presentations to be given. Special considerations for specific time allocation requests will be made on a case by case basis.

Accommodations will be available locally and this information will also be provided on the website. In mid-July, the website will offer a wealth of information about other accommodations and information about Bangkok.



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# ARTICLES

Biawak, 8(1), pp. 12-14

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## A Dubious Account of Breeding *Varanus olivaceus* in Captivity at the Paradise Reptile Zoo in Mindoro, Philippines

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**Abstract - *Varanus olivaceus* is one of the most valuable monitor lizards in wildlife trade and considered vulnerable throughout its range. A published report claiming “the world’s first successful breeding of *V. olivaceus*” is reviewed critically in the light of established facts about the reproduction of this species in captivity, and experience of the establishment in question in the year of the supposed breeding. Regulatory authorities and peer reviewers should require unambiguous proof of captive breeding success before accepting such claims in the future.**

*Varanus olivaceus* is a large, frugivorous monitor lizard endemic to Luzon and some smaller adjacent islands in the Philippines. Its current IUCN classification is “Vulnerable” (Sy *et al.* 2009). Accounts of captive breeding of this species in the literature are rare. A single egg hatched at the Dallas Zoo, USA in 1992, but the hatchling survived for only a few hours (Card 1994, 1995). Yuyek (2004a,b, 2012) produced two hatchlings at Ailon Zoo, Philippines in 2004, only one of which survived. Both accounts were accompanied by photographs of the neonates and the eggs they hatched from.

Lutz (2006) published a report claiming the “world’s first successful breeding” of *V. olivaceus*. According to his account eight eggs were produced by one pair of *V. olivaceus* 74 days after mating was observed in February 2005, of which four hatched after 194 days. He further stated that a different pair of *V. olivaceus* produced eggs in June 2005, three of which hatched after 137 days and five after 201 days. All eggs were incubated in a homemade incubator with the temperature varying between 27.5° and 34° C. Photographs of juvenile animals (but not hatchlings) were included in this report, together with a photo of an egg and another showing a dorsal view of what was claimed to be a gravid female.

On 10 June 2006, I visited Mario Lutz at the

Paradise Reptile Zoo (also known as the Zoological Institute of Herpaworld Inc.) in Mindoro, Philippines, at his invitation. During my visit I saw four juvenile *V. olivaceus*, each with estimated total lengths of about 40 cm (Figs. 1 & 2), but saw neither adult animals nor incubating eggs. Mario Lutz told me that his pair of adults had been killed earlier in the year during a typhoon, that there were no photographs of the eggs hatching, and that he had retained neither the corpses of the adults nor the eggs from which the juveniles had hatched. During my visit, Mario Lutz referred to only a single pair of *V. olivaceus* and the four juvenile animals which were present. Based on the dorsal head patterns of the juveniles and the kinked tail of one specimen, I believe these are the same animals that appear in Lutz’s (2006) report as Figure 8, captioned “The first four Butaan hatchlings”.

In September 2006, Mario Lutz exported 14 *V. olivaceus* from the Philippines to the United States. The relevant CITES documentation indicates that these animals were identified as captive-bred (CITES 2014). However, known incubation times for *V. olivaceus* eggs (with assisted hatching) range from 209 to 217 days (Card, 1994, 1995; Yuyek, 2004, 2012). Thus, even if Lutz had obtained a gravid adult female on the day after my visit, and that animal had produced eggs



Fig. 1. Three of four juvenile *Varanus olivaceus* photographed 10 June 2006 at Paradise Reptile Zoo, Mindoro.



Fig. 2. All four juvenile *V. olivaceus* photographed 10 June 2006 at Paradise Reptile Zoo, Mindoro.

immediately, it is inconceivable that the eggs could have hatched within three months, i.e., in time to be exported as juveniles in September 2006, even if his report of 137 days incubation was correct.

None of the evidence presented by Lutz (2006) can be considered incontrovertible. In particular, the lack of photographs of any eggs hatching or of neonatal animals is surprising, particularly in the age of digital cameras and considering the unique and unprecedented success reported in breeding a species that had previously proved almost impossible to reproduce in captivity. My

observations at the Paradise Reptile Zoo in 2006 lead me to the conclusion that Lutz's (2006) paper must be at least partially fabricated.

Government agencies in some countries will only issue documentation that allows legal export of animals for wildlife trade if those animals are bred in captivity (e.g., Siswomartono, 1998; Lyons & Natusch, 2011). Nijman & Shepherd (2009) carried out a review of breeding facilities of five species of reptiles in Indonesia, including two monitor lizards; *V. prasinus* and *V. timorensis*. They found that wild-caught animals were regularly misdeclared to circumvent Indonesian wildlife trade restrictions and exported as captive-bred. For both *Varanus* species, Nijman & Shepherd (2009) concluded that all specimens exported as captive-bred were in fact wild-caught.

Fabricated accounts of captive breeding in rare species are highly detrimental to genuine attempts at propagating the animals in captivity and to efforts to monitor and regulate the wildlife trade. Furthermore, they threaten to damage the reputations of individuals and institutions who buy the animals in good faith, believing them to be genuine captive-bred stock. Because the value of such animals is often extremely high in the international pet trade, there are very strong incentives for making false claims.

Few falsified reports of captive breeding in *Varanus* can be identified from the literature. The most obvious is a report by Zwineberg (1972) describing the breeding of *V. albigularis* which included a photograph of an animal which was clearly not a neonate "hatching" from a hard-shelled bird's egg (Kratzer 1973). Another account by Carlzen (1982) reported on a captive breeding of *V. prasinus* which Eidenmüller (1992) could not reconcile with his experiences of breeding the species. Eidenmüller (1992) suggested that the dates or



temperatures may have been recorded incorrectly, but no such excuse seems warranted in the present case involving *V. olivaceus*.

Many facets of the study of animal behaviour and ecology do not strictly qualify as science, because conditions in the field or in the terrarium are rarely reproducible. There is therefore an element of good faith required whenever such a study is considered for publication. However, editors and reviewers should treat unprecedented reports of captive breeding in highly valuable species with caution, and it does not seem unreasonable to require unambiguous evidence, such as photographs of eggs hatching or at least of juveniles of hatchling size with distinctive neonatal coloration, in such cases. Alternatively, molecular evidence that unambiguously links sibling animals with a parental individual would allay any doubts that the breeding success claimed was genuine.

**Acknowledgments** - Thanks to Theresa Rüger for translating parts of the original Sauria article, and to anonymous reviewers for improving the manuscript.

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# The Arboreal Foraging Behavior of the Frugivorous Monitor Lizard *Varanus olivaceus* on Polillo Island

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**Abstract** - Conjecture exists over the degree that arboreal frugivorous foraging is used by *Varanus olivaceus*. Here I present evidence from still camera traps, video camera traps, direct observations and spool and line tracking that indicate these monitor lizards take fruit directly from trees, rather than feeding exclusively on fallen fruit as suggested previously.

## Introduction

The butaan, *Varanus olivaceus*, is an obligately frugivorous monitor lizard restricted to Luzon, Polillo and Catenduanes islands in the northern Philippines. Its diet consists almost entirely of fruit and snails. In his seminal work on the species, Auffenberg (1988) stated that butaan fed exclusively on fallen fruit from the forest floor and rarely, if ever, took fruit from trees. However, a ten year study of the species on Polillo Island in Quezon Province found no evidence to support his assertion that the lizards typically forage on fallen fruit. Direct observations and evidence from camera traps and spool and line tracking indicated that the animals normally climbed fruiting trees of all species and picked fruit directly from branches or syncarps.

## Methods

All investigations were carried out in and around Sibulan Watershed Reserve, Polillo Island Quezon Province (14° 45' N; 121° 57' E) between July 1999 and May 2009. Habitat was primary and secondary lowland dipterocarp forest.

### *Spool and line tracking*

Twenty one butaan of between 1 and 9 kg were released at the point of capture (or best guess) with 1-6 cocoon bobbins of polyester thread (Danfields, Leigh, UK) tied in color-coded series and wrapped in plastic, attached to the proximal third of the tail with duct tape.

Each spool contained about 240 m of thread and weighed 5 g. Total weight of the devices was between 12 and 55 g. Threads were followed and characteristics of trees climbed (species, fruit absent/present) were noted.

### *Camera trapping*

Trailmaster 550 passive infrared camera traps (Goodman & Associates, Lenexa, Kansas) with Canon Sureshot A1 35 mm cameras (Canon Inc., Ota, Tokyo) and Trailmaster 770 passive infrared video traps with Sony camcorders were set at fruit-bearing trees of species known to be locally important in the diet of *V. olivaceus* (Bennett & Clements, this volume).

### *Direct observation*

Volunteers equipped with video cameras were positioned in camouflaged hides 4-8 m from fruiting *Pandanus*, *Canarium* and *Microcos* trees, usually from 0700 h until 1800 h. To reduce observer effects, individuals were deprived of mosquito repellent, food, cigarettes and music. All vertebrate visitors to the tree were recorded and filmed when possible. Footage obtained was examined and foraging behavior recorded.

## Results

None of the thread trails from spool and line tracking suggested that lizards had foraged for fallen fruit below the canopy, although fresh digging suggested the animals often stopped to root around in decayed wood,



Table 1. Arboreal foraging events recorded by different methods.

Species	Observations	Spool and line	Video camera traps
<i>Micrococos stylocarpa</i>	9	1	4
<i>Canarium</i> spp.	7	4	5
<i>Pinanga insignis</i>	0	3	0
<i>Ficus</i> sp.	0	1	0
<i>Gnetum gnemon</i>	0	2	0
<i>Pandanus</i> spp.	19	3	10

apparently searching for snails. Spool and line data from 12 individuals indicated that lizards climbed *Canarium*, *Pandanus*, *Pinanga*, *Microcos*, *Gnetum* and *Ficus* trees while they were in fruit (Table 1). In all cases the threads led to and from the trees in a more or less straight line.

Eighty four days of observations from hides between 2003 and 2009 recorded 35 visits by *V. olivaceus* to fruiting trees (Table 1 and Fig. 1). All lizards approached fruiting trees directly and climbed the trunk without foraging for fruit on the ground. During three of nine events at *Microcos* trees the lizards appeared to show interest in fallen fruit (stopped walking, flicked tongue at fallen fruit), but were not observed to eat any of it. In all events observed, lizards climbed the fruiting trees and picked fruit directly from peduncles or syncarps, often selecting fruit from more than one branch.

All 19 sequences from infra-red triggered video traps all indicated that lizards climbed trees to obtain fruit and appeared to ignore any fallen fruit below the canopy.

Seven hundred and twenty nine events from camera traps indicated that lizards climbed fruiting *Pandanus*, *Canarium* and *Microcos* trees and typically remained there for periods of 11 - 30 min depending on species. No lizard was recorded spending more than 111 minutes in a fruiting tree.

## Discussion

Auffenberg (1988) made the following remarks about the foraging habits of the butaan (page 207): “*In spite of the fact that V. olivaceus* claw marks are often found on the trunks of trees whose fruits they eat, the scratches are also found on many other species whose fruits they do not eat. I have never seen any individuals feed in the trees, nor have any hunters stated so with any degree of conviction. Though adults can and do climb out onto terminal branches of some tree species, other species have slender terminal branches that

are not capable of supporting them. The butaan is not morphologically or behaviorally adapted to feed effectively in terminal branches, in spite of the fact that some of its fruit species have remarkably robust terminal twigs. Almost all food selection takes place on the ground. The only regular exception is *Pandanus radicans*; its drupes are evidently picked individually from the syncarp (see chapter 11). All fruits growing in trees are selected after the fruit have fallen”.

