BIAWAK

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On the Cover: *Varanus mitchelli*

The Mitchell's water monitor (*Varanus mitchelli*) depicted on the cover and inset of this issue was photographed by **Lou Guillette** in the Yellow Waters Wetland Reserve of Kakadu National Park, NT, Australia on 16 April 2011. The individual, estimated to be 65-70 cm in total length, was observed from a boat during early morning (0830 h – approximately an hour and a half after sunrise) sitting on a paperbark tree that was surrounded by water for hundreds of meters in all directions. The wetlands were completely flooded at this time since it was the end of the rainy season.

There was another *V. mitchelli* on the backside of the tree which remained motionless and out of view. *Varanus mitchelli* are not commonly seen in the wild as they are quite secretive, but this individual remained still on the trunk as the photographer floated by in the boat. Just beyond this tree (ca. 50 m), was another very large paperbark tree on which sat a large white-bellied sea eagle (*Haliaeetus leucogaster*), which may be the reason why this individual posed perfectly and remained flat against the trunk while photographed.

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INTERNATIONAL VARANID INTEREST GROUP
www.varanidae.org

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*, a quarterly journal of varanid biology and husbandry, and is available online through the IVIG website.

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May 2011

Varanus panoptes panoptes courtship behavior. Townsville, Queensland. Photograph by **Jurgen Otto**.

NEWS NOTES

Invasive Nile Monitors May Be Declining in Cape Coral

A downward trend is beginning to be noticed among Cape Coral's population of alien Nile monitors (*Varanus niloticus*). While escapees are found all over Florida, it is believed that Cape Coral possesses the only breeding population. So far this year, no specimens have been captured. In 2010, only thirty specimens had been caught which represented a 32% decline from 2009 according to city biologist Kraig Hankins. Sightings have also been down in recent years: 120 in 2010 versus 151 in 2009. Officials believe last year's cold weather to have been a major factor in the continued declines. Exactly how eradication efforts have affected the population as well as whether the decline can be expected to continue are not known.

Source: News-press.com, 6 February 2011

Possible Parthenogenesis Observed in Prague Zoo Komodo Dragon

Aranka, a female Komodo dragon (*Varanus komodoensis*) housed at the Prague Zoo, has laid a second set of fertilized eggs without the aid of a male. After her partner died a year ago, keepers paired Aranka with another male though the two have never mated. A first clutch of six fertilized eggs (three of which appear to be developing) was laid last August and another five late this January. It appears that Aranka may join a succession of female dragons at other zoos which have successfully reproduced via parthenogenesis. However, zoo officials note that these might instead be instances of delayed fertilization from Aranka's deceased partner. Aranka is one of the most prolific dragons in captivity, having produced three previous clutches; a record tied only by a female kept at the National Zoo in Washington D.C.

Source: Prague Daily Monitor, 4 February 2011

Varanus olivaceus. Wingham Wildlife Park, Canterbury, England, UK.
Photograph by **Dominic Knower.**

Malaysian Customs Officials Seize Monitor Lizards

Malaysian officials seized a large shipment of more than 1,800 reptiles including Asian water monitors (*Varanus salvator*), as well as a number of threatened turtle species. This particular confiscation, made near the Thai border, was the largest of 2010 and totaled 4.3 metric tons of reptiles. No plans have been set for what will happen to the confiscated reptiles though it was noted that those found during previous seizures are typically auctioned off to dealers while protected species are handed over to the Wildlife and National Parks Department.

Source: Mongabay, 4 January 2011

Thai Wildlife Trafficker Arrested

One of Thailand's largest reptile poachers was arrested during a raid by the Thai Nature Crime Police. The raid of a warehouse in Ang Thong province, central Thailand uncovered over two-hundred illegally captured Asian water monitors (*Varanus salvator*) which authorities claim were destined to be shipped to Chinese food markets.

Source: The Straits Times, 17 February 2011

Young Komodo Dragons Go On Display at Zoo Atlanta

Two juvenile Komodo dragons (*Varanus komodoensis*) hatched last August at the Los Angeles Zoo have gone on display at Zoo Atlanta. Their addition complements the zoo's other resident dragon, an 18 year-old male which has been on display since 1993. Zoo Atlanta is a participant in the Komodo Dragon Species Survival Plan, though no information on the long-term future of the two has been announced.

Source: My Fox Atlanta, 20 January 2011

Krakatoa's Death Solved

According to veterinarian Darryl Heard, Krakatoa, the nine year-old Komodo dragon (*Varanus komodoensis*) which died last August at the St. Augustine Alligator Farm (see *Biawak* News Notes 4[3]), died from a viral infection. Neurological damage such as lesions and other changes in Krakatoa's spinal cord, as well as weakness in the legs, had been noted and have been attributed to the as-yet unknown viral infection. Krakatoa had been a popular draw at the facility over the years.

Source: Florida Times Union, 30 January 2011

Smugglers Busted in Thailand with 2,000 Lizards

Thailand officials have made the country's largest seizure of *Varanus bengalensis nebulosus* ever,

Varanus bengalensis combat. Yala National Park, Sri Lanka. Photograph by **Harsha Matarage**
harsha.matarage@gmail.com

Varanus bengalensis for sale in a market in Warora (Maharashtra), India. The tails are tied around their necks, and their lower jaws are broken and folded into their mouths. Photograph by **Jeff Wilson**, Museum of Paleontology, University of Michigan.

discovering more than 2,000 individuals smuggled in a series of utility vehicles heading for Bangkok. The live monitors, valueed at 1.8 million baht ($57,000 USD), were discovered when stopped by authorities in Prachuap Khiri Khan province, south of Bangkok. Customs officials believe the animals were destined for Chinese food markets.

Source: Abc.net.au, 8 April 2011

Three Komodo Dragons Missing from Surabaya Zoo

Three juvenile Komodo dragons, each approximately one year old and 50 cm in total length, have gone missing from Surabaya Zoo, Jakarta, Indonesia. Zoo officials state that dragons disappeared from their enclosure in early March and may have been eaten by predators, were stolen, or escaped. Trees in the enclosure have since been trimmed to prevent any further possible escapes from the more than 50 dragons kept by the zoo. Police investigations are ongoing.

Source: Asiaone.com, 23 March 2011

Suspect Arrested in Komodo Dragon Disappearance

Indonesian authorities have arrested a man suspected of attempting to sell juvenile Komodo dragons stolen from the Surabaya Zoo, Jakarta on 28 February 2011. Authorities received intelligence reports that the suspect attempted to sell a juvenile dragon that matched the characteristics of one of the three individuals which disappeared from the zoo. Information received from the suspect is expected to lead to further arrests.

Source: Jakarta Globe, 21 April 2011

Varanus acanthurus stuck in beer can. Namatjira Way, West MacDonnell Ranges, NT.
Photograph by **Owen Gale**.

41 Clouded Monitors Seized in Malaysia

Acting on as tip-off, Malaysian wildlife officials seized 41 clouded monitors (*Varanus bengalensis nebulosus*) from a house in Bukit Serok. Sources in the Department of Wildlife and National parks stated that the house had been raided on several occasions, but failed to result in the arrest of the suspect responsible for capturing the lizards. Officials suspect that the lizards were caught in a nearby oil plantation and were destined for food markets overseas.

Source: New Straits Times, 17 May 2011

Report from the Third Annual Meeting of the AG Warane

Unlike previous years, the third annual meeting of the AG Warane of the Deutsche Gesellschaft für Herpetologie und Terrarienkunde (DGHT) took place on 09-10 April 2011 at the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK) in Bonn. For the first time in the history of the AG Warane, the annual meeting lasted two days. This gave attendees enough time for conversation and exchange of experiences. An additional highlight of this year's annual meeting was a visit to the Cologne Zoo on Saturday afternoon with a guided tour through the Aquarium. Before attendees toured the zoo, two talks were held at the ZFMK in the morning. The program began with an informative talk by Frank Mohr (Würzburg) about the successful husbandry and breeding of *Varanus kordensis*, a rarely-kept tree monitor from New Guinea. In particular, his technical efforts and naturalistic terraria impressed the 35 attendees of the meeting.

Next, Ralf Sommerlad (Frankfurt) and Natascha Behler (Bonn) jointly reported on a unique conservation project in Southeast Asia, the Danau Mesangat on Borneo. Although their research focuses on the highly-threatened Siam crocodile (*Crocodylus siamensis*) and not monitor lizards, the talk attracted much interest. This compelled the advisory board of the AG Warane to financially support this ambitious project in Indonesia. The audience was impressed to learn about the adverse circumstances in which Natascha Behler, a young student of biology from Bonn, lived and carried out research for several months on Lake Mesangat in the eastern part of Indonesian Borneo (Kalimantan). In particular, Southeast Asian water monitors (*Varanus salvator*) and large river

Varanus salvator macromaculatus feeding on the carcass of a calf. Butterworth, Malaysia. Photograph by **Chris Li**.

Some of the attendees of the third annual meeting of the AG Warane.

turtles such as *Orlitia borneensis* have benefited from the new conservation status of the peat swamp area, even though local people still put much pressure on its reptile populations.

Following the morning talks and a lunch break, attendees drove to the Cologne Zoo where they were met by three keepers of the Aquarium. The keepers took their time while touring the attendees around and explaining the husbandry of various reptile species. Special attention was paid to a new enclosure housing the highly-threatened Philippine crocodile (*Crocodylus mindorensis*). In addition to the quince monitor (*V. melinus*), *V. prasinus*, *V. macraei* and *V. acanthurus* are also successfully kept and bred (see e.g., BIAWAK 4[3]: 82-92). The keepers also have high hopes for a pair of *V. spenceri*, which arrived at Cologne Zoo following a seizure. The feeding of the large male offered AG members the seldom opportunity to photograph this rarely-kept Australian species. After visiting the Aquarium, attendees enjoyed the rest of the zoo's grounds.

