BIAWAK

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On the Cover: *Varanus cerambonensis*

The *Varanus cerambonensis* depicted on the cover and inset of this issue were photographed on Buru Island, Maluku province, Indonesia by **Valter Weijola** on 19 and 23 March 2009. Both specimens were encountered in mangroves on the eastern part of the island at 1250 and 1330 h, and measured approximately 100 cm (specimen pictured on cover) and 70 cm (specimen pictured below) in total length..

Belonging to the *V. indicus* species group, *V. cerambonensis* was described in 1999 (Philipp, K.M., W. Böhme and T. Ziegler. 1999. The identity of *Varanus indicus*: redefinition and description of a sibling species coexisting at the type locality [Sauria: Varanidae: *Varanus indicus* group]. Spixiana 22[3]: 273-287.), and is reported to occur on several neighboring islands within the central Moluccas, including Ambon, Banda, Buru, Obi, and Seram. Field observations of *V. cerambonensis* have been scarce, and little has been published on its natural history and occurrence.

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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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Varanus bengalensis bengalensis. Captive. Indira Gandhi Zoological Park. Vizag, Andhra Pradesh, India.
Photograph by **Siddy Lam** siddy.lam@gmail.com

Australian Zoo Liaison Needed

The IVIG currently seeks a member of the Australian zoo and aquarium field to serve as a regional zoo liaison for *Biawak*, Primary duties and responsibilities will include networking with zoological institutions in your respective region to report quarterly announcements of recent captive breedings, as well as promote *Biawak* among related institutions. This is a volunteer position. For additional details, please contact the IVIG at info@varanidae.org.

Layout Editor Needed

The IVIG currently seeks a motivated individual to join the editorial board of *Biawak* as layout editor. A proficiency and ability to work with Adobe InDesign (must furnish your own copy) is required, as well as the ability to work under deadlines. The layout editor will be responsible for working with the senior and associate editors on the publication's layout as well as assembling each quarterly issue of *Biawak*. This is a volunteer position. Interested parties, please contact info@varanidae.org for more details.

IVIG Logo Submissions

A total of nine insignia designs were submitted to the IVIG for consideration. The winning design will be announced in the organizational news section of the next issue of *Biawak*. The IVIG would like to thank all who participated and submitted their designs.

Varanus nuchalis. Boracay Island, Philippines.
Photograph by **Gilbert De Vera**
http://www.flickr.com/photos/39933896@N02/

NEWS NOTES

Man Arrested for Selling Monitor Skin Products

A local vendor at Matheran, a tourist spot in the Indian state of Maharashtra, was arrested and charged with illegally selling reptile skin products. Among the items confiscated were 72 monitor lizard (*Varanus* sp.) skins. The skins are believed to have been collected from somewhere in the Western Ghats.

Source: Press Trust of India 12 October 2009

IUCN Reviews Status of Philippine Varanids

The Panay monitor (*Varanus mabitang*) has been listed as 'endangered' in the latest assessment by the International Union for Conservation of Nature (IUCN). The IUCN cited a limited natural range of around 400 square km which is becoming increasingly fragmented for agricultural uses, as well as the continued hunting of this species, as causes of its decline. The related Gray's monitor (*V. olivaceus*) continues to be listed as 'vulnerable', though a review of the taxonomy of populations recently discovered in the Northern Sierra Madre Range is needed. The IUCN also listed two Philippine members of the *V. salvator* species-complex (*V. marmoratus* and *V. cumingi*) as 'least concern' and the third (*V. nuchalis*) as 'near-threatened' and declining.

Source: IUCN Red List of Threatened Species 3 November 2009, 4 November 2009

Komodo Dragons Displayed at Phoenix Zoo

The Phoenix Zoo opened a new exhibit featuring a pair of Komodo dragons. The two siblings, named Ivan and Gaia, were hatched at the Cincinnati Zoo fifteen years earlier and originally sent off to separate facilities before being brought back together in Phoenix. Gaia made headlines at the Sedgwick County Zoo, Kansas in 2008 when she became the first North American dragon to produce young via parthenogenesis. The cost of the new $1 million exhibit was paid for through private donations.

Source: Zoo and Aquarium Visitor News 11 November 2009

Varanus gouldii. Queensland. Photograph by **Andrzej Krzyzanowski** ajk@konstancin1.pl

Announcement of the Second Annual Meeting of the "AG Warane" of the DGHT

After the positive feedback from the first meeting held last April (see news note in *Biawak* 3[2]: 35), we are pleased to announce that the second annual meeting of the AG Warane is in preparation. The meeting will take place on 24 April 2010 in Hanau near Frankfurt. The meeting starts at 10.30 a.m.

Location:
Cafe-Restaurant Sandelmühle
Philipp-August-Schleissner-Weg 2a
63452 Hanau

Preliminary Program:

Thomas Hörenberg (Stuttgart):
"Keeping and breeding of Macrae's tree monitor (*Varanus macraei*) and caesarean section in *V.* (*Odatria*) *tristis orientalis"* (in German).