That peduncles are rarely ingested along with fruit is supported by an examination of nearly 2000 fecal samples from *V. olivaceus* on Polillo Island (Bennett, 2008 and field notes), only one of which contained identifiable twigs (from a *Canarium* tree). That butaan take *Pandanus* drupes directly from the syncarp is confirmed by this study. My observations suggest that *Pandanus* drupes do not fall from syncarps until they are overripe, and that butaan often ignore the lowest drupes (which detach easily) in favor of perfectly ripe ones higher up the syncarp that require considerable force to remove.

Auffenberg (1988; Table 9-12) gave terminal twig diameters of trees whose fruits are regularly eaten by *V. olivaceus*. Of the species listed, *Microcos stylocarpa* (identified at *Grewia stylocarpa* in Auffenberg, 1988) has the slenderest terminal twigs (range 3-4.9 mm, mean 3.4 mm, SE 0.15). Footage obtained for a wildlife documentary at the Polillo study site in May 2005 (Mutual of Omaha's Wild Kingdom, 2006; Fig. 2) shows a butaan estimated at 5 kg picking fruit from the terminal branches at the top of a *Microcos* tree and indicates that Auffenberg underestimated the dexterity of the lizards in trees. It follows that if large butaan are able to forage in *Microcos* trees, there is no morphological or behavioral impediment to their feeding in any of the tree species whose fruits are commonly consumed.

Data from camera traps do not provide direct evidence of lizards picking fruit from trees (except for *Pandanus* spp.) because the cameras were trained on



Fig. 1. *Varanus olivaceus* eating fruit in *Canarium* tree – from video taken by **Alice Clarke**. Polillo, 27 April 2005.



Fig. 2. *Varanus olivaceus* feeding in *Microcos* tree – Polillo, May 2005. From video by **Simon Normanton/Steel Spyda**.

tree trunks whilst the fruit was in the canopy. However, it is difficult to interpret the multiple short visits to fruiting trees made by many different individuals in any context other than arboreal foraging behavior. In the case of video camera traps, footage shows butaan approaching *Canarium* trees without making any obvious deviations to look for fallen fruit.

In his discussion of fruit availability and foraging behavior, Auffenberg (1988) makes it clear that, with the exception of *Microcos*, the number of fallen fruits available to butaan from individual trees is very low. Thus, although a lizard that climbs a fruiting tree would usually have access to far more fruits than it could possibly consume at one time, an animal restricted to fallen fruit might have to forage under a number of trees to fill its stomach.

The descriptions of feeding behavior in *V. olivaceus* given by Auffenberg (1988) all appear to have been recorded from captive animals and it is not clear whether any free living animals were observed taking fruit from the ground during his study. Elsewhere in the book he states that plans to watch animals from hides were abandoned early in the project because dense vegetation made it impractical. The fact that arboreal foraging was not observed is therefore not a reliable indication that it did not occur.

No observations were made of butaan feeding at *Caryota* or *Livistona* trees. Scratches that looked like butaan claw marks were recorded on *Caryota* trees, but such marks on the trunks of fruiting trees are not a reliable indication of feeding activity of *V.*

*olivaceus* because the sympatric monitor lizard *V. marmoratus* often climbs the same trees (particularly *Pandanus* spp.) in search of animal prey between leaf axils. Local guides on Polillo were skeptical about the butaan's ability to climb *Livistona* trees, and the possibility that the animals are obliged to take these fruits from the forest floor cannot be discounted. Fruits of both *Caryota* and *Livistona* are rare in the diet of *V. olivaceus* on Polillo and were also rare in Auffenberg's (1988) sample (on Polillo 6.1% of 1604 fecal samples contained *Caryota* seeds and 4.7% contained *Livistona* seeds; Auffenberg reported finding *Caryota* in 4.3% and *Livistona* in 0.5% of his samples).

There is no obvious reason why butaan would take fallen fruit in preference to fruit that is still attached to the parent tree, unless they were unable to reach fruit in the canopy or lizards perceived the fruit-bearing canopy as dangerous. My experience with the lizard suggests that they spend as little time on the ground as possible. That they never overnight in fruiting trees is probably due to the fact that these trees provide neither suitable hollows nor dense thickets in which to shelter. That they apparently spend as little time as possible in fruiting trees before returning to larger trees that provide greater protection from predators, and that they appear to approach fruiting trees directly without searching for fallen fruit below the canopy makes it unlikely that they would preferentially take fruit from the ground. In contrast, snails are probably found and consumed on the forest floor rather than in trees (Fig. 3). Spool and line tracking of the large (mean mass 46.0 g,





Fig. 3. *Varanus olivaceus* with snail. Polillo, 5 September 2004 – from camera trap.

mean length 69 mm, N = 29) *Helicostyla* species most common in the diet of the butaan on Polillo suggests that the snails are largely terrestrial, rarely climbing higher than 3 m in trees (unpublished data). Spool and line tracking of lizards indicates that they often dig under roots and rotting wood in search of snails, and that the shells are crushed and discarded on the ground (unpublished field notes).

The present study suggests that Auffenberg's (1988) posit about the terrestrial feeding habits of *V. olivaceus* was probably in error. Although butaan of all sizes do forage on the ground for animal prey (almost exclusively snails and hermit crabs in the case of animals > 2kg) and may collect fallen fruit (especially *Microcos*) when there is none left in the parent tree, the present study indicates that the animals preferentially take fruit directly from the canopy, and that they are adept at doing so.

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# The Use of Passive Infrared Camera Trapping Systems in the Study of Frugivorous Monitor Lizards

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**Abstract:** The use of camera traps in a non intrusive study of the butaan (*Varanus olivaceus*) on Polillo Island is described. The use of camera traps in the study of living frugivorous monitor lizards is advantageous because the animals are highly susceptible to disturbance and spend very little time on the ground. However, the passive infrared system depends on the target animal being warmer than its surroundings, which cannot always be assumed. Furthermore commercial camera traps are designed to detect horizontal rather than vertical movement. Despite these limitations, camera trapping on tree trunks can provide very valuable information about individuals and populations which would be almost impossible to collect by other means.

## Introduction

Passive infrared triggered camera traps have been used in many studies of mammals (see Swann *et al.*, 2004; Trobler *et al.*, 2008 for reviews) and for some ground dwelling bird communities (Grassman *et al.*, 2006, Jayasilan & Davison, 2006), but few studies of reptiles have utilized the technique. Bennett & Hampson (2003) reported on a successful trial of camera traps used to detect the large monitor lizard *Varanus olivaceus* in the Philippines, and Ariefiandy *et al.* (2013) evaluated the efficiency of baited camera traps compared to cage traps for population monitoring of the much larger species *V. komodoensis* in the Sunda Islands.

This note reports on experiences with camera traps in the study of the butaan, *V. olivaceus*, a large (to at least 180 cm in total length, 9 kg), extremely shy, frugivorous monitor lizard restricted to lowland dipterocarp habitats, on Polillo Island, off the eastern coast of Luzon in Quezon Province, Philippines. This paper discusses the use of camera traps in the study of frugivorous lizards, highlights areas where they have been particularly

informative, identifies potential pitfalls of using the method, and suggests ways of improving the technique for future studies.

## Background

Frugivorous monitor lizards are highly arboreal and notoriously shy. Auffenberg (1988), who conducted a 22 month study of the butaan in southern Luzon, stated that it would be possible to remain in the animals' habitat for many years without being aware of its presence. He considered the animals impossible to observe in their natural habitat, and his methodology involved sacrificing 110 of 126 study animals. Given the apparent rarity and completely protected status of the lizard, no similar studies have been conducted. Preliminary studies using spool and line tracking to follow butaan on Polillo Island (Bennett, 2000; Bennett & Hampson, 2003), indicated that the lizards spent almost all their time in trees, descending only to travel to other trees in more or less straight lines, sometimes digging for snails under roots and debris while on the ground. However,



butaan released at the point of capture took longer to return to “normal” activities than other monitor lizard species that the researchers had experience with, and any human disturbance in an area appeared to result in a cessation of butaan activity. Subsequent experiences suggested that all butaan, but particularly large adult males, are extremely shy animals that halt activity for periods of hours up to three weeks when frightened by people. Consequently, only methodologies that did not disturb the animals were employed in subsequent studies. A three week pilot study in 2001 using passive infrared camera traps yielded the first ever photograph of a wild butaan (Bennett & Hampson, 2003), and consequently 35 mm film camera traps were employed in the study of the population between 2002 and 2007.

## Methods

### Camera-trapping

Only camera traps that utilized 35 mm film cameras were tested, because start-up time from standby for digital camera traps available at the time (2002-2003) were prohibitively slow. Four types of camera trap were evaluated of which only the Trailmaster 550 (Goodman & Associates, Lenexa, Kansas, USA) regularly captured images of lizards. The Trailmaster system had the advantages of a having a separate infrared monitor that could be positioned independently of the camera, the ability to position the camera in portrait orientation (thus

maximizing the area of tree trunk photographed) and a shorter minimum time between captures (6 seconds) than any of the other models available.

The study used Trailmaster 550 passive infrared trail monitors with Canon Sure Shot A-1 Water Resistant 35 mm cameras (Canon Inc., Ota, Toyko, JP), loaded with 36 exposure color print film with a 200-1600 ISO rating. The cameras had databacks that printed the date and time (in hours and minutes) on the negatives and a panoramic option that allowed more of the tree trunk to be included in the frame and backed the time stamp in black for easy visibility. Usually infrared monitors were used at the most sensitive setting ( $P = 2$ ,  $Pt = 10$ ) and with a six second delay between pictures ( $cd = 0.1$ , the minimum possible). Infrared monitors were trained on tree trunks, at a height of 1.5-2.5 m above the ground and a distance of 2-5 m. The width of the infrared beam was adjusted by covering part of the infrared lens with vertical strips of electrical tape and the monitors were angled to point downwards at approximately  $10^\circ$ . Where camera traps were on sloping ground (8 of 9 fruiting *Canarium* sp. were on slopes  $> 30^\circ$ ) the trap was set on the higher side of the slope (Fig. 1). Camera traps were checked several days after initial setup and weekly thereafter. Depending on lighting conditions and the speed of available films, camera flash was set to either off or on, but not on automatic. From 2002 until July 2004, camera traps were set to operate 24 hours a day. Because no lizards were photographed during the hours of darkness (but film was often consumed by

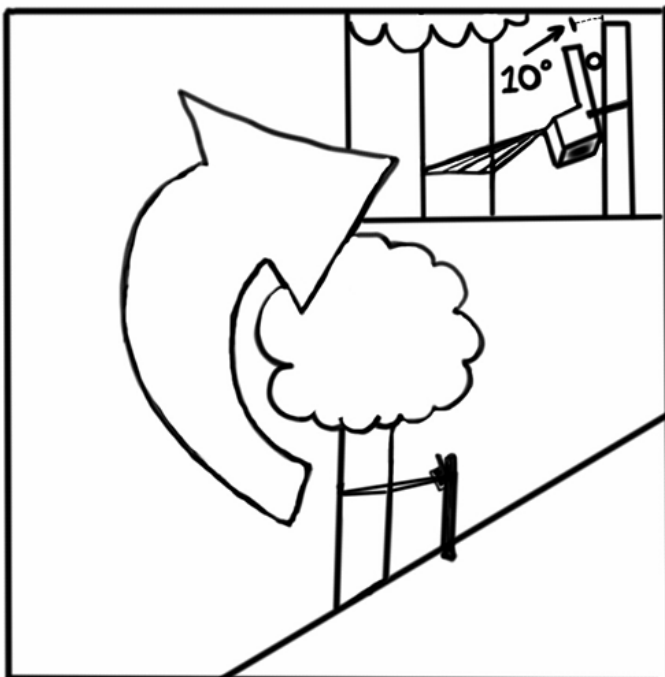


Fig. 1. Placement of infrared trail monitors at target trees. Drawing by **Sekki Tabasuares**.

mammalian activity) traps were set to operate between 0600 and 1845 h from August 2004. Exposed films were processed and uncut negatives scanned at maximum resolution with a Nikon 1500 scanner (Nikon, Tokyo, JP). For pictures with animals, the species, date, time and orientation on the tree trunk (usually ascending or descending) was recorded. Snout-vent lengths (SVL) of photographed butaan were estimated by comparing pictures to ones of the same trees with a 10 cm scale bar held against the trunk.