The program on Saturday was closed by a joint dinner in an Italian restaurant next to the Museum Koenig in Bonn. There, the conversation was dominated by various observations on the remarkable cognitive abilities of monitor lizards.

The second day of the meeting was opened with a talk by André Koch (ZFMK, Bonn) about the contributions of Wolfgang Böhme to monitor lizard research (see BIAWAK 4(4): 132-152). Next, Thomas Hörenberg (Stuttgart) reported on the husbandry and breeding of *Varanus t. tristis*. This interesting talk was followed by the general meeting of the AG Warane members. As in earlier years, the advisory board consisting of Kay Dittmar (Kahl) and André Koch (Bonn) was confirmed. This year's meeting ended with a guided tour through the Museum Koenig and its herpetological collection of monitor lizards. Accordingly, the attendees were fascinated to see such a high diversity of monitor species in one place.

The advisory board of the AG Warane gives sincere thanks to the speakers for their informative talks and to Thomas Ziegler and his team from the Cologne Zoo for their kind hospitality.

André Koch & Kay Dittmar

100 Water Monitors Rounded Up at Lumpini Park, Bangkok

Following a recent incident involving a water monitor (*Varanus salvator macromaculatus*) dropping from a tree in Bangkok's Lumpini Park onto the head of a woman, resulting in a wound from the claws that required stitches, Bangkok's city hall has decided that the Lumpini Park monitor population has grown too large (estimated at around 400 individuals) and should be reduced in size. Beginning 19 April 2011, 100 specimens were captured over the course of the next several days were transferred to the Wildlife Conservation Office at Bang Khen, and from there will be sent to Huay Kha Kaeng Wildlife Sanctuary in Uthai Thani.

Source: Wancharoen, S. Catch those pesky lizards. Bangkok Post, 7 May 2011.

Captive Monitor Lizards to be Banned in Dodge City, Kansas

Several categories of reptiles which the Dodge City Commission has added to a list of those banned from private ownership within the city limits are to include monitor lizards, *Varanus* sp. The move came after a recent incident involving an individual in possession of an alligator but was widened to include a number of forms "not considered common" including crocodilians, large constrictors, and monitors. No word at present on whether the ordinance will pertain to all members of *Varanus* or merely to those which attain large adult sizes.

Sources: Dodge City Daily Globe, 6 April 2011; BBC, 8 April 2011

ARTICLES

Biawak, 5(1/2), pp. 10-16

Solar Absorptance, Reflectance and Emissivity of the Skin of Lace Monitors (*Varanus varius*) in South-eastern Australia

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Abstract - The ability of lace monitors (*Varanus varius*) skin to absorb, reflect and re-radiate energy from the solar spectrum is briefly examined. The solar absorptance (formerly also known as 'absorptivity'), reflectance and emissivity across the solar spectrum were measured from the skin of ten living *V. varius* from south-eastern Australia (body masses 0.75–6.7 kg, mean 2.5 kg). Measurements were taken from the dark 'black' dorsal bands, dark 'black' ventral bands, pale 'yellow-cream' ventral bands, and the dorsal head. The lowest absorptance measured was the pale ventral band of an animal from coastal lowland forests (0.579) and the maximum was dark mid-dorsal skin (0.852), also on a coastal animal. The skin of animals from the higher, inland forest varied a little less, and absorptance ranged from 0.851 (head) to 0.647 (pale ventral skin). Energy reflectance spectra across the solar spectrum of 300 nm to 2500 nm (i.e., long-wave ultraviolet, visible, and near infra-red) were also measured and graphed. Emissivities of *V. varius* skin range from 0.971 (mean of mid-dorsum) to 0.955 (mean of dorsal head). Although solar absorptance shows more obvious variation in magnitude than emissivity, both absorptance and emissivity are highly significantly different between different parts of the body.

Introduction

The importance of solar radiation in the thermoregulation of heliothermic reptiles has been well investigated for a long time (*e.g.*, Cowles & Bogert, 1944; Regal, 1978; Terpin *et al*., 1979; Waldschmidt, 1980; Bartholomew, 1982). Consequently, I was interested to understand the efficiency with which *Varanus varius*, a large heliothermic predatory lizard in a temperate climate, manages to collect (and lose) solar energy at its first intercept—its skin.

Solar energy arrives at the Earth's surface in a broad spectrum of light, and more than half of the energy is contained in parts of the spectrum that are invisible to the human eye. Only 35–45% of solar energy arrives in visible light, less than 7% in the ultraviolet, about 47–57% in the near infra-red, and less than 1% in the far infra-red (Norris, 1967). Thus the visible coloration of *V. varius* clearly does not convey the complete story about how efficiently the animal is likely to be able to collect solar energy at its skin.

The ability of the skin of *V. varius* to absorb, reflect and reradiate the full spectrum of available environmental radiation is characterised by the absorptance of the skin and its emissivity. Solar absorptance is the ratio of 'total solar radiant flux absorbed by a body' to 'total incident flux' (Bligh & Johnson, 1973). Emissivity (ε) is the ratio of 'total radiant energy emitted by a body' to 'energy emitted by a full radiator (blackbody)' at the same temperature (Bligh & Johnson, 1973). A surface displaying unit absorptance (i.e. absorptance = 1) would be a perfect receptor of solar energy, and a surface with unit emissivity (ε = 1) would be radiating as a blackbody at that temperature. A surface with zero emissivity would be a perfect selective surface at the temperature of measurement (Pasquetti & Papini, 1978).

Methods

The animals measured came from two sites in south-eastern Australia in the southern part of the range of *Varanus varius*. Both sites are on the eastern side of the Great Dividing Range. Eight animals came from the Deua National Park in south-eastern New South Wales (35.958 S, 149.744 E, about 38 km west and inland from the coastal town of Moruya), with elevation ranging from 300 m to nearly 700 m above sea level. Two animals came from a more southerly site directly on the coast in the Croajingolong National Park (37.537 S, 148.685 E, near Mallacoota, Victoria), which ranges from sea level to 60 m.

To facilitate handling, animals were cooled in a constant temperature room to about 10° C (body and skin temperature) before measurement. Since a poor seal of the animal skin against the machine aperture may have led to inclusion of room light in the plotted spectra, measurements were conducted in a darkened room. The combination of these procedures also helped calm these large, powerful animals, which were being hand-held.

Varanus varius of body masses 0.75–6.7 kg (mean = 2.5 kg) were used. The same 10 animals were used for solar absorptance, solar reflectance and emissivity measurements. The method broadly follows that of Norris (1967), although I did not consider it necessary to apply Norris' 'shock' treatment to stimulate changes in skin color. This was because changes in the visible color of individual *V. varius* skins according to body temperature or other factors were not observed (unlike some other lizards such as the sympatric Australian eastern water dragon *Physignathus lesueurii*, which can vary widely in shade from dark to light according to body temperature; pers. obs.). Christian *et al.* (1996) also consider that there is no evidence for varanids being able to change their absorptance.

For all measurements, the animal being measured was held firmly over the measuring aperture (which is about 15 mm in diameter) until a stable reading or scan was obtained.

For each parameter (solar absorptance, reflectance and emissivity, see Fig. 1), three measurements were taken from each of the dark 'black' dorsal bands, the dark 'black' ventral bands, the pale 'yellow-cream' ventral bands, and the dorsal-head (avoiding the parietal-pineal complex) of the eight inland Deua and the two coastal Mallacoota *V. varius.*

Solar absorptance

Following the method of Harding (1978), solar absorptance (= 1 - solar reflectance) was calculated from the total light reflected from a Sylvania (USA) ELH300W, 120 W lamp measured with a Gier Dunkle type reflectometer at the Department of Applied Physics, University of Sydney. The spectrum of this light source is about equivalent to the solar spectrum. The reference standard for emissivity and solar absorptance was a copper metal film vacuum-sputtered onto a glass slide by

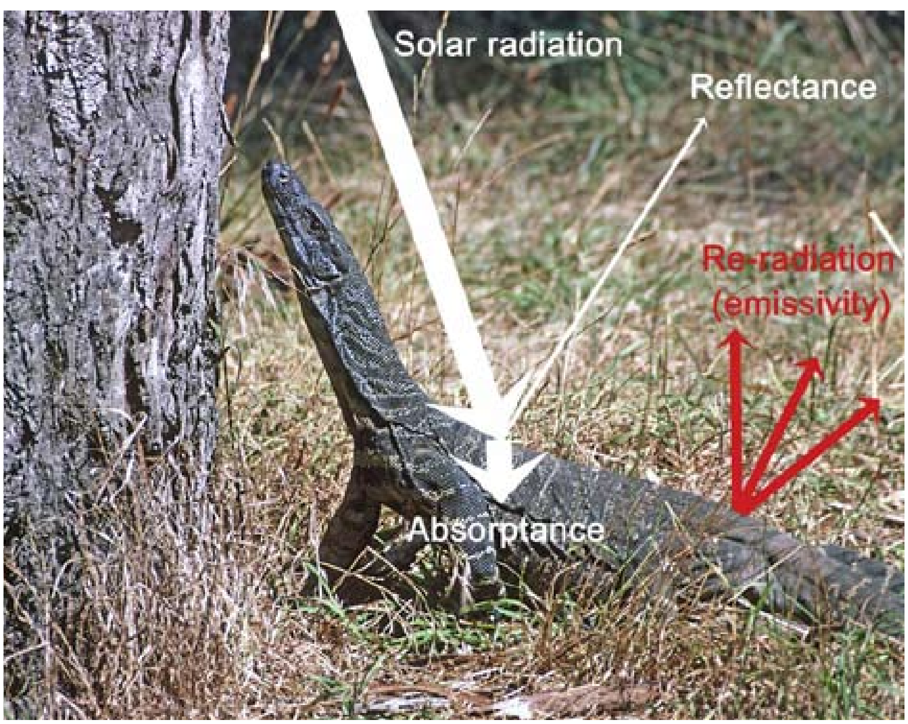

Fig. 1. A lace monitor in the sun**.** Solar radiation strikes the dorsal skin-surface of a lace monitor from coastal Mallacoota, with about 85% of the energy being absorbed (absorptance) and about 15% reflected (reflectance). At the same time, energy is being re-radiated from the skin (mostly in invisible infrared wavelengths), and the amount re-radiated depends on the emissivity (ε) of lace monitor skin (about 0.97) and the temperature of the skin (which can be physiologically controlled by the monitor, and may be different to its core body temperature).

the Department of Physics using the method of Harding (1976, 1978). The solar absorptance of the copper slide was taken as 0.90 and the emissivity of the slide as 0.98.