Klaus Wesiak (Frankfurt) and **André Koch** (Bonn):
"Successful husbandry and first nreeding of *Varanus juxtindicus* Böhme et al., 2002, with remarks on the development of juveniles of this rarely-kept endemic Solomon monitor species" (in German). See report in this issue of *Biawak* pp. 106-121.

Monika Labes (Germering):
"Report on the Husbandry and Breeding of *Varanus exanthematicus*" (in German).

André Koch (Bonn):
"News about Southeast Asian monitor lizards" (in German).

Further information and a detailed schedule of events can be found early in 2010 on the AG Warane homepage at www.agwarane.de, or contact Kay Uwe Dittmar (working group leader) at dittmar@ag-warane.de or André Koch (scientific leader) at a.koch.zfmk@uni-bonn.de.

Varanus niloticus basking on deceased *Crocodylus niloticus*. Masai Mara, Kenya.
Photograph by **Joseph Kimojino**

Biawak, 3(4), pp. 100-105

Conservation Status of *Varanus flavescens* in Chitwan, Nepal

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Abstract: In Nepal, the biology and conservation status of *Varanus flavescens* is poorly known. Hence we undertook direct visual and indirect (questionnaire) surveys to assess the presence of monitor lizards across four areas of Chitwan to aid in assessing their conservation status. The species was reported present in all four surveyed areas. Mostly, the species was directly observed associated with agricultural land. Illegal hunting for meat and skin, habitat degradation and disturbance, particularly in patchy forests adjoining the agricultural land, appear to be the most significant threats to *V. flavescens* in the areas surveyed. In order to ensure the long-term survival of the species, it is essential to develop an adequate conservation strategy and have effective law enforcement to stop poaching.

Introduction

Varanus flavescens is poorly studied in Nepal and generally across its range in south Asia. Its distribution includes the south Asian countries of Nepal, India, Pakistan and Bangladesh (Shah and Tiwari, 2004). It is categorized as lower risk/least concern on the IUCN Red List (IUCN, 2009) but all south Asian populations are listed in CITES Appendix I. Similarly, it is legally protected by the government of Nepal under Schedule I (Section 10) of the National Parks and Conservation Act (1973). It prefers swamps around bodies of water, but is also found in forests and cultivated lands (Shah and Tiwari, 2004). *Varanus flavescens* has been reported from the entire lowlands of Nepal; however, its current conservation status is still unknown. Herpetofaunal studies have reported a total of 143 species of amphibians and reptiles from Nepal (Shah and Tiwari, 2004; Schleich and Kätsle, 2002). The lowland Terai is hot and humid and is extremely rich in its herpetofaunal assemblage. So far, there has been a lack of baseline data for *V. flavescens*. In addition, increased poaching of monitor lizards for their valuable skin is suspected of being a significant threat to the species. They are also used directly and indirectly as food and medicines in various parts of Nepal (Shah, 1997). *Varanus flavescens* and *V. bengalensis bengalensis* are the only two monitor lizards found in Nepal, and both species have been previously recorded from the Chitwan. This paper attempts to provide the conservation status and distribution of *V. flavescens*, and identify the threats to its existence in the area. The intent of our study is to provide preliminary information to assist planning for potential conservation interventions for this species in lowland Terai Nepal.

Study Site

The study (Fig. 1) was carried out in the Chitwan district of Nepal across four different localities (Bachhauli Village Development Committee (hereafter VDC), ward no. 7, 8 and 9; Kumroj VDC: 1, 2, and 3; Ratnanagar Municipality ward no. 4 and 5; and Bharatpur Municipality ward no. 8 and 9). These areas lie in the buffer zone of Chitwan National Park. Chitwan lies in the inner Doon Valley in the central Terai of Nepal, between the Siwalik Hills in the south and the