The number of traps in use varied throughout the study period. In 2002 four traps were used, six in 2004 and 22 in 2005. Thereafter, the number declined rapidly, until by June 2007 none remained functional.

Trees monitored on Polillo were classed as fruit-bearing trees suspected to be used as a food source by lizards, and other trees suspected to be used as overnight shelters. Fruiting trees were subcanopy species, 2-15 m high with trunk circumferences of 28-130 cm. For the purposes of this study screw palms (*Pandanus*) were classed as trees. Shelter trees tended to be larger canopy trees, 25 to more than 40 m in height with trunk circumferences of at least 1 m and often with thickets of epiphytes in the canopy.

Usually one camera trap was set per tree, on the side judged most likely to be climbed by lizards based on slope (see discussion) or claw scratches on trunks. Two camera traps were set on opposite sides of the trunks at two fruiting *Canarium* trees of approximately equal size for a period of 30 days between April and June 2004. One of the trees was on a typical slope (gradient ca. 35°) and one on flat ground.

Video camera traps comprised Trailmaster 770 PIR units attached to Sony video cameras (Sony, Tokyo) via L-Anc cables. Cameras were placed in watertight boxes with a glass window fixed with silicone glue to accommodate the lens. Video camera traps were used irregularly between 2002 and 2010 to target fruiting trees.

In order to quantify the efficiency of camera trapping on Polillo, fruiting trees monitored with camera traps were observed by volunteers from camouflaged hides at a distance of 4-8 m, between 0700 and 1800 h for a total of 33 days, with times of visits by lizards noted.

### *Terminology*

An event was classified as a single visit to a tree by one individual when one or more pictures showed the animal on the tree trunk. Complete events were sequences where pictures of the animal both ascending

and descending the trunk were recorded. Incomplete events were those where only the ascent or descent was recorded. Time series refers to a chronological (but not necessarily complete) series of pictures taken at the same tree over a single period.

### *Recognition of individuals*

For individual time series with more than a single event where pictures were of sufficient quality, attempts were made to distinguish individual lizards. Two people looked at image sets independently and where a consensus was reached the pictures were deemed to be of the same individual. Where identifications disagreed, both identifiers looked at the pictures together and attempts were made to reach agreement. Usually disputed images were deemed to be one of two similar individuals. No attempt was made to determine the sex of animals photographed, but based on Auffenberg's (1988) statement that female butaan do not exceed 5 kg, any animals deemed larger than this were presumed to be males.

### *Estimating sizes for individuals*

Size classes of tree visitors assumed the minimum number of individuals for each time series. The SVL of each individual from each time series was estimated by eye, based on all available measurements of that individual obtained by comparing pictures of lizards with those of the target tree with a scale ruler.

## **Results**

In total, 2,784 days of tree trunk camera trapping at 59 trees consumed 249 rolls of film and yielded 755 separate events involving *V. olivaceus* (total yield 0.27 events per trap day), 31 involving *V. marmoratus* and four involving *Sphenomorphus* skinks. Rats (see below), monkeys (2), birds (2), civets (2) and bats (1) were also recorded. Of 123 rolls of film that contained no images of lizards, 71 recorded irregular false events caused by motion in the environment, 32 failed because the cameras were triggered at regular intervals by malfunctions in the infrared monitors, 15 were repeatedly triggered by rats, three failed because film jammed and two were accidentally exposed to light and destroyed. Time series were often fragmented when cameras ran out of film earlier than expected, cables were damaged by rats, or units were incorrectly set. Approximately 200 days of camera trapping were lost because of damage to cables



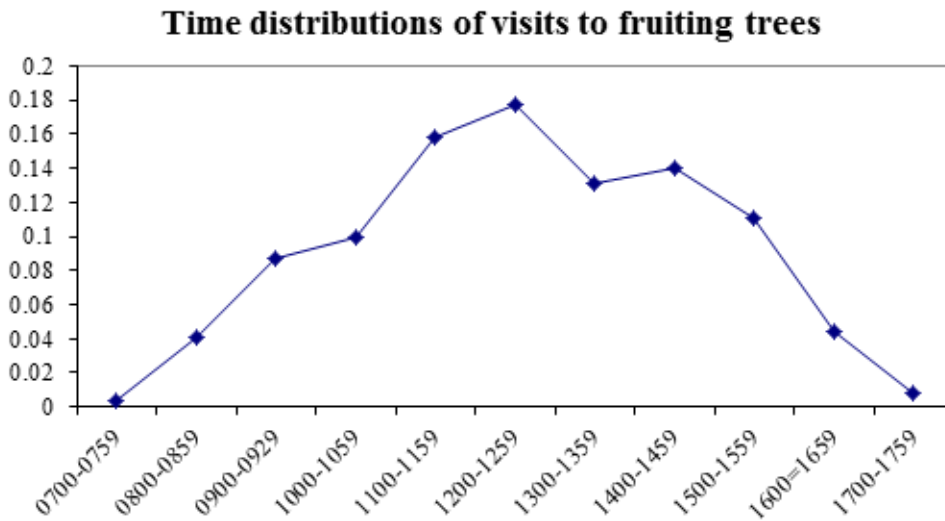


Fig. 2. Time of visits to fruiting trees by *Varanus olivaceus* (N = 656).

by *Rattus everetti*.

At shelter trees, a total of 644 days of camera trapping at six trees recorded 26 events involving *V. olivaceus* (0.04 events per day). Lizards were recorded at five of the six trees monitored. At the most regularly monitored shelter tree, 358 days of camera trapping over three years recorded eight events involving *V. olivaceus*. A ground level tree cavity that was monitored for 62 days between May and August 2005 was used by two *V. olivaceus*, one *V. marmoratus* and at least one *Sphenomorphus* skink. The only complete event recorded at a shelter tree with visible time stamps showed a lizard ascending a tree at 1507 h and descending at 0745 h the next morning.

At fruiting trees, 2,118 days of trapping recorded 329 complete events and 400 incomplete events (0.34 events per day). Of incomplete events, 99 were of lizards ascending and 301 of lizards descending trees.

In total, photographs from 656 visits by butaan to fruiting trees had legible stamps that enabled the time and date of the visit to be established. Of these 72% occurred between 1100 and 1559 h (range 0744 to 1703 h; Fig. 2). Butaan spent considerably longer in the larger *Canarium* tree species than the smaller *Pandanus* (Table 1). There was no apparent relationship between the size

of the animal and the time spent in *Canarium* sp. 2 trees (Fig. 3).

To evaluate differences in detection rates data from camera trapping, data from one species of tree (*Canarium* sp. 2) was considered, to remove major biases such as buttressed trunks and low crown height. A total of 534 events were recorded at these trees, of which 44% were captured completely, 43% only included photographs of the lizard descending and 13% only included photographs of the lizard ascending.

At the *Canarium* tree on flat ground one camera captured 9 events and the other captured 8 events. Only two events were recorded by both cameras. At the tree on a slope 13 events were captured by the camera on the higher slope and 0 events by the camera on the lower slope. Overall, the tree on flat ground had a lower complete event detection rate (17% complete, 63% down, 17% up, n = 64, 200 trapping days) than the tree on a slope (36% complete, 46% down, 19% up, n = 145, 270 trapping days), or of any other *Canarium* sp. tree monitored during the study.

Thirty-three days (0700 - 1800 h) of direct observations at fruiting trees with camera traps recorded nine events, of which seven were at least partially

Table 1. Length of time spent in fruiting trees by *Varanus olivaceus* from camera trap data.

	<i>Pandanus</i> sp. 1	<i>Pandanus</i> sp. 2	<i>Microcos</i>	<i>Canarium</i> sp. 1	<i>Canarium</i> sp. 2
Mean (minutes)	13.5	10.6	24.8	29.1	22
SD	6.93	4.47	7.28	15.8	13.22
N	35	8	9	18	230

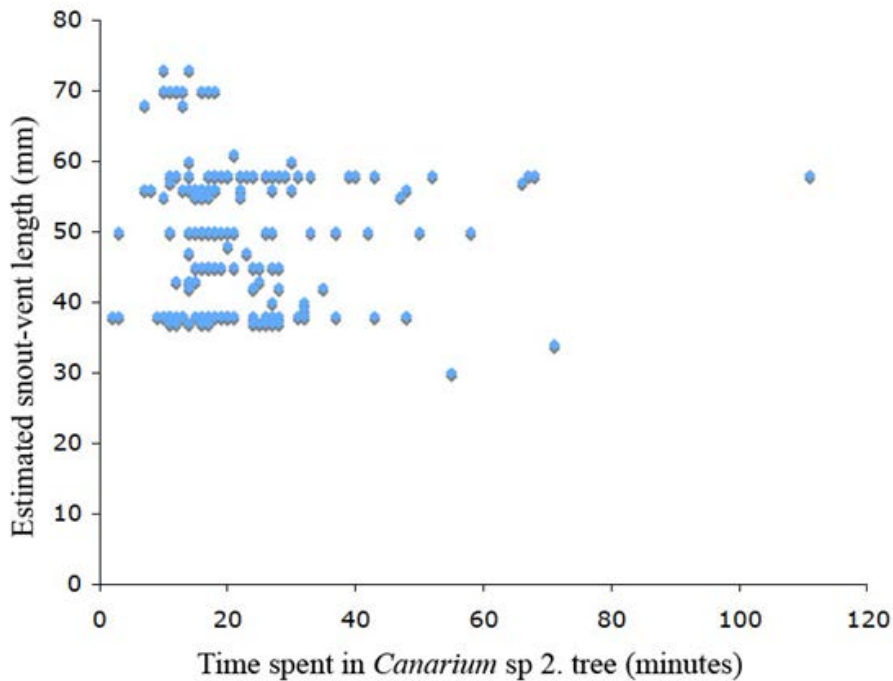


Fig. 3. Time spent in fruiting trees by *V. olivaceus* according to estimated snout-vent length.

recorded by camera traps. Camera traps detected an additional two events that were missed by observers in the same period. In all observed cases the animals climbed the tree using the side of the trunk that was monitored by infrared detectors. Attempts to measure trap efficiency by direct observation were deemed unsatisfactory because in some cases there was evidence suggesting lizards were deterred by the presence of observers (observers reported lizards approaching trees and running away because of noises or movement from hides).