Reflectance spectra

Energy reflectance spectra of the skin of living *V. varius* were measured across long-wave ultraviolet, visible and near infra-red wavelengths (300–2500 nm) on a Beckman DK-2A spectrophotometer with reflectance accessory, at the Department of Theoretical Chemistry, University of Sydney. The reflectance reference standard was Halon G-80 with a 92% reflectivity across the spectrum of interest.

Emissivity

The Windbourne emissometer used for measuring emissivity was the Gier Dunkle type reflectometer maintained and operated by the Department of Applied Physics, University of Sydney (using the method of Nelson *et al.,* 1966; Harding**,** 1976, 1978). Calibration of the emissometer was checked after each animal was measured.

Results

A tabulation of solar absorptances and emissivities of the skin of living *V. varius* is given in Table 1.

Solar absorptance

There is a larger and highly significant difference among the mean solar absorptances of the skin of the four measured parts of the Deua animals. The mean absorptance of the skin of the Deua animals ranged from 0.836 (dorsal-head) to 0.703 (pale ventral skin), and Mallacoota animals from 0.850 (mid-dorsum) to 0.621 (the pale ventral band of one animal).

Reflectance spectra

The measured spectra of the reflectances of *V. varius* skin surfaces are shown in Fig. 2 following the convention of Norris (1967). Since the sample size for Mallacoota animals was so small (n=2), the range of spectra for the eight Deua animals was drawn first. As it happened, the dark dorsal skin and head skin spectra of Mallacoota animals fell within the range of the Deua animals. However, the pale ventral skin spectra of the two Mallacoota animals fell outside the range of the Deua monitors, and so a separate graph is drawn of the pale ventral color of the two Mallacoota animals.

Reflectance is highest in the visible spectrum (approximately 400–700 nm) and the early near-infrared, and subjectively corresponds with the brightness of coloration perceived by the human eye (*e.g.***,** the greatest reflectance is from the bright yellow ventral bands of the coastal Mallacoota animals). However, reflectance is very low in the longer infrared wavelengths of the measured spectrum (about 1850–2500 nm), and is similar at these wavelengths for all skin-types regardless of the visible color.

Emissivity

There is a small but statistically significant difference among the mean skin emissivities of the four measured parts of the body of the Deua animals. Mallacoota (lowland-coastal) animals appear to follow the same pattern, but there are too few replicates for valid statistical comparison. The emissivities of *V. varius* skin ranged from a mean of 0.971 for the mid-dorsum skin (both Mallacoota and Deua), to 0.955 (Mallacoota) and 0.957 (Deua) for the dorsal-head skin.

Table 1. Solar absorptance and emissivity of the skin surface of living *Varanus varius*

		Dorsal (Dark)		Ventral (Dark)		Ventral (Pale)		Head	
		Deua	Mallacoota	Deua	Mallacoota	Deua	Mallacoota	Deua	Mallacoota
Absorptance	Mean	0.825	0.85	0.773	0.779	0.703	0.621	0.836	0.845
	s.d.	0.143	—	0.344	—	0.464	—	0.082	—
	Range	0.804–0.842	0.848–0.852	0.722–0.804	0.756–0.802	0.647–0.789	0.579–0.663	0.825–0.851	0.845
	n	8	2	8	2	8	2	8	2
Emissivity	Mean	0.971	0.971	0.961	0.962	0.964	0.966	0.957	0.955
	s.d.	0.038	—	0.071	—	0.036	—	0.037	—
	Range	0.964–0.975	0.969–0.972	0.952–0.971	0.960–0.964	0.957–0.967	0.964–0.968	0.951–0.961	0.952–0.957
	n	8	2	8	2	7	2	8	2

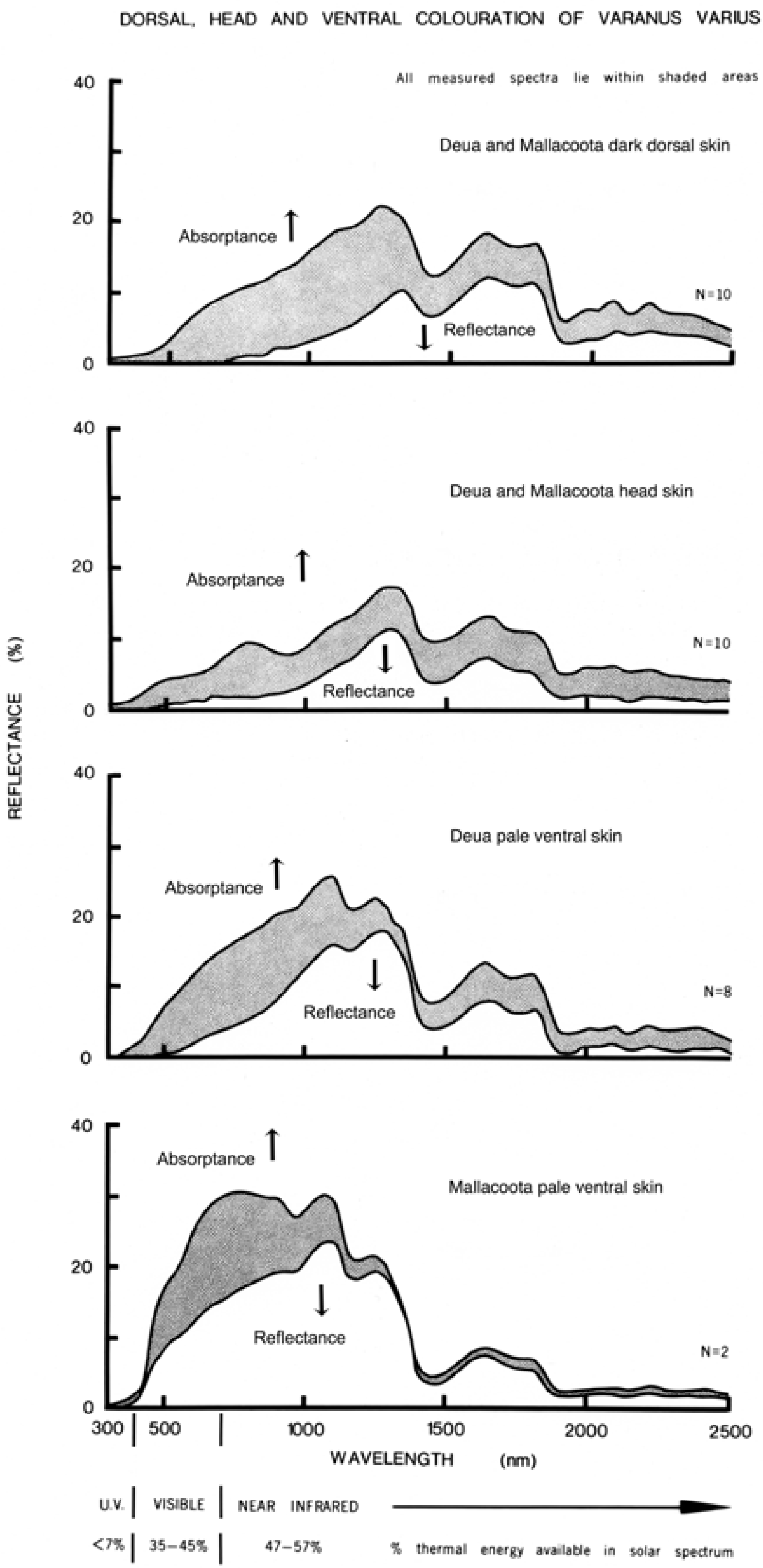

Fig. 2. Dorsal, head and ventral coloration of *Varanus varius*. The reflectance spectra of the dark dorsal, dorsal-head, and pale abdominal skin of Deua and Mallacoota *V. varius* are illustrated following the convention of Norris (1967). The reflectance spectra of the skin are the areas below the graphs, and the absorptance spectra are the areas above. The shaded portions cover the range of measurements from different animals in the sample.

One-way analysis of variance

A one-way ANOVA was carried out on the solar absorptance and emissivity measurements from the Deua *Varanus varius* (although, with n = 2, there were too few measurements from the Mallacoota sample to do the same).

Solar absorptance: $F_{[3,28]} = 32.77$; $p < 0.001$

Emissivity: $F_{[3,27]} = 11.88$; $p < 0.001$

Discussion

The solar absorptance of the living dorsal dark-colored skin of the body of Deua *V. varius* was 0.825, and 0.850 in Mallacoota animals. Thus the dorsal surface of the animal that is responsible for first intercepting the radiant energy was 83–85% efficient at retaining it and reflects only about 15% of the solar spectrum. Some differences occur because of the visible color of the skin, but all skin has similar and very low reflectance in the longer infrared wavelengths. The superficial, visible condition of the skin did not appear to influence absorption—freshly moulted animals were not obviously more 'efficient' than animals with skin that was old and dirt-covered. This is consistent with the long speculated view that visible coloration is not necessarily a guide to thermal capabilities of heliotherms, but may instead be for cryptic or other purposes (*e.g.*, Cole, 1943**;** Norris**,** 1967).

For the subjects of the present study, clean dorsal skin between the scales on the dorsal surface is black and it is the scales that are colored, ranging from bands where many scales are pale cream or yellow, to bands where scales may be as dark as the surrounding skin. The irregular and patchy nature of the pale and dark banding creates the lace-patterning effect that gives the animal its best-known common name of 'lace monitor'. On the ventral surface, both skin and scales are predominantly yellow or cream, irregularly interspersed with darker bands (Weavers**,** 2004).

Despite the small sample (especially of coastal animals), these measurements coincide with my own subjective observations that — at least in the southern part of the range — inland animals appear less brightly colored and less 'contrasty' the further from the coast that they originate. I find this most noticeable when comparing animals from west of the Great Dividing Range with those from coastal East Gippsland (particularly in the broad ventral yellow bands). Unfortunately, however, I was unable to measure and compare any animals from west of the Great Dividing Range. No 'Bell's monitor' was available either to test my subjective opinion that the striking broad cream and black dorsal bands of this morph of the species has less color saturation and contrast than the skin colors of coastal animals.

The re-radiation of thermal energy, a major pathway for heat loss, occurs at very long infrared wavelengths (corresponding to body temperatures between about 283–313 K or 10–40° C) and is indicated by the emissivity value. Emissivities of the skins of living *V. varius* from the lowland and elevated sites were within the range 0.95–0.98 at all measured parts of the body at about 10° C (283 K), meaning that the skin of *V. varius* re-radiates long-wavelength thermal energy very 'efficiently'. These figures are typical for many terrestrial animals, including humans ($\varepsilon = 0.98 \pm 0.01$ reported by Steketee**,** 1973). Such high emissivities would be desirable for overheated lace monitors suffering heat stress and needing to lose heat, but undesirable in situations where a monitor is trying to conserve body heat in a cooling environment. So, in situations where a lace monitor is trying to conserve body heat in a cooling environment, it may physiologically restrict the blood flow to and from the skin, thus thermally isolating the body core and allowing skin temperatures to drop with less effect on the core temperature.

In extreme ambient conditions significantly outside the 'operating temperature range' (32.8 to 36.4° C) for *V. varius*, air temperatures, wind, and substrate may also play significant roles (Weavers**,** 2004). Limiting blood flow to and from the skin when trying to conserve body heat would also limit other thermal losses via convection and from conductive contact with a cooler substrate.

My method of measurement differs from Horn (2007), and so our results can only be compared in a very general way. Horn used shed-skin for his measurements, through which some light can pass (transmission, T), some is reflected (reflectance, R), and some is absorbed (absorptance, A) (with the formula suggested by Horn being $1 = T + R + A$). Although this is obviously a very valuable method of measuring reflectance and absorptance from many species of varanids that could not otherwise be measured, the shed skin samples will not have exactly the same characteristics as living skin that is still attached to a live goanna. For instance, moisture content, body oils, the effects of sub-dermal vascularization and other factors will be different. With the living *V. varius* in my measurements, the layers of living skin ultimately absorb all the solar energy that is not reflected at the skin surface, and so I only measured reflectance and absorption (1 = R + A). Consequently, I have no measurement of 'transmission'. In a sense, all the energy that is not reflected can be said to be 'transmitted' through the skin to the body of the goanna.

If absorptance, reflectance and emissivity are factors that can be selected for (rather than simply being fundamental properties of vertebrate skin-tissue), then these factors for thermoregulation are likely to be selected for more strongly in goannas of temperate terrestrial environments, because these environments typically experience greater extremes (and more rapid changes) in ambient environmental conditions.

Although lace monitors are found from temperate zones to the tropics, my own studies are confined to animals from a temperate climate.

In temperate environments, enhanced warming ability for a goanna is going to frequently be useful and, occasionally, an enhanced cooling capacity will also be valuable. Temperate conditions contrast with environmental conditions in the tropics: in the tropics, air (and water) temperatures are relatively high, but have less variation across the day or between day and night, and so absorptance, reflectance and emissivity may be less significant for thermoregulation. A quite different set of conditions prevail in many open arid habitats, where high insolation and great extremes in environmental temperatures occur. In these situations, ability to avoid heat overload might be very useful, for example by reflecting more of the incoming radiation, or perhaps reflecting energy that is being re-radiated from the ground beneath the animal.

But as Christian *et al*. (1996) and Horn (2007) found, absorptances of varanids are not readily explained by the climate they live in (*e.g.*, some tropical species have high absorptances). Horn also suggests that other factors may have been involved in selecting for particular color patterns (*e.g.*, camouflage from predators, especially when young, and camouflage from prey throughout life). I imagine that even the ventral surface of a lace monitor may be relevant in camouflaging this predator from small ground-dwelling prey that will be looking upwards towards the brightness of the sky. Or perhaps the coloration is relevant for mating rituals? Horn remarks that *V. varius* presents a 'bundle of problems' because the species displays a very wide range of reflectances and absorptances (across various color-morphs) that do not seem closely related to the particular climate or habitat where an animal comes from, and Bartholomew (1982) regards behavioural factors such as posture and where the animal locates itself as "...quantitatively more important than the effects of changes in reflectance".

In full sunlight, the radiant solar energy from above a lace monitor will provide the greatest thermal load for it (and more than half of this energy is in the invisible infrared spectrum). The visible coloration of the ventral surface will be even less significant for thermoregulation because the re-radiated heat-energy from hot ground is predominantly in the infrared spectrum (not the visible). So the visible colors of a lace monitor — on either dorsal or ventral surfaces — do not seem to be adequately explained by thermoregulatory factors alone.

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References

Bartholomew, G.A. 1982. Physiological control of body temperature. Pp. 167-211. In Gans, C. & F.H. Pough (eds.), Biology of the Reptilia Vol. 12. Academic Press, New York.

Bligh, J. & K.G. Johnson 1973. Glossary of terms for thermal physiology. Journal of Applied Physiology 35: 941–961.

Christian, K.A., G.S. Bedford & S.T. Shannahan 1996. Solar absorptance of some Australian lizards and its relationship to temperature. Australian Journal of Zoology 44: 59–67

Cole, L.C. 1943. Experiments on toleration of high temperatures in lizards with reference to adaptive coloration. Ecology 24: 94–108.

Cowles, R.B. & C.M. Bogert 1944. A preliminary study of the thermal requirements of desert reptiles. Bulletin of the American Museum of Natural History 83: 261–296.

Harding, G.L. 1976. Sputtered metal carbide solar-selective absorbing surfaces. Journal of Vacuum Science and Technology 13: 1070–1072.

Harding, G.L. 1978. Sputtered metal silicide solar selective absorbing surfaces. Journal of Vacuum Science and Technology 15: 65–69.

Horn, H.-G. (2007). Transmission and reflection spectra of shed skin of various varanids in the UV, VIS and IR and their intra- and interspecific meaning. Pp. 291-303. In**:** Horn, H.-G., W. Böhme & U. Krebs (eds.), Advances in Monitor Research III, Mertensiella 16; Deutsche Gesellschaft für Herpetologie und Terrarienkunde e.V., Rheinbach.

Nelson, K.E., E.E. Luedke & J.T. Bevans 1966. A device for the rapid measurement of total emittance. Journal of Spacecraft and Rockets 3: 758–760.

Norris, K.S. 1967. Color adaptation in desert reptiles and its thermal relationships. Pp. 162-229. In: Milstead, W.W. (ed.), Lizard ecology: a symposium. University of Missouri Press, Columbia.

Pasquetti, R. & F. Papini 1978. Thermal conversion of solar radiation. Theoretical performance of collectors furnished with an absorbent selective surface. Solar Energy 21: 129–138.

Regal, P.J. 1978. Behavioral differences between reptiles and mammals: an analysis of activity and mental capabilities.Pp. 183-202**.** In Greenberg, N. & P.D. MacLean (eds.), Behavior and neurology of lizards. National Institute of Medical Health, Maryland, USA.

Steketee, J. 1973. Spectral emissivity of skin and pericardium. Physics in Medicine and Biology 18: 686.

Terpin, K.M., J.R. Spotila & R.E. Foley 1979. Thermoregulatory adaptions and heat energy budget analysis of the American alligator, *Alligator mississippiensis*. Physiological Zoology 52: 296–312.

Waldschmidt, S.R. 1980. Orientation to the sun by the iguanid lizards *Uta stansburiana* and *Sceloporus undulatus*: hourly and monthly variations. Copeia 1980: 458–462.

Weavers, B.W. 2004. *Varanus varius*. Pp. 488-502. In Pianka, E.R., D.R. King & R.A. King (eds.), Varanoid Lizards of the World. Indiana University Press, Bloomington.

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Mating and Intraspecific Behavior of *Varanus salvator macromaculatus* in an Urban Population

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Abstract - Very little literature exists on mating events or intraspecific behavior of wild *Varanus salvator*. Populations in urban environments allow observation of behaviors rarely seen in the wild because of improved visibility and habituation to human presence. This study documents combat, pre-courtship, courtship, and mating behaviors, including polyandry and polygyny, and addresses seasonal variation in intraspecific interactions, among *V. salvator macromaculatus* in an urban park in Bangkok, Thailand.

Introduction

In May 2008, courtship and mating was observed in a wild population of water monitors, *Varanus salvator macromaculatus* at the Dusit (Bangkok) Zoo in the Dusit District of Bangkok, Thailand. The timing of observations was chosen based on prior observations of hatchlings, back-estimated on the basis of reproductive chronology (Andrews and Gaulke, 1990; Gaulke and Horn, 2004) and what Kratzer (1973) reported about incubation time. The site may support the highest population density of *V. salvator* in Thailand (pers. obs.); one census counted 36 adults (> 1.25 m in total length [TL]) within 0.25 km^2, corresponding to a density of 144 adults per km^2 (Cota unpl. data). Counts of juveniles were not made due to their cryptic behavior.