A total of 24 events showing lizards feeding at fruiting trees were obtained by video camera traps. No estimates of effort are available for the method, but time series rarely exceeded 3 days. Video traps stopped working when cameras ran out of film or power, or when cables were destroyed by rats.

## Discussion

Camera traps have proved extremely useful in the study of frugivorous monitor lizards. Because their movements to fruiting trees are predictable, high quality information can be collected about members of the local population with minimal disturbance to the animals. Because important fruit resources for the lizards are rare but can be readily identified even in highly diverse forests,

camera trapping allows monitoring of adult populations with temporal and spatial limitations imposed only by availability of equipment and knowledge of local resources. However, the method only works when the lizards' surface temperatures are higher than ambient temperature, and indiscrete use of the methodology presents a very serious risk of making the lizards more vulnerable to human predation. Furthermore, no commercially produced camera trap system is designed to detect vertical movement of animals on tree trunks.

## Application of data

Camera trap data allowed identification of trees that were used by butaan and estimates of the frequency with which animals of different size classes visited trees. Where events were complete, it enabled precise measurement of the time lizards spent in trees, and where individuals could be identified, it permitted estimates of how many lizards used targeted trees during the monitoring period. Thus the method provides information on population demographics, resource use and movement of individuals.

## Information about foraging and marking behavior

Feeding events at *Pandanus* trees are shorter than



for *Microcos* or *Canarium* trees (Figs. 4-8). The most likely explanation for this is that *Pandanus* fruits are on syncarps rather than scattered through canopies, and that *Pandanus* trees are rarely more than 4 m high and afford no hiding places. The longest visit to a fruit tree recorded was 111 minutes, but most visits were of much shorter duration. Possibly some visits were extended when the lizards sensed danger below (almost certainly due to human activity) and remained in the tree until the danger had passed. There was no apparent relationship between the length of time spent in fruiting trees and the estimated size of the lizard, but it is noteworthy that the largest individuals ( $> 7$  kg) never spent more than 20 minutes in fruiting trees.

Video evidence shows that butaan constantly investigate the trunk with their tongues when ascending and descending trees. At least two types of possible marking behavior are visible in the camera trap pictures. One butaan was recorded rubbing the side of its head on a shelter tree, at the entrance of a ground level cavity (Figs. 9-11). Another butaan was recorded at the same place and appeared to be rubbing its chin in the same

area. In another sequence, a lizard appears to have been disturbed while climbing a fruiting tree, jumped off the tree and left an obvious dark stain on the trunk. Other pictures that give a lateral view of the lizards suggest that the cloaca is sometimes dragged or rubbed on the trunk during descent. Scent marking by wild *Varanus* lizards has been documented by a number of workers (e.g., Tsellarius & Men'shikov, 1994), but the implications are particularly interesting in the context of a large, solitary living, obligate frugivore with an extremely narrow dietary range and a highly developed sense of smell. As a communal resource, fixed in space and persisting over many decades, fruiting trees provide a unique opportunity for local enhancement (as defined by Galef, 1988) and for information exchange between members of the local population.

#### *Use of shelter trees*

Camera trap data suggests that butaan rarely use the same shelter tree for very long (Figs. 12-13), although evidence was found suggesting that more than one



Fig. 4. Adult butaan at fruiting *Pandanus*.



Fig. 5. Adult butaan at fruiting *Canarium*.





Figs. 6 & 7. Adult and juvenile butaan at fruiting *Canarium*.



Fig. 8. Adult butaan at fruiting *Microcos*.

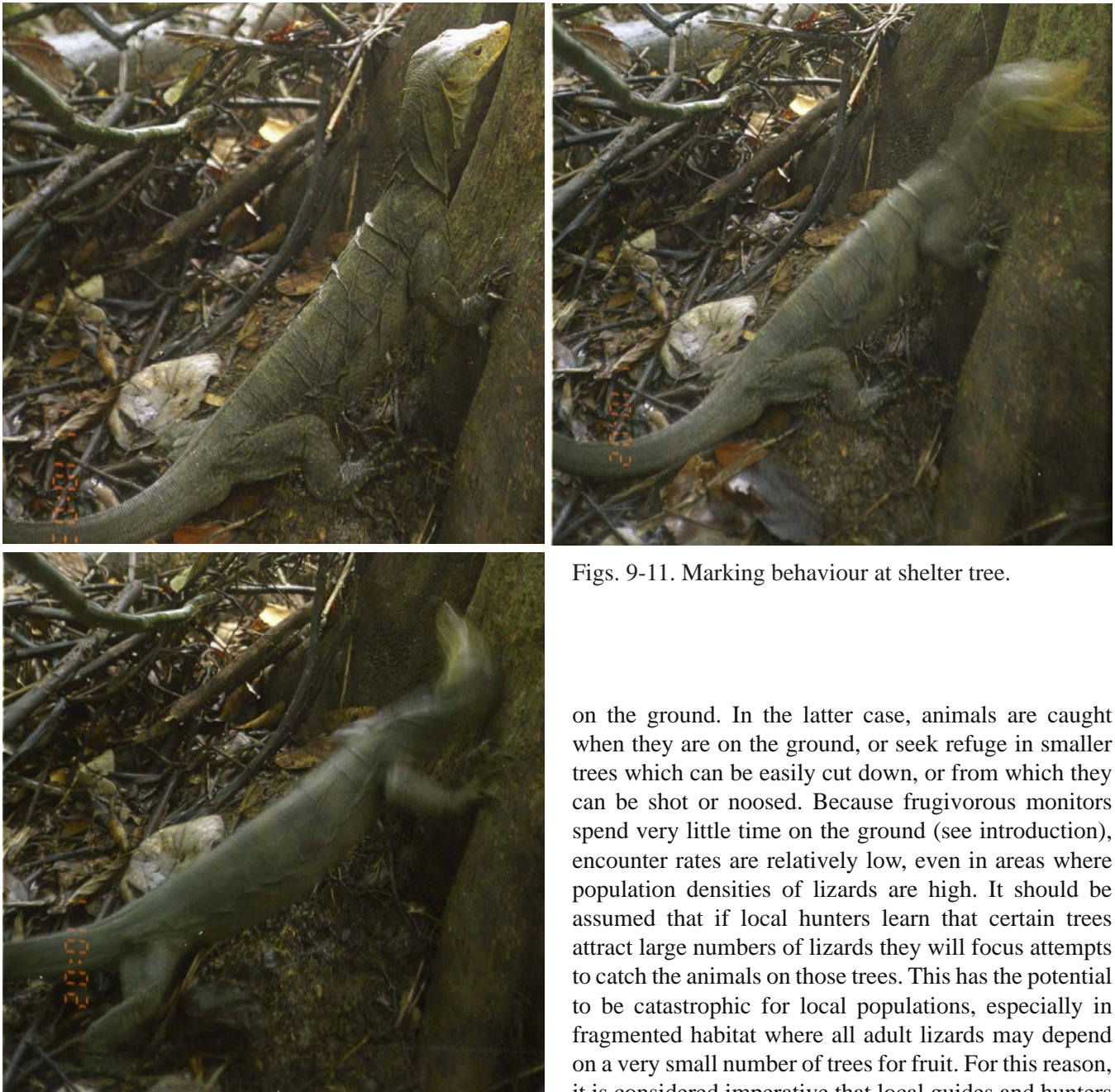
butaan used particular shelter trees at different times. Because yields from camera traps at shelter trees were comparatively low, greater effort was put into the monitoring of fruiting trees.

Some individual butaan were unambiguously recognisable on the basis of distinctive marks or injuries. For these animals, it was possible to establish partial activity areas, sometimes over several years. These issues will be investigated more thoroughly in a subsequent paper.

#### *Interactions between individuals*

Visits to trees by individual butaan very rarely overlapped, suggesting that they are usually solitary animals, using both fruit and shelter trees individually. However, the four occasions when two or more lizards were recorded visiting a fruiting tree at the same time all occurred in July and August (Fig. 14). Auffenberg (1988) found that female butaan in Bicol, southern Luzon, contained eggs between July and October and it is possible that interactions at fruiting trees are connected with courtship activity.





Figs. 9-11. Marking behaviour at shelter tree.

#### *Safeguarding populations studied with camera traps*

Although camera trapping appears to be an almost entirely non-intrusive method of studying frugivorous monitor lizards, the method carries significant risks if local hunters learn the identity of trees which are used by many lizards. Frugivorous monitors are renowned for their tasty flesh and considered a great delicacy wherever they occur. Hunters normally catch frugivorous monitor lizards either with noose traps placed along trails or by random searches, often with dogs, that disturb lizards

on the ground. In the latter case, animals are caught when they are on the ground, or seek refuge in smaller trees which can be easily cut down, or from which they can be shot or noosed. Because frugivorous monitors spend very little time on the ground (see introduction), encounter rates are relatively low, even in areas where population densities of lizards are high. It should be assumed that if local hunters learn that certain trees attract large numbers of lizards they will focus attempts to catch the animals on those trees. This has the potential to be catastrophic for local populations, especially in fragmented habitat where all adult lizards may depend on a very small number of trees for fruit. For this reason, it is considered imperative that local guides and hunters are not made aware of the identity of rare fruiting trees unless they can be trusted not to use or share the information to the detriment of the animals.

Passive infrared motion detectors operate in the thermal infrared band (3,000-10,000 nm) and trigger cameras by detecting a temperature differential between a moving object and the surrounding environment (Swann *et al.*, 2004). Typically, they are used to detect movement of birds and mammals, and under these conditions capture probability increases with animal size (Rowcliffe & Carbone, 2008; Tobler *et al.*, 2008) and probably also with decreasing ambient temperature (Clarke & Orland, 2008). For poikilotherms, dorsal skin





Fig. 12. Adult butaan descending from shelter tree.



Fig. 13. Butaan entering shelter crevice.

surface temperature must also be considered a major factor determining the likelihood of capture; lizards that are close to, or below ambient temperatures will not be detected. Based on data from telemetry, Auffenberg (1988) found that *V. olivaceus* maintain deep body temperatures above ambient from 1000-1100 h, and have a narrower thermal range than other *Varanus* lizards measured in comparable terms (29-32° C for *V. olivaceus*, 27-38° C for *V. komodensis* and 27-35° C for *V. bengalensis*; Auffenberg, 1988, 1981, 1994).

In the present case, “ambient” temperatures mean tree trunk surface temperatures, which are liable to greater or lesser fluctuation than surrounding air temperatures depending on their exposure to direct sunlight. When tree trunks are warm, lizards must be correspondingly warmer to trigger camera traps, suggesting that trees on shaded lower slopes might yield higher trap success than those in more exposed situations. This hypothesis

has not been tested.

Camera trap systems are universally designed to detect horizontal movement in animals, but in climbing lizards, horizontal movement is largely restricted to sinusoidal movements of body and tail. The TM550 uses 20 infrared beams to create a “wedge” radiating 150° and extending as far as 20 m, through which animals walk and trigger the camera trap when warmth is detected by more than one beam. When used as described in this note, success depends on the infrared monitor being able to detect vertical movement of animals up and down tree trunks, despite the fact that the infrared monitor beams are perpendicular to the tree trunk. The infrared monitor units could not be set at a 90° angle (which would create a set of vertically arranged beams on the target tree trunk) because of severe impairment to the drainage system. It appears crucial that the infrared monitor is positioned close enough to the tree to ensure



Fig. 14. Two butaan descending *Canarium* tree, 14th August 2003.

that a number of beams are trained on the trunk and that the wedge is narrowed to eliminate false triggers by movement from the area around the trunk. It would seem advantageous to use a system that detects vertical movement (i.e., with beams arranged in a column), but no such system is produced commercially at present.