The Dusit Zoo is 0.25 km^2 in area, with waterways forming two islands (Fig.1). One island is located in the middle of a large pond located at 13° 46’ 15” N 100° 30’ 58” E, 11 m elev. Many of the largest individuals reside here and most of the observations during this study were made on this island. The other island supports a number of bird aviaries and has only a small strip of land accessible to the monitors (Fig. 1). The water originates from a canal system pervading Bangkok, which merges with the Chao Phraya River within 2 km of the zoo. Flood gates prevent tidal along with river level fluctuations and maintain relatively stable water levels. Monitors can access other parts of the city using

Fig. 1. Dusit (Bangkok) Zoo, a resource rich urban environment which contains a *Varanus salvator macromaculatus* population of high density. Image: Google Earth.

Fig. 2. Pair of large *V. salvator macromaculatus* mating.

the canal system. Populations seem to be fairly static and individual monitors are recognizable. The largest resident was a male of ca. 250 cm TL.

The urban environment differs in comparison to typical natural habitats of *V. salvator*, offering very limited shallow water areas, large open expanses without visual barriers, and physical barriers such as walls and fences. The population at the Dusit Zoo is generally undisturbed by humans and the animals are not wary, allowing observations of behaviors not often possible to observe in other areas (Fig. 2).

Resource-rich area

The reason why the Dusit Zoo has such a high density of *V. salvator macromaculatus* is most likely because water monitors are the top predator locally and the area is rich in available resources. Although there may be frogs, occasional rodents and human refuse to augment their diet, *V. salvator macromaculatus* in this population feed primarily on fish. Live fish are caught in open water (Fig. 3) or in aggregations formed when they are fed by humans (pers. obs.); dead fish are also taken from the water (pers. obs.). *Malayemys macrocephala* have been recorded as being eaten in Bangkok (Bundhitwongrut *et al.*, 2008), but turtle predation was not observed in this study, even though there are large numbers of *Heosemys annandalii* and *Trachemys scripta elegans* present.

Resources available to monitor lizards at the zoo provide more than mere sustenance. The zoo has numerous natural and artificial basking areas. Nesting areas are relatively safe, since there are no other egg eating predators, except for other *V. salvator macromaculatus*, which normally do not venture far from the water, even to raid nests; additionally, nest sites on the zoo grounds are higher in elevation. Whereas much of the remaining natural habitat in the Chao Phraya flood basin is underwater during the rainy season (June to November), the Dusit Zoo is safely situated above flood levels, adding further safety to eggs.

Fig. 3. A large adult *V. salvator macromaculatus* emerging the water with a large live *Talapia* it has caught.

Triggering of the mating season

The first heavy rains preceding the rainy season appear to trigger the mating season in *V. salvator macromaculatus*, at least for populations in Bangkok and the Chao Phraya flood basin. Mating behavior was observed after an exceptional week-long period of continual heavy rain in March 2008. Additional mating events have been observed even earlier and may have also been brought on by unusual weather events. Thus, the first heavy rains at the end of the long dry period of the cold season (November to February) and the hot season (March to May) may trigger hormonal changes in both males and females. Studies of this potential relationship in *V. salvator* are unfortunately lacking. The mating season of the monitors in Bangkok and the Chao Phraya flood plains may differ from that of populations in Eastern or Southern (peninsular) Thailand, which experience different climates. Whereas Bangkok has a distinct rainy season, usually from May to October, Eastern Thailand receives a much higher annual rainfall and Southern Thailand has only two seasons, with the rainy season lasting from April to November or December.

Social interactions

Males in this population and possibly other populations appear to have an established hierarchal rank of dominance. This hierarchy rank appears to be based primarily on size. Dominance behavior in smaller individuals is rare and usually limited between individuals of similar size. There is little sexual dimorphism between male and female *V. salvator macromaculatus*; however, in sexually mature male specimens, very slight differences can be seen by observing the width of the snout, jaw line, slight bulging in the tail base and overall length.

Intraspecific aggression was observed outside the mating season when females rebuffed the advances of males at other times of the year. In this case, the female inflates the throat, laterally compresses the body, slightly arches the back (fig. 4), hissing and if the male comes too close, the female uses the tail to whip the male or runs into the water. Hierarchical rank appears to be rarely attained by conflict, with the larger male usually attaining dominance by size alone, which appears to intimidate smaller individuals. Occasionally, a large male would make a short run of usually no more than a few meters and chase off a smaller male. Establishment of hierarchical rank and male-female compatibility outside the mating season possibly occurs at a constant low level of aggression, which may contribute to the near lack of intraspecific aggression during the mating season.

Scent marking

Scent marking has been observed on two occasions during the mating season by two large males; however, one large male was not large enough to be of the size of those that were observed to commonly succeeded in mating. One male (no larger than 2 m) rubbed the bottom and side of the neck, as well as the anterior side of the torso against a small tree (ca. 2.5 m in height) (Fig. 5a-5c). Only smaller sexually mature individuals (ca. 1.5-1.8 m TL) appeared to take any notice of these markings (Fig. 5d). Those that took notice spent many minutes investigating the scent before moving on. In this population there were no signs of territoriality, primarily due to the dense population. Additionally, the individual that marked the small tree was too small to

Fig. 4. Unreceptive female display. Photograph by **Michael Cota**.

Fig. 5. A, B, C) Scent marking;. D) Small sexually mature individual investigating scent marking. Photographs by **Michael Cota**.

Fig. 6. Scent marking my large male. Photograph by **Michael Cota**

Fig. 7. *Varanus salvator macromaculatus* in ritual combat. Photograph by **Michael Cota**.

claim one of the areas of highest population density, where much larger conspecifics up to 2.5 m (TL) are frequently present, so it appears to rule out marking of territory. In the other case, an old large male (ca. 2.2 m TL) scent marked the base of a large fig tree in an area where there were no other monitor lizards in the vicinity (Fig. 6). Scent marking behavior in *V. salvator* has not been studied and requires further investigation.

Pre-courtship behavior

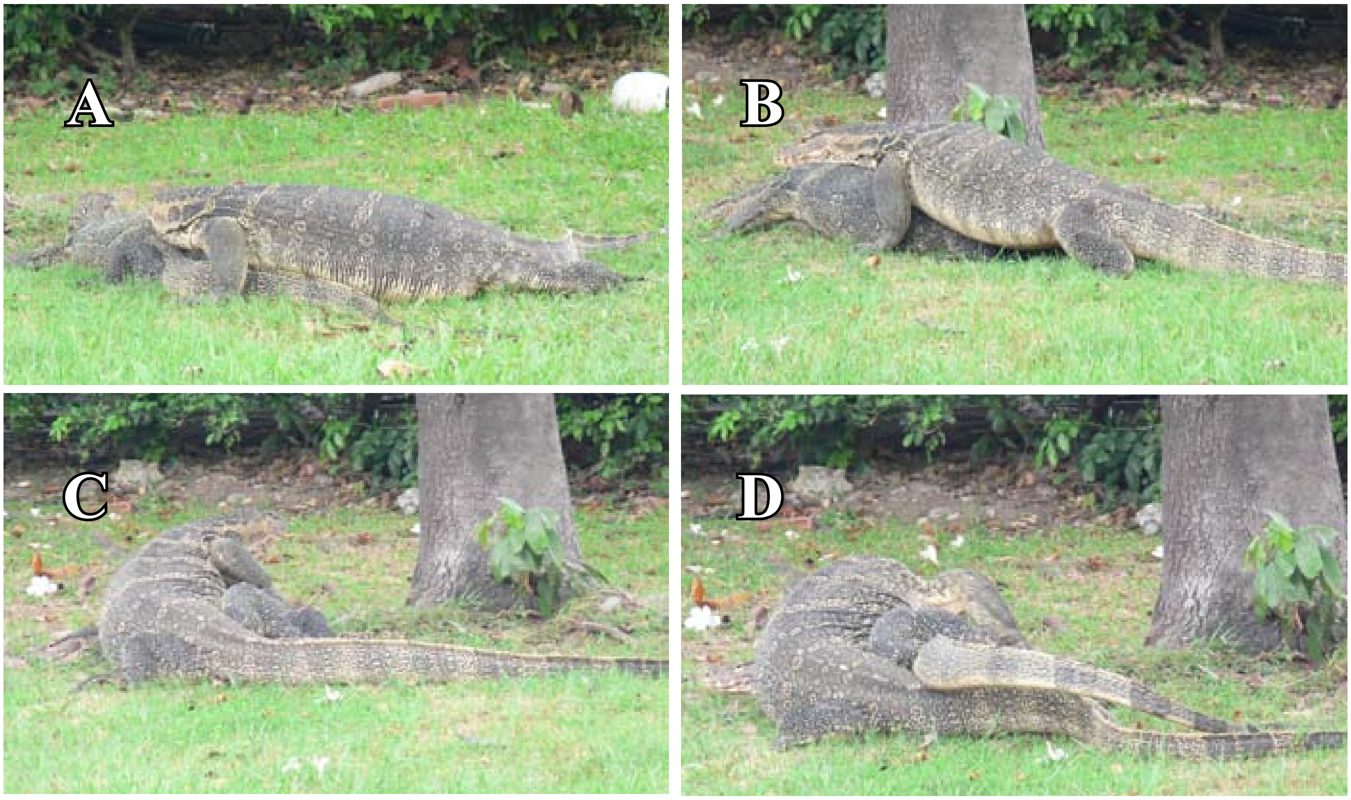
When two *V. salvator macromaculatus* approached each other, one always gave way to the other, usually to a larger male. When more than one male was in the vicinity of a potentially receptive female, the largest was usually the only one to approach. Smaller individual males closely watched its actions from nearby. Not a single act of aggression between males was observed on the numerous occasions when multiple males were in close proximity to a potentially receptive female. The only case of ritual combat seen between males during this observations occurred where there was no female in the vicinity (Fig. 7). The reason for the ritual combat is unclear.

Courtship behavior

Females were approached by males, from either side at the rear quarter or from behind. Females rejected male advances shown a defensive posture or taking defensive action. Defensive posture consisted of throat inflation, lateral compression of the body, hissing, and turning the head to observe the oncoming individual. Receptive females that were on the move proceeded slowly. Receptive females that were already prone, lying with the ventral region of the body downward, against the ground, remained prone and appeared submissive (Fig. 8a).

Despite the defensiveness of females, males continued to approach females until they retreated into the water. If a female is receptive to the male's advances, the male moves along adjacent to the tail of the female or straddles the female's tail with legs of one side. A completely submissive female will keep her head down to the ground and may close her eyes as the male continues anteriorly, while constantly tongue flicking her. Tongue flicking reaches its greatest frequency when the male's head reaches the neck and head of the female as the male places his head on top of the female's. The male's pelvis is positioned either to the left or right of the female's pelvis. Whatever side the female is on in relation to the male, the male will raise that leg over the female's tail base and attempt to lift the tail. Females that are not receptive will move out from under the male at this time. A receptive female, on the other hand, keeps her head low to the ground and lifts her tail, at which point the male will maneuver his pelvis underneath the female and insert one of his hemipenes. After copulation begins, the male's head is generally positioned above the female, often making lateral jerking movements (Fig. 8b-8d).

Mating behavior has not been documented in any other wild population of *V. salvator* and was only recently recorded on film (*Lizard Kings*, Kaufmann Productions, 1999). This is not surprising, since most wild *V. salvator* are extremely wary of human presence. Most of the mating events in these observations were on land; however, it is possible that *V. salvator macromaculatus* in other populations prefer to mate in shallow water. Herrmann (1999) reported copulation in captive *V. salvator* Cologne Zoo in the water basin or at the edge of the water basin. A pair of *V. salvator* was found in a small pool on the second floor of a restaurant adjacent to the water (Fig. 9).



Figs. 8a, b, c, d. Male *V. salvator macromaculatus* maneuvering to mate with a receptive female. Photographs by **Michael Cota**.

Polyandry and polygyny

A total of ten cases of polyandry and polygyny were observed. In the most extreme case observed, four males surrounded a single female (Fig. 10). Of these four males, three successfully mated with the female before she escaped into the water. Such numerous cases of polygyny and polyandry suggest that there is no pair bonding in this species, as has been suggested may be the case with individuals other species, such as *V. komodoensis* (Auffenberg, 1981) and *V. bengalensis* (Auffenberg, 1994).

Of the eight observed cases of polyandry, six involved a male attempting to interrupt a copulating pair. Although already copulating males appeared to show some signs of distress, such as reacting to another approaching male by moving their head away from the female's and moving the neck and head to face the oncoming male, they were unable or unwilling to take any action and most pairings were not broken. This was the case even when a male mounted an already copulating pair, effectively mounting the male (Fig. 11). In the three cases observed where a copulating pair was broken up, it was always done so by a much larger male.

There were only two observed cases of polygyny, where males moved on to other females and were observed doing so. This was much more difficult to observe than the polyandry, since males often surrounded the females. It is possible that there were more cases, which could have only been recorded by tracking individual males.

Fig. 9. *Varanus salvator macromaculatus* pair mating in a shallow artificial pond of water. Photographs by **Michael Cota**.

Fig. 10. Four male *V. salvator macromaculatus* surrounding a female, 3 of which successfully mated with the female before she escaped into the water. Photographs by **Michael Cota**.

Fig. 11. Male *V. salvator macromaculatus* mounting a copulating pair. Photograph by **Michael Cota**.

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References

Andrews, H.V. & M. Gaulke. 1990. Observations on the reproductive biology and growth of the water monitor (*Varanus salvator*) at the Madras Crocodile Bank. Hamadryad 15(1): 1-5.

Auffenberg, W. 1981. The Behavioral Ecology of the Komodo Dragon. University of Florida Press. Gainesville. 406pp.

Auffenberg, W. 1994. The Bengal Monitor. University Press of Florida. Gainesville. 561pp.

Bundhitwongrut, T., Saguensab, S., Thirakupt, K. & O.S.G. Pauwels. 2008. A case of predation oft he water monitor *Varanus salvator* on the western snail-eating turtle *Malayemys macrocephala* (Reptilila: Varanidae & Bataguridae) in Bangkok. Biawak 2(3): 106-108.

Gaulke M. & H.-G. Horn. 2004. *Varanus salvator* (Nominate Form). Pp. 244-257. In Pianka, E.R., D.R. King & R.A. King (eds.), Varanoid Lizards of the World. Indiana University Press, Bloomington, Indiana.

Hermann, H.-W. 1999. Husbandry and captive breeding of the water monitor, *Varanus salvator* (Reptilia: Sauria: Varanidae) at the Cologne Aquarium (Cologne Zoo). Pp. 95-104. In H.-G. Horn & W. Böhme (eds.), Advances in Monitor Research II, Mertensiella 11. DGHT, Rheinbach.

Kratzer, H. 1973. Beobachtungen über die Zeitgungsdauer eines Eigeleges von *Varanus salvator.* Salamandra 9(1): 27-33.

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Mertens, R. 1960. Seltene Gäste im Zoo: Der Papua-Waran. Kosmos 56: 547-549.

Rare Guests in the Zoo: The Papua-monitor

ROBERT MERTENS

Translated by PAUL GRITIS

"I was rather surprised when there came a call from the animal import firm of Andreas Werner in Munich that they were in possession of a *Varanus salvadorii*, for the first time in captivity. Recently the Australian press had treated this animal as a mythical beast, similar to the Loch Ness monster or to Siegfried's Dragon. In spite of the high price I decided to go to Munich, where I immediately bought the wonderful beast, and brought it back to Stuttgart. It was very gratifying that this zoological treasure came to Germany, because an extremely high bid was made on behalf of the Sydney Zoo. It is a creditable reflection on the honor of Reverend Cribb that he did not accept the higher offer, but kept his promise to send the first "Papua monitor" caught to Herrn Schultze-Westrum, from whom it arrived at the Werner firm, and then to the "Wilhelma" (Zoo).

At the "Wilhelma" the monitor developed a good appetite (every third day it devours ca. 600 g of meat and a few eggs) and became somewhat obese in a short time. It is hoped that it will survive here a long time, and enable valuable observations to be made on a living specimen".

– *A. Schochle* (Director, "Wilhelma" Zoo).

Early in July the sensational news was spread by the press, by radio, and even by television, about the giant lizard from New Guinea. The "Wilhelma" (Zoo) in Stuttgart had acquired the animal from the animal import firm of Andreas Werner in Munich and placed it on exhibit. The author was notified of this by the director of the "Wilhelma", Herrn Albert Schochle, and was kindly invited to answer questions at a press conference.

To the herpetologist, the lizard displayed at the "Wilhelma" was truly a treasure. It clearly was a member of the well known family of monitor lizards (Varanidae), those carnivorous lizards of about 30 species of various sizes living in the warm regions of the Old World — from Australia to southern Asia to Africa. This particular species is notable not only because of its large size, but also because it is one of those species whose life history is almost completely unknown. The Papua-monitor (its German name) or as it previously observed alive by a herpetologist! Thus the "Wilhelma" specimen was the first of the species captured alive and displayed in a zoological garden. Besides, *V. salvadorii* is represented in very few museum collections. Among German museums only the one in Berlin has a specimen, a young animal preserved in alcohol, one which, as I discovered, had been misidentified as another species. In addition to this one, the Senckenberg Museum in Frankfurt am Main has a few elements of the jaw bone preserved. The type, that is, the specimen that *V. salvadorii* was originally described from, is in the Civic Museum of Natural History "Giacomo Doria", in Genoa, Italy. This animal was part of the collection made by Dr. Odoardo Beccari; it was collected in 1875 near Dorei in northwestern New Guinea. It was scientifically described three years later jointly by Wilhelm Peters, at that time director of the Zoological Museum in Berlin, and by Marchese Giacomo Doria, the great patron of, and at that time also the director of, the Natural History Museum in Genoa. The monitor was named in honor of Count Tomasso Salvadori, the greatest Italian ornithologist.

In its dimensions *V. salvadorii* ranks below the largest monitor lizard, as do all other lizards. This giant is the famous Komodo monitor (*V. komodoensis*) from the islands of Komodo and Flores, as well as two other nearby islands. The maximum length actually observed- in contrast to statements in the popular literature — is no more than 3 meters; this is valid for the largest accurately measured specimen, a male, which the author brought back from Rintja Island to the Senckenberg

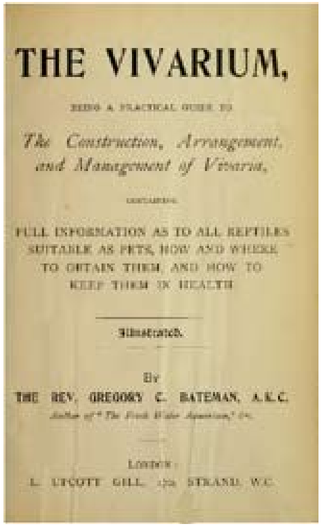
Museum and placed on display. A very magestic specimen may still be seen at the Frankfurt Zoological Garden. The next largest monitor, in length but not in mass, to the Komodo monitor, is the banded monitor (*V. salvator*). This monitor is widely distributed in southern Asia and the Sunda Archipelago. The Papua-monitor may agree closest in maximum length to the Australian "perentie" (*V. giganteus*) or to the African Nile monitor (*V. niloticus*): both species may reach 2.4-2.5 meters in length. The largest specimen of *V. salvadorii*, based upon a skin in the American Museum of Natural History in New York, was determined by the author (1950b) as 2.25 meters in length. The Papua-monitor at the "Wilhelma" is probably not completely grown and is smaller.