Positioning of infrared detectors and cameras is crucial to the success of the method and some trapping attempts failed because objects in the environment constantly triggered camera traps. Best results were obtained by avoiding buttressed trees and areas of trunks receiving direct sunlight, positioning infrared units so that they pointed down at a 10° angle and targeting trees on slopes rather than on flat ground.

Clearly, a triggering method that did not depend on a temperature differential between the target animal and its substrate would be an improvement on the PIR system under discussion here. Active infrared camera

traps work by utilising a narrow beam of infra red light between a transmitter and receiver. Any interruption of this beam triggers the camera. As far as we are aware there have been no attempts to use active camera trapping systems on lizards, and their potential for use in monitoring animal activity on tree trunks is uncertain.

Possible explanations for the differences in detection rates for ascent and descent of trees include: 1) that lizard surface temperatures are higher on descent than ascent from fruiting trees resulting in increase in capture rate; 2) differences in speed of ascent or descent might affect likelihood of capture; or 3) lizards take alternative routes up trees and avoid the area of detection. There is insufficient video data available to look for differences in ascent and decent speeds and, although lizards do jump from one tree to another tree, experience suggests the animals are much more likely to jump from a tree to the ground. That large lizards might be substantially warmer after foraging for 15 minutes in a low subcanopy tree in dense forest is surprising, but appears to be the most likely explanation for the results, and perhaps the most easily tested.

Camera trap evidence supports the view that butaan normally climb the side of tree trunks that faces the highest side of sloping ground. Additional evidence for this includes the concentration of scratches on bark on that side of trees and evidence from spool and line tracking of individuals. On hillsides, the face of the tree most likely to be climbed by butaan is therefore easily determined. On ground without a definite slope, at least two camera traps would be required to monitor a tree. It might be possible to prevent lizards from climbing areas of trunk not covered by camera traps by partially blocking access with a collar, although it was considered that this might deter animals from visiting trees, and was not attempted.

Although there is evidence to suggest that some individuals were disturbed by their early encounters with camera traps (based on posture of lizards photographed), there is no evidence that animals were deterred from using trees because of noise or light from the cameras. Light levels in closed canopy forest are relatively low, and better quality images were always obtained using flash photography regardless of the light sensitivity (ISO rating) of the film used.

The main disadvantages of the system used were the high costs of equipment, film and processing, the failure of Trailmaster units (attributed to the high levels of rainfall and humidity in the study area), damage to cables caused by rats, and mistakes made in setting devices by project members due to the rather complex



control system on the PIR units.

#### *Size estimates from camera trap pictures*

Estimating the lengths of butaan photographed by comparing them to pictures of the same tree with a 10 cm scale provided only a rough estimate of length. These estimates varied according to the posture of the lizard, its orientation and its position on the trunk. More accurate estimates could be produced by fixing a scale to the tree during periods of camera trap use.

#### *Identification of individuals*

The ability to recognise individual butaan unambiguously in this study was limited by the fact that the local population are not conspicuously patterned. Lighting conditions, the orientation of the animal on the tree trunk, shedding state and the amount of moisture on the animals' skin compounded the difficulties. Attempts at distinguishing individuals indicated that crease patterns around the neck might be a very useful diagnostic feature, but in the absence of any control, this hypothesis could not be tested. Identification of individuals was often possible over shorter time periods (usually the fruiting season of a single tree), and this allowed estimates of how often individual animals made visits to a particular tree and the number of animals that used the tree. Identifying individuals from pictures taken years apart was more problematic. For lizards with more prominent patterns (including local populations of *V. marmoratus*, strongly patterned populations of *V. olivaceus* from karst habitats and many *V. bitatawa* populations), unambiguous identification of individuals from dorsal photographs should be relatively straightforward.

#### *Improving the system*

Digital cameras provide major advantages over the emulsion film technique employed by this study. Apart from financial savings due to the removal of processing and printing costs, digital photography allows hundreds or thousands of pictures to be taken between inspections. It also allows results to be checked at regular intervals and any necessary adjustments to be made accordingly. On a number of occasions during the study, camera traps were left for extended periods at certain trees because they appeared to be recording lizards, only to find after film processing that only false events were recorded. Conversely, cameras were sometimes removed from

trees in the belief that they were not recording lizards, but after film had been processed it became apparent that this assumption was incorrect. The ability to monitor results immediately and *in situ* with digital camera traps is a vast improvement over 35 mm film systems. However, all commercially produced digital camera traps are single units which combine both the camera and the PIR. A distinct advantage of the Trailmaster system is that the PIR can be positioned close to the tree trunk whilst the camera can be situated further from the tree and in portrait orientation, allowing pictures of lizards to be taken that include the whole body and tail. Positioning a combined unit sufficiently close to the tree trunk to be triggered by lizard activity precludes the possibility of taking pictures at a distance from the tree that would enable pictures of the entire animal to be taken, and subsequently only partial pictures of the animals are produced.

Although the cameras used in the *V. olivaceus* study have been rendered obsolete by advances in digital cameras, the principles of passive infra red camera trapping remain the same, and the Trailmaster 550 units used in this study are still in production. However, the leads required to connect the PIR devices to digital cameras are at least 10 times more expensive than the leads used to connect to 35 mm film cameras, and unless measures were taken to eliminate the risk of rodents chewing cables, the cost of using the system with digital cameras in this habitat might be prohibitive.

As mentioned above, IR beams in camera traps are universally designed to detect horizontal movement, with beams arranged in a row, but in the case of lizards on tree trunks horizontal movement is largely restricted to sinusoidal movement associated with climbing or descending. It would seem advantageous to use a system that detects vertical movement (*i.e.*, with beams arranged in a column or a non linear arrangement), but no such system is produced commercially at present.

Although passive infrared systems do not capture all events, they proved invaluable in these studies because they allowed lizard activity at trees to be monitored in a way that presented minimal disturbance to animals and without the need for a permanent team of camouflaged observers. They also provided evidence of aspects of lizard activity that would be very difficult to collect by other means. The method seems eminently suited to the frugivorous monitors of the Philippines, but may also be useful in the study of shy or cryptic reptiles elsewhere.

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## An Inexpensive, Non-Intrusive, Repeatable Method for Surveying Frugivorous Monitor Lizards

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**Abstract:** Frugivorous monitor lizards are large (to at least 8 kg), highly arboreal and notoriously shy. They spend almost all their lives in the canopy of dense dipterocarp forest and cannot be attracted with bait. Consequently they are only very rarely observed, and generally only recorded by destructive faunal surveys. This note describes an inexpensive, non intrusive, quantitative, repeatable method for determining the current or recent presence of frugivorous monitor lizards based on feces or elements of feces that persist in the environment for periods ranging from days to years after deposition.

### Introduction

The occurrence of *Varanus* lizards at study sites is most usually established using traps with or without bait (e.g., Auffenberg, 1981; Lenz, 1995). For species or age classes that cannot be attracted to bait, animals have been captured by excavation from their burrows (e.g., Bennett, 2000a) or captured with dogs (Auffenberg, 1988). Non intrusive surveys of monitor lizards have included visual surveys along transects (e.g., Bennett 1998; Karunarathna *et al.*, 2012; Ghimire & Phuyal, 2013), through random encounters (e.g., Dwyer, 2008; Weijola, 2010; Del Canto, 2013), and by road kills (e.g. Karunarathna *et al.*, 2012).

None of these methods are suitable for the frugivorous monitor lizards of the subgenus *Philippinosaurus*: butaan (*Varanus olivaceus*), bitatawa (*V. bitatawa*) or mabitang (*V. mabitang*) because the animals are highly arboreal, cryptic, and extremely susceptible to both disturbance and fatal infection from dog bites (Auffenberg, 1988; Bennett & Hampson, 2003; Gaulke *et al.*, 2005). Camera traps (Bennett & Hampson, 2003; Ariefiandy *et al.*, 2013; Bennett & Clements, this volume) have been employed to record monitor lizards, but the method requires expensive equipment, lengthy survey periods, and only provides information on animals within the detection range of the camera.

An attempt to devise an affordable method of surveying butaan on Polillo Island, Quezon Province,

Philippines, took advantage of the fact that the feces of butaan are unique in size and composition, and therefore easily and unambiguously identified in the field (Bennett, 2008). Frugivorous monitor lizards swallow fruits whole, and excrete seeds in clumps on the forest floor, together with fragments of durous prey, usually snail shells or crab legs (Auffenberg, 1988; Bennett, 2000b; Gaulke *et al.*, 2007, Gaulke, 2010). Here, the use of a standardized directed transect search method for the feces of frugivorous monitor lizards is described.

### Methods

Between 12 May and 1 June 2002, fixed-length surveys for the feces of *V. olivaceus* were conducted in forest fragments around Sibulan Watershed Reserve, Polillo Island. Sites were individual hills that were known to have been previously occupied by *Varanus* lizards (but not necessarily *V. olivaceus*). A start point on each hilltop was chosen at random and each surveyor assigned a color-coded 4.8 g cocoon bobbin (Danforth, Leigh, UK) containing 320 m of polyester thread (weighed to ensure uniformity). The leading end of the thread was tied to the start point. Searchers were directed to move away from each other, but otherwise had complete freedom over where to search. When the thread expired, the search was over. Feces were identified by their size or unique composition, and assigned to an age class of fresh (still smelling) or old (not smelling).

Feces whose origin was in doubt, or in which seeds had begun to sprout or degenerate, were excluded.

## Results

Ninety five transects (total length 30.4 km) conducted at 13 sites yielded a total of 18 fresh feces and 35 old ones (Table 1). No feces were found in 74 transects. Mean number of feces per transect was  $0.61 \pm 1.0$ , (range 0-6), mean number per site was  $4 \pm 4.1$ .

## Discussion

Searches for feces have been the basis of surveys for a number of reclusive, cryptic, and/or rare animal species (e.g., Bennett *et al.*, 1940; Plumptre & Harris, 1995; McGregor *et al.*, 2013). In the current case, the method relies on being able to distinguish the feces of *V. olivaceus* with absolute certainty, which is usually possible because of their unique size and composition. The animal with the highest dietary overlap is the civet *Paradoxurus*, which feed on crabs and some of the smaller fruits eaten by *V. olivaceus*, but not on snails. Fresh feces are easily distinguishable by their smell, but after a few days the origin of some feces cannot be determined with certainty. On Polillo, these ambiguous feces are < 70 g and consist of palm seeds (*Pinanga*, *Caryota*, *Livistona*) with or without crab fragments. Seeds and seedlings from fecal clumps of butaan have been documented to survive for at least four years on the

forest floor (Bennett, 2008). Therefore, distinguishable elements from the feces of frugivorous monitor lizards persist in the environment for much longer than those of carnivorous species, and the condition of feces found provide clues about time since activity at the search area (Figs. 1-3).