In addition, the Papua-monitor has two other noteworthy characters: first, the head is fairly large and in lateral view shows a strongly vaulted muzzle, and secondly, the tail is very long. The head, because of its shape and the position of the nostrils, is somewhat similar to that of the Komodo monitor. The skull of *V. salvadorii* examined by the author (1950b) is certainly more slender and gracile than that of *V. komodoensis*. The long and pointed teeth of *V. salvadorii* are especially noteworthy for being implanted nearly perpendicularly in the jawbone, in contrast to those implanted at an angle in *V. komodoensis*. The most notable feature of *V. salvadorii* however, is its long, whiplike tail, the relative length of which is not equaled or exceeded by any other monitor. The tail is about 2.5-2.6 times as long as the head and trunk. Therefore the Papua-monitor appears quite graceful and not so massive as other large varanids, in one of which the tail is twice as long as the head and trunk. The tail of the Papua-monitor is noteworthy in another aspect: in cross-section the tail is not particularly rounded, as it is in many small monitors, it is quite low (dorso-ventrally) and slightly laterally compressed. Therefore the Papua-monitor differs from many other varanids with strongly laterally-compressed tails, which may serve as a rudder during swimming. This suggests that *V. salvadorii*, unlike many other members of the genus (e.g., *V. mertensi*, *V. salvator*, and *V. niloticus*) does not lead a largely amphibious way of life. The "Wilhelma" animal always holds its tail rolled spirally, leading to the assumption that *V. salvadorii* is actually arboreal and uses its tail to hold onto branches. Also, the heavy, strongly curved claws would serve better for a life in the trees than one on the ground.

The coloration and pattern show nothing distinctive. As in many other varanids, the Papua-monitor is blackish dorsally with oval, yellowish-white flecks arranged in transverse rows across the back. At the sides of the throat are many flaps of skin. Possibly these may communicate with each other and serve to inflate a gular pouch as a defensive reaction. Or perhaps they only serve to allow expansion to assist in the swallowing of large food items. The specimen at the "Wilhelma" would [take] quite large pieces of horsemeat without hesitation before numerous spectators, after it had tasted the meat with its long, whitish tongue. In the wild small mammals, birds and their eggs, frogs, and probably other small animals may be taken.

Details about the circumstances of capture of the "Wilhelma" specimen were relayed to us by the Reverend John B. Cribb, who received the animal from the natives, and also from a student, Th. Schultze-Westrum, who was involved in the importation of this herpetological treasure. This animal came from the tropic swamps of the Gulf District in southeast New Guinea, which seems to be its main area of distribution, and within which it may occur widely (Mertens 1942: 286; 1950a: 2). Along with *V. salvadorii* there live five other smaller monitors, among which the splendid, arboreal emerald monitor (*V. prasinus*) has a specialized prehensile tail. Nothing definite can be said about which species might be the most closely related to the Papua-monitor. But perhaps a careful study of the living animal will throw some light not only on the details of its life history, but also on the details of its relationships.

Although several German language works pertaining specifically to herpetological husbandry had been published by the late 19th century, Gregory C. Bateman's 1897 book entitled "The Vivarium, Being a Practical Guide to the Construction, Arrangement, and Management of Vivaria, Containing Full Information as to All Reptiles Suitable as Pets, How and Where to Obtain Them, and How to Keep Them in Health" was possibly the first English language book dedicated entirely to the subject of keeping of reptiles and amphibians in captivity.


THE VIVARIUM,

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Illustrated.

By

THE REV. GREGORY C. BATEMAN, A.K.C.

LONDON:
L. UPCOTT GILL, 170, STRAND, W.C.

This important treatise embraces the founding motivation of herpetoculture's pioneers- maintaining reptiles and amphibians in naturalistic enclosures intended to replicate their natural environment for the purpose of studying aspects of their behavior and natural history. Early enthusiasts such as Bateman were guided by a passion and interest in learning from their captives; a mentality which I feel has largely disappeared from contemporary herpetoculture, which is now largely driven by the allure of profit and self-betterment through captive breeding and mass-importation of wild-caught specimens.

In terms of varanid lizards, this book is an important contribution to the history of their study for several reasons, even though material on varanids comprise just six pages of the 424 page work. First, it provides numerous accounts and anecdotes on varanid natural history and behavior which may have long been forgotten or missed by other works altogether. It reflects a time when field studies on varanids did not exist, where details on the habits and occurrence of species were largely based on individual observations and accounts made by amateur naturalists. Second, the use of different and conflicting vernacular names to those currently in practice demonstrate the confusion and uncertainty that common names may cause. Lastly, the account briefly documents the trade and availability of monitor lizards in late 19th century Europe, and provides information on early attempts at keeping them in captivity.

Relatively few copies of this work remain in circulation or are readily available through book dealers, and it has rarely been cited in works on the family Varanidae. For this reason, we have decided to reprint Bateman's chapter "Varanidae" in its entirety here for all who may be interested.

-RWM

Bateman, G.C. 1898. Varanidae. Pp. 75-80. In, The Vivarium, Being a Practical Guide to the Construction, Arrangement, and Management of Vivaria, Containing Full Information as to All Reptiles Suitable as Pets. L. Upcott Gill, London.

Varanidae

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"Would you like to see him swallow an egg whole, sir?" said the attentive keeper of the Reptile House, Regent's Park, to me one day. Naturally I answered in the affirmative, and watched the animal spoken of. He was looking rather sleepy, and his attitude was far from elegant. Presently, however, his eye brightened, and his long forked tongue commenced to vibrate from his snake-like head, and he quickly became quite alert. He heard something that I could not hear. But as in a second or two a rumbling sound reached my ears, the door at the back of the den suddenly opened and the keeper's head and shoulders appeared in view. The noise, I afterwards discovered, was caused by the moving of the wheeled steps along the corridor behind. The keeper, by means of an iron rod, drove or coaxed the strange beast to the front part of the Vivarium near the glass, and by the help of a cloth dropped a large egg close to him. The animal eagerly and deftly seized the egg, and by a clever toss of his head arranged it lengthwise in his mouth, cracking it slightly as he did so, and swallowed it with evident relish. The feat, however, was not done to the keeper's satisfaction, so another egg was produced which was not even cracked as it slipped down the throat of the big Reptile. The animal who possessed this rather uncommon accomplishment was a large Lizard belonging to the family Varanidae. This clever performer was, if I remember rightly the Two-banded Monitor (*Varanus salvator*), which had been in the gardens for several years. From time to time I have seen him take many eggs, but the only one I ever saw him crack was the first.

The family of the Varanidae, or of the Monitoridae as it is also called, numbers amongst its members the largest of all the true Lizards, some of them reaching a length of seven feet, and perhaps, occasionally, even more. The Varanidae differ from the rest of their relatives of the order Lacertilia, with the exception of the Heloderms, in the formation of their nasal apertures. The Monitors have a long and rather snake-like head covered with very small inimbricate polygonal shields, a long tongue which is deeply forked and sheathed posteriorly, and a long and powerful tail, rounded or compressed according to the manner of life of its owner. The under part of their body is covered with small oblong scales arranged "in crossbands", while those on "the back and tail are rhombic". For their size, they are fiercer, stronger, and braver than any of the Lizards. Their teeth are acute, compressed, triangular or conical- there are none on the palates. Each foot possesses five toes, armed with sharp and powerful claws. The young of this family are very prettily marked, the markings more or less disappearing with age. The Monitors inhabit the Old World- Africa, Southern Asia, and Australia- in the New World they are represented by the Iguanidae. There is only one genus, which contains about twenty-eight species.

Some of these creatures live in water or in its neighborhood, others on dry and sandy ground, occasionally quite remote from water. Those Monitors which frequent water have compressed tails, serrated above, by the help of which they are able to swim very quickly. On the slightest alarm they plunge into the water, and often remain for a considerable time beneath its surface. Dr. Günther explains in the following words why these creatures are able to continue under water for so long: "the external nasal opening leads into a spacious cavity situated on the snout; when the animal dives it closes the nasal aperture, and retaining a certain quantity of atmospheric air in that pouch, or rather in the two pouches, it is enabled to remain under water for a prolonged period without the necessity of rising to the surface in order to breath. It is the same plan of structure as that with which a large northern seal (*Cystophora borealis*) is provided".

The Land Monitors have rounded tails, and live in little caves in the rocks or burrow in the soil; in the vicinity of these they hunt for their food, some of them in the day-time, some in the evening, and others probably during the night. The Varanidae live upon eggs, often those of the Crocodile, Rats, Mice, Lizards Snakes, Fish, Frogs, Birds, Worms, and Insects. One writer says that he has seen some Monitors pursuing a Fawn, and when they caught it, draw it into the water; and he also records that in the dead bodies of others he has found the remains of Sheep. Dr. Brehm, however, thinks that there must be some mistake here, fore he does not believe that these Reptiles would hunt such large animals for the purpose of eating their flesh.