The major biases in the method used here are differences in individuals' ability to spot and recognize feces, and from differences in search patterns used. More experienced or agile surveyors may recognize features of animal, trails and concentrate search efforts along them regardless of topography, whereas other surveyors might restrict themselves to the most accessible search routes. Although we did not test for these differences, thread trails would allow search paths to be checked by a second surveyor, to ascertain differences in detection rates. Thread trails also allow surveyors' exact paths to be mapped (when required) with better accuracy than would be obtained using GPS under forest canopy. A visual search trail prevents surveyors from searching areas that have previously been covered, and greatly simplifies the process of revisiting areas of interest that have been found during surveys.

High standard deviations reflects the clustered distribution of feces, which is in part due to replication (more than one feces from the same individual), but also reflects the fact that many animals feed from the same resource trees (Bennett & Clements, this volume) and often repeatedly use the same paths between trees (Auffenberg, 1988; Bennett, 2008). Smaller *V. olivaceus*

Table 1. Summary of feces of *Varanus olivaceus* found in transects.

Site	Number of transects	Number of feces	Yield
1	4	1	0.25
2	17	5	0.3
3	10	0	0
4	9	16	1.78
5	8	6	0.75
6	8	2	0.25
7	6	5	0.83
8	10	2	0.2
9	4	6	1.5
10	4	1	0.25
11	4	3	.0.75
12	7	2	0.29
13	4	3	0.75
mean			0.61
sd			0.53





Fig. 1. Feces of *Varanus olivaceus*, several days old.



Fig. 2. Feces of *V. olivaceus*, about 1 week old.



Fig. 3. Feces of *V. olivaceus*, at least 14 months old.

are active within smaller areas than larger individuals (Auffenberg, 1988), and may feed (and hence defecate) more frequently. However, feces of small individuals are more likely to be overlooked than those of larger animals, so the direction of bias in the search method cannot be assumed.

This method is particularly effective because although searchers have complete freedom of movement, standardized effort is maintained through the thread trails. On Polillo Island, searches of 780 50 x 5 m random, straight line transects (totaling 195,000 m<sup>2</sup>) conducted by an experienced team over five years found just two feces of *V. olivaceus* (Bennett, 2008). No area can be attached to thread transects; experience suggests that butaan feces of any size in these habitats are normally detectable only within 1 m of the surveyor. The surveys discussed here were conducted by a relatively inexperienced team, with a maximum of two months previous experience searching for lizard feces. As is the case for all observational techniques, yield per unit effort is influenced by experience and ability. The author's experience suggests that a team of five people could easily conduct 20 transects per day, which would be more than sufficient effort to detect the animals' presence at the lowest densities found in the Polillo forests. Individual transects take about one hour to complete, which approaches the concentration limit of searchers when nothing is found.

Recent work relying on feces to survey animals has often employed molecular techniques to identify and sex individuals (e.g. Hedmark *et al.*, 2004; McGregor *et al.*, 2013). If such techniques were developed for frugivorous monitor lizards, fecal surveys would provide a way of monitoring populations indefinitely without any direct disturbance to the animals. This has its most obvious application in the study of the endangered *V. mabitang*, which is restricted to lowland dipterocarp habitat on Panay Island (Gaulke, 2008, 2010). The diet of this species differs from that of frugivorous monitors on Luzon in that it consists partly of leaves and apparently does not include *Canarium* fruits, but does include highly conspicuous *Pandanus* drupes (Gaulke *et al.*, 2007).

A secondary, but not inconsequential advantage of the method may be termed the "Ariadne effect". Inexperienced surveyors are easily disorientated in dense forest, especially where GPS signals are weak or absent, and consequently have to be constantly accompanied by guides with sufficient local knowledge of the terrain to ensure they do not get lost. This effectively doubles the search effort required. When spool and line devices

are attached to surveyors they can be allowed to work individually without risk of disorientation; surveyors find their way back to the start point by following their own thread trails. Conversely, when surveyors fail to return to the start point they can be easily tracked and (hopefully) found.

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## Water Monitor Lizard (*Varanus salvator*) Satay: A Treatment for Skin Ailments in Muarabinuangeun and Cisiuh, Indonesia

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**Abstract - *Varanus salvator* meat is consumed as a protein source in certain areas throughout its Southeast Asian range, while in others it is shunned because of religious or traditional beliefs, or simply avoided due to taste preferences. Here we document the use of *Varanus salvator* for medicinal purposes in Muarabinuangeun and Cisiuh, part of Pandeglang District in the Province of Banten, Indonesia, where villagers report consuming grilled *V. salvator* meat as a cure for various skin ailments.**

The meat of *Varanus salvator*, a large-bodied species of monitor lizard found in southern and Southeast Asia (Gaulke & Horn, 2004; Bennett *et al.*, 2010; Koch *et al.*, 2013), is not often consumed as a source of protein in Indonesia (Luxmoore & Groombridge, 1990). However, there are a few local ethnic groups that will eat *V. salvator*, such as the Bataks in North Sumatra, the Dayaks in Kalimantan (Luxmoore & Groombridge, 1990), and the Minahasa people of North Sulawesi who consider *V. salvator* to be a favored delicacy (De Lisle, 2007). This note documents the consumption of *V. salvator* meat in two village areas on the southwest coast of Java, Indonesia, where some consider it to be an effective remedy for common skin ailments such as *Pityriasis versicolor* and eczema.

*Varanus salvator* is a species common to both Muarabinuangeun and Cisiuh, two village areas

located approximately 45 km apart in Banten province, Indonesia. Residents of Muarabinuangeun and Cisiuh were interviewed as part of a larger interdisciplinary study investigating local perceptions and attitudes towards *V. salvator* as well as the behavior and resource use of this species (Uyeda *et al.*, 2012, 2013). Through the use of open-ended interviews, participants were asked about experiences and knowledge related to *V. salvator*. Each interview consisted of 1-3 participants, with a total of 55 participants over the course of 35 interviews. Interviews were conducted in Bahasa Indonesia, digitally recorded, and later transcribed and translated into English.

Interviews revealed local knowledge regarding the consumption of *V. salvator* meat as a cure for skin ailments associated with itching. Fourteen participants mentioned specific knowledge regarding the medicinal use of *V. salvator* meat, with four of these detailing



Table 1. Individual knowledge and use of *Varanus salvator* meat for medicinal purposes in Muarabinuangun (MB) and Cisihi, Indonesia.

Location	Knowledge from a third-party source/ personal experience	Ailment Treated	Preparation	Reported Effectiveness
MB	local knowledge	eczema	-	-
MB	local knowledge	eczema, asthma	-	-
MB	local knowledge	"itching"	satay	-
MB	local knowledge	"itching"	grill meat	-
MB	local knowledge	"skin disease"	satay	-
MB	local knowledge	"itching"	-	-
Cisihi	local knowledge	asthma	satay	-
Cisihi	local knowledge	-	satay	-
Cisihi	local knowledge	"itching"	-	-
Cisihi	local knowledge	"itching"	-	-
MB	consumed meat	<i>P. versicolor</i> , eczema, <i>T. corporis</i>	satay	healed by the next day
MB	consumed meat	eczema, "skin disease"	-	healed
MB	consumed meat *	eczema, "sores"	grill meat	healed within a week
Cisihi	consumed meat	eczema	satay	healed within 2-3 days

\*the interviewee and his wife indicated that their young son had consumed the meat for his skin ailment

personal experiences in utilizing *V. salvator* meat for its curative properties (Table 1). Participants mentioned the use of *V. salvator* meat to treat *Pityriasis versicolor* (*panu* in Bahasa Indonesia), a yeast overgrowth on the skin common in many tropical areas (Erchiga & Hay, 2010), *Tinea corporis* (*kurap* in Bahasa Indonesia), a fungal infection commonly known as ringworm, and eczema (*eksim* in Bahasa Indonesia), a term often used synonymously with atopic dermatitis (Burgess *et al.*, 2009), a disease associated with itching and redness of the skin. Several participants did not specify a particular skin ailment treated with *V. salvator* meat, using instead either the Indonesian phrase *gatal-gatal*, which translates to a general "itching", or *penyakit kulit*, translating to "skin disease". One participant referred to "ulcerations" or "sores" (*koreng*) that could be alleviated by the consumption of *V. salvator* meat. A single preparation method was reported; *V. salvator* meat was prepared as a satay (the meat grilled on a skewer) or grilled, and then eaten. Participants indicated that consuming a one-time "dose", consisting of only a small amount of meat, was enough to achieve the curative effect. Each of the individuals who had personal experience with the consumption of *V. salvator* for a skin ailment indicated

that eating the *V. salvator* meat resulted in a noticeable improvement in the skin condition within a short period of time (Table 1).

Interviewees further explained that *V. salvator* meat was only effective for the treatment of certain types of skin ailments, indicating that direct injuries or scars would not be positively affected by the consumption of *V. salvator* meat. However, one individual reported that oil extracted from *V. salvator* could be applied topically to effectively reduce the prominence of scars. Two interviewees mentioned that *V. salvator* meat could be eaten to combat the symptoms of asthma, although none of the study participants reported personal experience in consuming *V. salvator* for this purpose.

Muarabinuangun and Cisihi are located in predominantly Muslim areas, where *V. salvator* is generally not consumed as a regular dietary item or source of protein due to religious beliefs. Individuals who had eaten *V. salvator* meat as a skin cure specified that they would not have eaten the meat other than for medical purposes, although it was not clear if this was for religious reasons or simply due to a dislike for *V. salvator* meat. Throughout the course of the study, only two individuals indicated that they had occasionally

eaten *V. salvator* meat as a protein source rather than as a medical treatment.

Throughout Asia, varanid body parts or extracts have been utilized in treating a variety of ailments. For example, varanid gall bladders are said to cure heart problems, impotency, and liver failure (Bennett, 1995) and gall bladders from *V. salvator* have been noted in the Asian medicine trade (Luxmoore & Groombridge, 1990). The fat and oil of *V. bengalensis* have been utilized by tribes in Pakistan as a salve for skin infections and for relief of rheumatic pain (Hashmi *et al.*, 2013). In India, *V. bengalensis* meat is believed to aid lung muscles in recovering from lack of oxygen, and powdered *V. bengalensis* meat is used in energy tonics for the relief of asthma (Subramanean & Reddy, 2012). Khatiwada & Ghimire (2009) reported that the meat of *V. flavescens* is consumed for medicinal purposes in Nepal, where individuals also believe it to be an effective treatment for asthma (in addition to other conditions such as tuberculosis and leprosy).

The number of interviewees who mentioned *V. salvator* satay as a known cure for skin ailments, and the presence of individuals who had engaged in the consumption of *V. salvator* meat as medicine despite the predominant religious practices suggest that belief in the efficacy of this treatment is strongly supported by traditional knowledge in our study areas. Reports of varanid meat consumption to treat asthma should also be noted as eczema and asthma are characterized by similar allergic mechanisms (e.g., Cookson, 2004), with recent literature identifying possible links between eczema and the development of asthma (e.g., Burgess *et al.*, 2009; von Kobyletzki *et al.*, 2012). To our knowledge, the effectiveness of varanid products in medicinal applications has not been systematically or empirically tested. Future research directions might include investigating the prevalence of medicinal *V. salvator* consumption throughout the species' range, as well as laboratory analysis to evaluate the potential curative properties of *V. salvator* meat.

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## Successful Repair of an Emerald Tree Monitor (*Varanus prasinus* Schlegel, 1839) Egg at Bristol Zoo Gardens

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**Abstract:** During the artificial incubation of a clutch of *Varanus prasinus* eggs, one egg ruptured. This article describes the successful repair of this egg, alongside reproductive data pertaining to the egg clutch and resulting hatchlings.

During artificial incubation, reptile eggs can be subjected to hazards resulting from human error or equipment malfunction. Two of the most important factors influencing the hatching success and viability of reptile eggs are the thermal and hydric conditions present during incubation (Booth, 2004). If these conditions fall outside the optimal incubation ranges for the species, or if a sudden fluctuation in these environmental variables occurs, eggs can become damaged - sometimes resulting in rupture of the eggshell.

Accounts describing the repair of ruptured reptile eggs are relatively uncommon in the literature, with few examples from the genus *Varanus* (Adragna & Madden, 2009; Fischer, 2012). An attempt to repair a ruptured tree monitor egg (*V. beccarii*) used hot wax to seal the perforation (Fischer, 2012). This repair occurred fairly late into the egg's incubation (day 136) and while the embryo developed fully, it failed to hatch and died in the egg. A single instance of successful monitor lizard egg repair was documented by Adragna & Madden (2009), after a *V. acanthurus brachyurus* egg was found ruptured 81 days into incubation. This egg went on to hatch (day 106) after it was patched with a piece of eggshell from a hatched *V. tristis tristis* egg. The following article details the successful repair of a damaged *V. prasinus* egg that had ruptured approximately half way through its incubation, and provides morphometric data on the egg clutch and resulting hatchlings.

### Oviposition and Incubation of Eggs

A five year old, second generation (F2) captive-bred *V. prasinus* female was introduced to a six year old wild-caught male's enclosure on 28 December 2012. Courtship began immediately, and the first observed copulation took place within an hour. Thirty four days after this first mating, the female laid five eggs in a horizontally-dug nest chamber 17 cm in depth, inside a nest box. The nest box, a plastic bucket measuring 30 cm high and 25 cm in diameter, was filled with a 1:2 mix by volume of dampened sand and coir and heated from beneath to provide a vertical temperature gradient ranging from 29 to 32° C. The surface temperature of the eggs and surrounding nesting medium in which the eggs were deposited was 31.1° C. One egg (egg # 5) was deflated and non-viable, and subsequently discarded.

Table 1. Clutch data.

Egg No.	Mass (g)	Length (mm)	Width (mm)
1	10.84	43	21
2	10.28	42	21
3	10.74	44	21
4	10.74	42	21
5*	6.8	40	21

\*Egg was deflated and nonviable, and subsequently discarded



After the eggs were retrieved from the nest site, they were weighed and measured (Table 1), and set up for artificial incubation inside a sealed, transparent plastic storage container. Vermiculite was used as an incubation substrate, and was hydrated with reverse-osmosis (RO) water to a 1:1 ratio by weight. The clutch was then placed in an incubator (Vickers Medical Neocare Baby-controlled Incubator, Model # 142; Vickers Medical, Ltd., London, UK) set to a constant temperature of 31.0° C. The lid of the container was initially removed weekly for aeration of the incubation environment and daily during the latter stages of development.

### Repair of Ruptured Egg

Egg number two ruptured 77 days into incubation, and lost approximately 0.2 ml of albumen from the opening (Fig. 1). The likely cause of the rupture was the sudden rehydration of the eggs after they had begun to dehydrate and deflate several days earlier due to humidity levels inside the egg container dropping to 67%. The egg was repaired by applying tissue adhesive (3M™ Vetbond™ Tissue adhesive; 3M, St. Paul, Minnesota, USA) to the surface of the damaged shell using a small gauge needle syringe. The albumen was wiped away, and the tissue adhesive was applied quickly before much more albumen could escape (Figs. 2 & 3). Including the initial seepage, approximately 0.4 ml of albumen was lost in total before the egg could be completely sealed.



Fig. 1. Egg number two had a small fissure where albumen began to seep out.



Figs. 2 & 3. Egg number two wiped free of albumen with clean tissue paper before applying tissue glue to the damaged section of the egg.

### Hatching

Sixty days after the repair (137 days total incubation), egg numbers one, two (the repaired egg) and three hatched on 16 June 2013. This incubation period falls within the known range of 123-215 days for this species (Baldwin, 2006; Biebl, 1993; Bosch, 1999; Dedlmar, 1994; Gorman, 2000; Horn & Visser, 1991; Jacobs, 2002; Kok, 2000; Mendyk, 2008, 2012; Pfaff & Sprackland, 1996; Polleck, 2004). The hatchling from egg number one had emerged by 1600 h, but the yolk sac had not internalized and a herniation at the umbilicus was present. It was left overnight in the incubator, but was found dead the next morning. Egg number four hatched two days later, after 139 days of incubation.

Hatchling number four had also pipped on 16 June, but did not fully emerge until two days later. It was inspected within the egg on 17 June, where the yolk sac was found to be ruptured. This is possibly the result of the yolk sac adhering to the eggshell and being pulled against the amniotic contraction, causing a tear (Perazo *et al.*, 2013). This failure to internalize residual yolk seems likely to have contributed to the remarkably small size of the hatchling. At just 4.8 grams, this



Fig. 4. Hatchling *Varanus prasinus* pipping from the repaired egg.



Fig. 5. Juvenile *V. prasinus* that hatched from the repaired egg.

hatchling falls outside of the known 5.7-11.0 g range for *V. prasinus* (Mendyk, 2012). All hatchling data for this clutch are summarized in Table 2. Each hatchling fed on pieces of chopped pinkie mouse parts three days

after hatching, and then moved on to a diet of almost entirely invertebrates (crickets and cockroaches). All three offspring continue to grow and do well at the time of writing (Fig. 6).

Table 2. Summary of hatchling measurements. Abbreviations used: SVL = Snout to vent length; TL = Total length ; TaL:SVL = Tail length to snout to vent length ratio.

Egg No.	Hatchling Mass	SVL (mm)	TL (mm)	TaL:SVL
1*	8.1	n/a	n/a	n/a
2**	7.9	86	214	1.5
3	8.2	88	218	1.5
4	4.8	68	177	1.6

\*Hatchling died within 15 hours of hatching; measurements from necropsy. \*\* Hatched from the repaired egg.

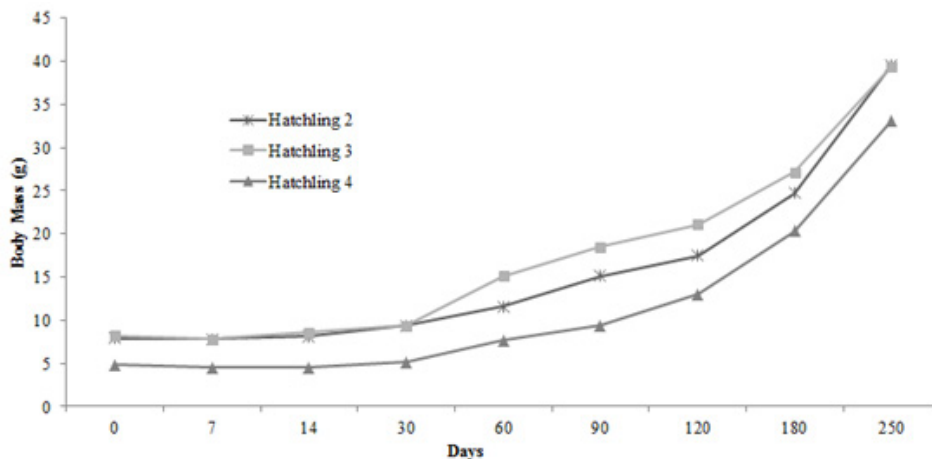


Fig. 6. Body mass growth of three captive-bred *V. prasinus* at Bristol Zoo Gardens.



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# HISTORICAL FACSIMILES

Lydekker, R., H. Johnston & J.R. Ainsworth-Davis. 1911. Monitors. Pp. 1532-1534. In: Hamsworth Natural History: A Complete Survey of the Animal Kingdom.

## Monitors

No better instance of the essential difference in the distribution of lizards as compared with tortoises is afforded than by those lizards commonly known as monitors (*Varanidae*). The tortoises of Australia, as mentioned later, belong to a different suborder from those of India, while there are no genera common to Australia and Africa. The monitors, all of which are included in the single genus *Varanus*, are, however, common to the three countries named, while one species actually ranges from India to Australia. That this widespread generic distribution is not a feature of the present epoch is proved by the occurrence of fossil monitors in both the two latter countries, whereas there is no evidence that they ever possessed genera of tortoises in common.

Before proceeding further, it may be well to mention that the Egyptian representative of the group is known to the natives by the name of *ouaran*, which appears to be the Arabic term for lizards in general. Transliterated as *waran*, this word has been confused with the German *warnen*, to warn, whence these reptiles have been termed *warneidechsen*, or warning lizards; this, again, having been translated into monitors – a name which, however erroneous in origin, is too well established to be superseded.

Monitors are distinguished from all the lizards hitherto described by the long and deeply-forked tongue, which is capable of being protruded far in front of the lips, and is furnished at the base with a sheath, into which it can be withdrawn, as in snakes. Including the largest members of the suborder, monitors are further characterised by the long body, the broad, uncrested back, the well-developed, five-toed limbs, and the long tail, which is very frequently markedly compressed. The head is covered with small polygonal scales; the eyelids are well developed; the opening of the ear is distinct; and the head is covered with small scales.

As regards the skull, the absences of a bony roof over the temporal pits and of teeth on the palate, as well as the union of the two nasal bones into a single ossification, are notable features. The teeth are large and pointed, with expanded bases fixed to the sides of the jaws. On

the back the scales are rounded and bordered by rings of minute granules, so that they do not overlap; while on the under surface the squared scales are arranged in cross-rows. Pores are absent both on the under surface of the thigh and in front of the vent. A peculiarity of the group is the presence of an imperfect midriff, found elsewhere among reptiles only in crocodiles.

Monitors inhabit Africa, Southern Asia, Oceania, Papua, and Australia, and are represented by nearly thirty living species, the largest of which attains a length a little short of 7 feet. A fossil species from Northern India was, however, probably 12 feet long, while one from Australia could not have fallen much, if at all, short of 30 feet. The group is an isolated one, without near relationship to any other family.

The genus may be divided into four distinct sections, the first of which is represented solely by the desert monitor (*V. griseus*) of North-Western Africa and South-Western Asia, where it extends from Arabia and the Caspian to North-Western India. This species differs from all the rest in that the nostrils are in the form of oblique slits, while the tail, except sometimes near the tip, is cylindrical. Attaining a length of 4 feet 2 inches, this species takes its name from its greyish yellow colour, which may be relieved by brown cross-bars on the back and tail, and streaks of the same hue along the sides of the neck, the young always having yellow spots and dark bars. In accordance with its sombre colouring, this species is an inhabitant of sandy deserts.

A far handsomer lizard than the last is the Cape monitor (*Varanus albigularis*) of Southern and South-Eastern Africa, where it is commonly known to the Boers as the “adder”. It is the first representative of the second group of the genus, in which, while the nostrils are in the form of oblique slits, the tail is compressed and keeled. Belonging to a subgroup characterised by the smooth scales of the abdomen, it is further distinguished by the absence of large (supraocular) scales above the eyes, by the nostril being three times as far from the snout as from the eye, and by the small size of the scales. It is slightly inferior in size to the last, and has the upper

parts greyish brown, banded and spotted with yellow, and the underparts yellowish. It generally frequents cliffs or low, rocky hills, in the interstices of which it delights to hide, coming out to bask on the flat surfaces. Gray's monitor (*V. grayi*) is an example of a second subgroup in which the abdominal scales are keeled.