These Lizards on the slightest alarm will, according to their kind, rush to the water or their holes but should their retreat be cut off they will then fight with great fierceness, sometimes even springing at their would-be captor's face. They are able to give severe wounds not only with their teeth and claws, but also with their tail. When they have once reached their holes, it is no easy matter to withdraw them, for with their great strength of claw they are able to cling with much tenacity to the interior of their refuge. It is beyond the power of one man, even if he has a rope attached to its body, to dislodged a full-grown Monitor when he has "run to earth". Because of a Monitor's very strong claws and its great power of climbing, it is said "that it is actually used by house-breakers in India to surmount obstacles' the robber retaining hold fo the creature's tail, while it endeavours to escape it draws him upwards". I dare say that some of my readers will think that this is very like the stories of Baron Mucnhausen.

Monitors lay from twenty to thirty eggs, which they bury in the sand. These large Lizards have received the name of Monitors because they are supposed to give warning by a loud hiss of the approach of the Crocodile. This, however, is only a delusion, as they are often found living in the same water with the larger Reptiles. The Arabs call this animal Waran; hence the generic name of *Varanus*.

The Nile Monitor (*Varanus niloticus*) is about 6ft. in length, of which the tail is one half. This animal is semi-aquatic, therefore it has a compressed tail, keeled at the top. The feet are not webbed, and the toes are unequal in length, the fourth toe being the longest and the fifth the shortest. The Nile Monitor is of dark green colour, and when young it is prettily spotted with yellowish white.

It was reverenced by the ancient Egyptians, and is often found engraved upon their ornaments and among their hieroglyphics.

The Ouaran, or Land Monitor (*V. griseus*), was the "Land Crocodile" of the ancients. It chiefly differs from the foregoing in having a rounded instead of a compressed tail. In this species the nostrils are large and placed obliquely near the eyes. There is a streak on each side of its head and neck. This animal is by no means rare in Egypt and Sinai, and extends to the North West of India.

The White-throated Monitor (*V. albigularis*) is another terrestrial species, like the above, and is found in South West Africa. Though a land Monitor, it frequently lives close to water, and feeds upon frogs, snails, rats, and mice. Like those already spoken of, when alarmed it rushes hastily to its hole in the crevice of a rock, or to a burrow among the roots of some tree, whence it is very difficult to dislodge. Dr. Boulenger describes its colour and markings in the following words: "Greyish brown above, with large round yellow dark-edged spots arranged in transverse series on the back; a dark temporal streak, extending along the side of the neck; tail with alternate brown and yellowish annuli; lower surfaces yellowish".

The Ocellated, or Two-banded Monitor (*V. salvator*), already referred to, is a native of China, Siam, Ceylon, and the East Indian Archipelago. The following is a part of Dr. Günther's description of this species: "Dark brown above, with transverse series of round white spots, snout with three or four white crossbands, a dark-brown streak runs from the eye to the neck, throat, and sometimes the belly, with irregular dark-brown transverse streaks, tail with white rings. All these markings become more and more obscure with advancing age, and finally may disappear entirely". According to the late Dr. Cantor, also quoted by Dr. Günther, the Two-banded Monitor is "very numerous in hilly and marshy localities of the Malayan 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 it 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 Hindoos capture these Lizards, commonly by digging them out of their burrows on the banks of rivers, for the sake of their flesh, which by these people is greatly relished. Some individuals attain to nearly 7ft. in length".

The Short-toed Monitor (*V. flavescens*) is, according to Dr. GUNTHER, in colour, greenish or brownish olive, with irregular dark markings, which are generally confluent with broad crossbands on the back and tail. This animal is found in Bengal, Penang, East Burmah, etc. Mr. Theobald speaks of these animals as being difficult, when large, to be obtained by Europeans because their flesh is so highly valued by the Burmese and Karens. They are hunted by dogs which, by means of the scent, track them to their hiding-places in hollow trees. Though a Burman is usually a very lazy man, he is quite ready to undergo the fatigue of cutting down a tree in the hollow interior of which he knows a Monitor to be hiding. These creatures frequently bury their eggs in a deserted White Ant's nest. Their eggs are much relished by the Burmese, and are preferred by these people to those of the ordinary fowl. They are "oily and feculent-looking", but as they have no unpleasant odour they are sometimes eaten readily by Europeans.

Gould's Monitor (*V. gouldii*) comes from Australia, and is fairly frequently imported into this country. It has two yellow streaks on each side of the neck.

The Gigantic Lace Monitor (*V. giganteus*) of Australia is one of the largest of the Monitors, sometimes attaining the length of 7ft. It is, according to Dr. Gray, "brown, back and tail with crossbands of large black-edged white spots"; the legs also are spotted with white.

I should not recommend anyone to attempt to keep in confinement a full-grown Monitor, but young ones are quite suitable for such a purpose, and are by no means uninteresting. They are generally hardy and good feeders- taking, as a rule, either live or dead food, preferring, however, the former. Water Monitors, of course, should be provided with a suitably-sized bath, the water of which should be changed every day. Soft water is decidedly better for these animals than hard. Monitors are occasionally sold in London for so little a sum as 5s. each. Those which are firm (i.e., not limp to the touch or listless in appearance, though I have known such to recover their health) and lively should be chosen, and if possible, when they are about 1ft. in length.

RECENT PUBLICATIONS

2010

Forth, G. 2010. Folk knowledge and distribution of the Komodo dragon (*Varanus komodoensis*) on Flores Island. Journal of Ethnobiology 30(2): 289-307.

Fry, B.G., K. Winter, J.A. Norma, K. Roelants, R.J.A. Naburrs, M.J.P. van Osch, W.M. Teeuwisse, L. van der Weerd, J.E. Mcnaughtan, H.F. Kwok, H. Scheib, E. Kochva, L.J. Miller, F. Gao, J. Karas, D. Scanlon, F. Lin, L. Griesman, C. Shaw, L. Wong, S. Kuruppu & W.C. Hodgson. 2010. Functional and structural diversification of the Anguimorpha lizard venom system. Molecular and Cellular Proteonomics 9(11): 2369-2390.

Frynta, D., P. Frýdlova, J. Hnízdo, O. Šimková, V. Cikánova & P. Velenský. 2010. Ontogeny of sexual size dimorphism in monitor lizards: males grow for a longer period, but not at a faster rate. Zoological Science 27(12): 917-923.

Gardner, B.R. & M.G. Barrows. 2010. Yolk coelomitis in a white-throated monitor lizard (*Varanus albigularis*). Journal of the South African Veterinary Association 81(2): 121-122.

Koch, A. & W. Böhme. 2010. Heading east: a new subspecies of *Varanus salvator* from Obi Island, Maluku Province, Indonesia, with a discussion about the easternmost natural occurrence of southeast Asian water monitor lizards. Russian Journal of Herpetology 17(4): 299-309.

Nowak, M., S. Cieniuch, J. Stariczak & K. Siuda. 2010. Detection of *Anaplasmaphagocytophilum* in *Amblyomma flavomaculatum* ticks (Acari: Ixodidae) collected from lizard *Varanus exanthematicus* imported to Poland. Experimental and Applied Acarology 51(4): 363-371.

Phongphaew, W., T. Sirinarumitr & C. Salakiij. 2010. Differentiation of *Varanus* spp. in Thailand using polymerase chain reaction-restriction fragment length polymorphism technique (PCR-RFLP). Proceedings of the 38th Kasetsart University Annual Conference: 67-74.

2011

Anon. 2011. Los Angeles Zoo Komodo dragons. Connect, March 2011: 38.

Arida, E. A. 2011. Phylogeography of the Komodo monitor *Varanus komodoensis* (Reptilia: Varanidae) inferred from mitochondrial DNA Control Region I and the implications for in situ management plans. Dissertation, University of Bonn. 156 pp.,

Buden, D.W. 2011. Reptiles of Fais Island, Yap State, Federated States of Micronesia. Pacific Science 65(2): 277-283.

Ciofi, C., A.C. Tzika, C. Natali, P.C. Watts, S. Sulandari, M.A. Zein & M.C. Milinovitch. 2011. Development of a multiplex PCR assay for fine-scale population genetic analysis of the Komodo monitor *Varanus komodoensis* based on 18 polymorphic microsatellite loci. Molecular Ecology Resources 11: 550-556.

Frýdlová, P., P. Velenský, O. Simková, V. Cikánová, J. Hnízdo, I. Rehák & D. Frynta. 2011. Is body shape of mangrove-dwelling monitor lizards (*Varanus indicus*; Varanidae) sexually dimorphic? Amphibia-Reptilia 32(1): 27-37.

Sutherland, D.R. 2011. Dietary niche overlap and size partitioning in sympatric varanid lizards. Herpetologica 67(2): 146-153.

Weichmann, R. 2011. Eigene Beobachtungen zur Parthenogenese bei Waranen. Elaphe 19: 55-61.

Zhang, H., S. Zhang & L. Zhang. 2011. Two species of the genus *Kalicephalus* Molin, 1861 (Nematoda, Diaphanocephaloidea) from the water monitor, *Varanus salvator* (Laurenti, 1768) in Guandong Province, China. Acta Parasitologica 56(1): 48-53.

ERRATA

In Wickramasinghe, L.J.M., L.D.C.B. Kekulandala, P.I.K. Peabotuwage & D.M.S.S. Karunarathna. 2010. A remarkable feeding behavior and a new distribution record of *Varanus salvator salvator* (Laurenti, 1768) in eastern Sri Lanka. Biawak 4(3): 93-98, the incorrect reference:

Whitarker, R. & S. Whitarker. 1980. Distribution and status of *Varanus salvator* in India and Sri Lanka. Herpetological Review 11(3): 81-82.

should instead read:

Whitaker, R. & Z. Whitaker. 1980. Distribution and status of *Varanus salvator* in India and Sri Lanka. Herpetological Review 11(3): 81-82.

Varanus albigularis. Etosha National Park, Namibia. Phottograph by **Rene Bond**.

Varanus salvator feeding on the carcass of a smooth otter (*Lutrogale perspicillata*). Sungei Buloh Wetlands Reserve, Singapore. Photographs by **Jacqueline Lau**.