In the third great group, of which the great water-monitor (*V. salvator*) is the largest member- as it is indeed, of the whole genus- round or oval nostrils are accompanied by a compressed tail. In the species mentioned there is a series of transversely elongated scales above the eyes, the oval nostril is situated as far from the eye as from the tip of the snout, there are more than eighty transverse rows of scales between the fold on the throat and the groin, and the scales on the nape are not larger than those of the back.

This fine species, which ranges from India through the Malay region and China to Australia, attains a length of nearly 7 feet. In colour it is dark brown or blackish above, with yellow rings; the snout being generally lighter, with transverse black bars, and a dark band, bordered by a yellow one, running backwards from the eye, while the under surface is uniformly yellow. The water-monitor frequents marshy localities, being often found on trees overhanging rivers, and taking readily to water, either fresh or salt (page 1510).

Another member of this group is the well-known Nile monitor (*V. niloticus*), whose range extends all over Africa except a portion of the north-western regions. Belonging to the same group as the last, it represents as a second subgroup characterised by the equality in the size of the scales above the eyes, and is distinguished from its allies by the nostril being rather nearer the tip of the eye than the snout. In size it is somewhat larger than the desert-monitor. The colour of the adult is brownish or greenish grey, with darker reticulate markings, and more or less distinct yellowish eye-like spots on the back and limbs; while beneath it is yellowish, crossed by some dark bands. This species is likewise found in the neighborhood of water, generally building itself a nest among the bushes on the banks, especially of those streams that dry up in the hot season (page 1562).

The Papuan monitor (*V. prasinus*) of New Guinea and the islands of Torres Straits is an example of the fourth group, in which, while the nostrils are round, the tail is nearly cylindrical. In colour it is bright green, with black markings.

As will be gathered from the foregoing remarks, monitors present considerable diversity of habitat, although the majority prefer the neighborhood of water. The Papuan species is, however, believed to be arboreal,

as, in fact, is made almost certain by its colour. All are carnivorous in their diet, feeding on frogs, snakes, the smaller mammals, and birds, as well as the eggs of both birds and reptiles, especially crocodiles.

Their movements are extremely rapid, both on land and in water; and many a sportsman in his first day's snipe-shooting in the rice-fields around Calcutta has been startled by the sudden rush of the common Indian *V. bengalensis* as it darts among the herbage close to his feet.

Those species in which the tail is most compressed are the best swimmers, this appendage serving as a powerful propeller in the water, and being also used as a weapon of offence on land. In order to enable these lizards to remain under water for some time, the nostrils are expanded into large cavities within the snout, and when the apertures are closed these pouches serve as reservoirs of air.

Writing of the great water-monitor Dr. Cantor states that it is "very numerous in hilly and marshy localities of the Malay Peninsula. It is commonly, during the day, observed in the branches of trees overhanging rivers, preying upon birds and their eggs and smaller lizards, and when disturbed throws itself from a considerable height into the water. It will courageously defend itself with teeth and claws and by strokes of the tail. The lowest castes of Hindus capture these lizards commonly by digging them out of their burrows on the banks of rivers for the sake of their flesh".

Sir V. Ball gives the following account of a meeting with a lizard of the same species in the Nicobars: "As I did not care to shoot him, though I wanted to capture him, I threw stones at him, whereupon he hissed and lashed his tail in a manner that might prove alarming to anyone not knowing the harmless nature alarming to anyone not knowing the harmless nature of the beast. As I was pressing him into a corner, he made a rush into the waves, but returned, apparently not liking the surf. Just as I thought he could not escape, he made a sudden dart into the water, dived through the surf, and disappeared".

From observations made on specimens in captivity, it appears that these lizards eat eggs by taking them in their mouths, raising their heads, and then breaking the shells, so that the contents are allowed to flow down their throats.

Although but little is ascertained regarding their breeding habits, monitors are known to lay white, soft-shelled eggs, which are sometimes deposited in the nests of white ants. As many as twenty-four eggs, of a couple of inches in length, have been taken from the body of a single female. By the Burmese these eggs are much



relished as articles of food, and command a higher price in the market than hens' eggs.

Gould's monitor (*V. gouldi*) is a well-known

Australian species. In colour it is brown above, with yellow spots on the back and limbs and yellow rings on the tail; yellowish, occasionally with black spots.



*Varanus varius* preying on kangaroo carcass. Merry Beach, NSW. Photographed by **Paul Latham**.



*Varanus niloticus*. Kazinga Channel, Queen Elizabeth National Park, Uganda. Photographed by **Kevin Arbuckle**.

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*Varanus bengalensis* juvenile. National Botanical Gardens, Dhaka, Bangladesh. Photographed by **Pallab Halder**.



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# ILLUSTRATIONS

## TELL HICKS

Websites: <http://tellhicks.weebly.com> ( *Europe* )

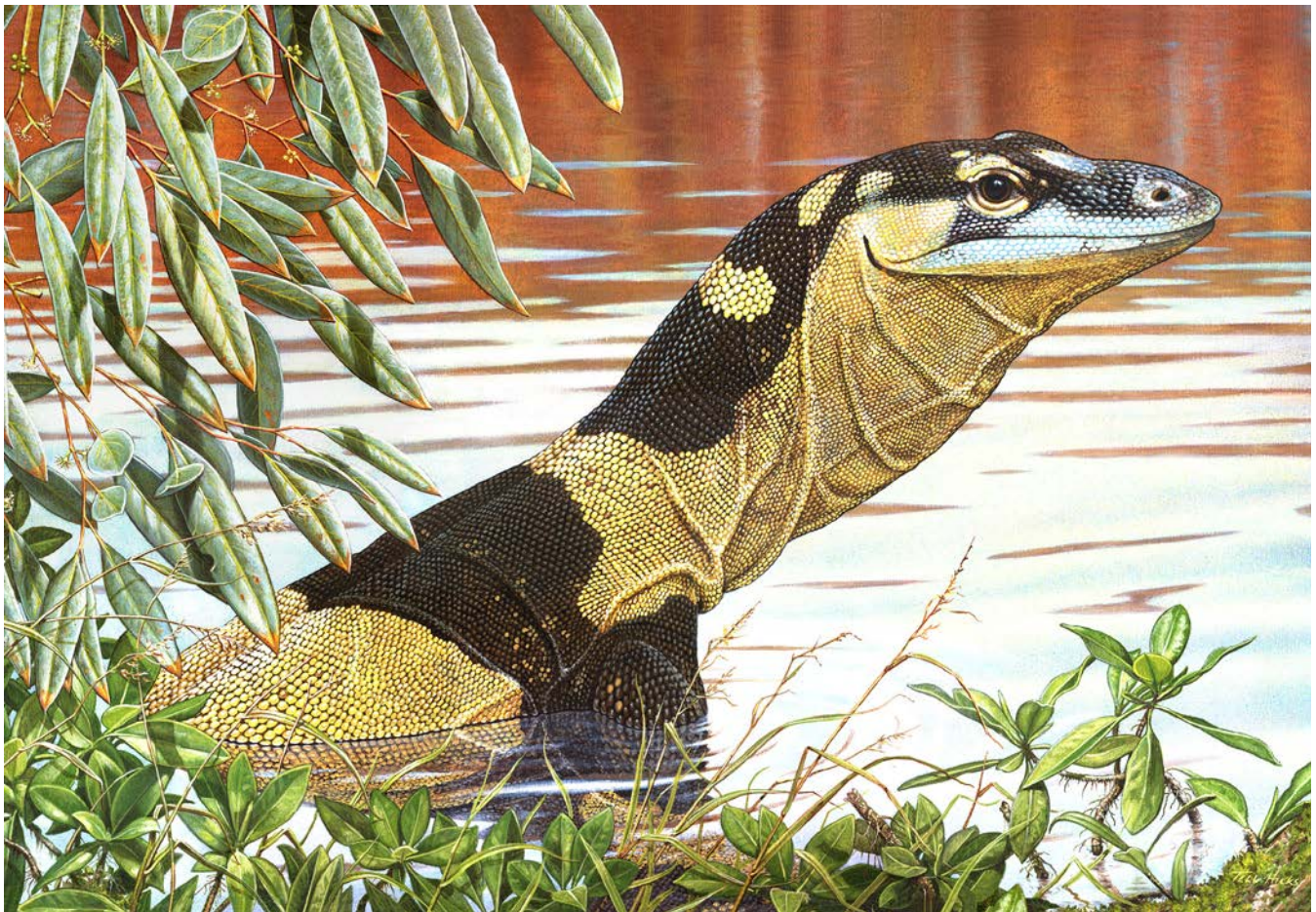
<http://www.reptileshirts.com> ( *USA* )

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Tell Hicks is one of the world's leading wildlife artists, specializing in reptiles and amphibians. He was a founding member of the International Herpetological Society in the 1960's, and has recently served as its President. In the 1960's he also assisted with field studies which gained legal protection for Britain's most endangered amphibians and reptiles. As a teenager, he worked in British zoos training and flying birds of prey, before eventually travelling overland through Europe and Asia, to Australia, catching and painting

amphibians and reptiles along the way. He lived in Australia for a year, travelling extensively throughout the country, and has returned on several occasions since to study its wildlife. Tell regularly gives talks to wildlife groups and natural history societies about his artwork, field trips and travels to such places as Turkey, Cyprus, the Canary Islands, Australia, New Zealand, the Galapagos Islands, Peru and the USA.

Tell's studio is located in Somerset, UK, where he lives with his wife and family. His fascination with



Lace monitor *Varanus varius* (Bell's form). Specimen ("Smiley") owned by the late Steve Irwin, Australia Zoo.  
Oil on canvas. 20 x 30" (ca. 51 x 76 cm).



reptiles and other wildlife continues to take him around the world, studying them in their natural habitat and gathering material for his detailed paintings. Tell's other work includes various wildlife subjects, landscapes and human portraits.

Despite being completely self-taught, he has won many major awards within the screen-printing industry for his t-shirt designs. He has been runner-up Wildlife Artist of the Year in the UK and still produces work for Eco and other leading t-shirt printers in the USA and Britain.

Examples of his artwork can be seen in several

museums. In the USA, the largest collection of his original paintings is currently displayed at the Chiricahua Desert Museum in Rodeo, New Mexico. Some of his other commissioned works include mosaics and sculptures. One such commission is of a sixteen foot sculpture of a rattlesnake tail at the Chiricahua Desert Museum, for which he collaborated with New Mexico state herpetologist Charlie Painter. For some time now, he has made regular trips to the USA, to exhibit paintings, to give talks, and to gather material for a collection of illustrations for a book on the rattlesnakes of Arizona.



Perentie *Varanus giganteus*. Oil on canvas. 16" x 20" (ca. 41 x 51 cm).





Emerald monitor *Varanus prasinus*. Depicted with birdwing butterfly *Ornithoptera priamus poiseidon*.  
Oil on canvas. 50 x 40 cm.





Komodo Dragon (juvenile) *Varanus komodoensis*. Specimen bred by Jim Pether, in the Canary Islands. Depicted with gliding lizard *Draco volans boschmai*. Oil on canvas. 30 x 20" (ca. 76 x 51 cm).