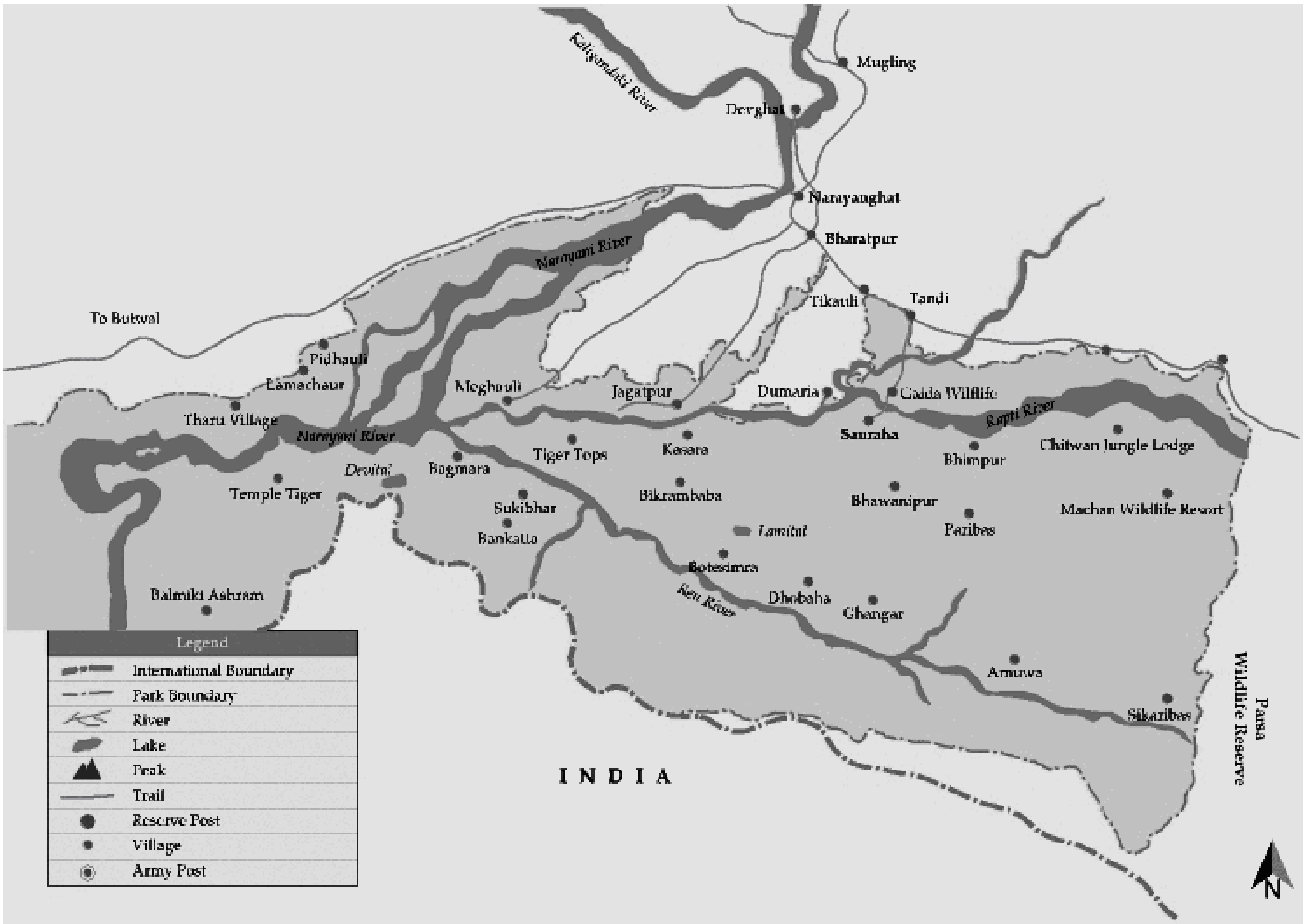

Fig. 1. Map of Chitwan showing Chitwan National Park (not to scale).

Mahabharat Hills to the north. The climate of the area is subtropical, mainly dominated by the southeast monsoon. The rainfall averages 2400 mm per year and about 90% of rainfall concentrates within four months of monsoon season (June-September). The monsoon rain causes dramatic flooding and changes in the character and course of rivers, and has a major seasonal effect on ecosystem dynamics. November to mid February is marked as the cool season where temperatures can drop to 9 °C. The hot season occurs from mid-February to May, where temperatures can reach 36 °C (Dinerstein, 2003). Residents in the study area were from different ethnicities and origins; however, the predominant ethnic group was the Tharus who typically live in close proximity to the forests of the Terai (Baral and Heinen, 2007).

Methods

The study was conducted from June to September 2008 during three field sessions: 13-23 June; 20-30 August; and 21-29 September. Observations of *V. flavescens* were conducted using the Visual Encounter Survey Method (Campbell and Christman, 1982; Corn and Bury, 1990; Crump and Scott, 1994; Heyer et al., 1994) through vigorous searching in different habitat types including forest, grassland, human settlements, wetlands, and agricultural lands; all areas suspected of supporting monitors. Whenever a *V. flavescens* was sighted, the time of observation, number of individuals, size class (juveniles ≤ 1 m total body length; adult > 1 m total body length) and habitat type with GPS coordinates were noted. Household surveys were carried out in the area to assess the conservation status of the species and to find out attitudes of local people towards *V. flavescens*. A total of 60 randomly selected respondents from four different areas within the study area were interviewed using structured questionnaires. A total of 20 respondents were interviewed from Bachhauli VDC, 15 from Kumroj VDC, 12 from Ratnanagar Municipality, and 13 from Bharatpur Municipality, respectively.

Results

Status and Distribution of Varanus flavescens

The survey covered four different study sites across the buffer zone area of Chitwan National Park. *Varanus flavescens* was present in all areas surveyed. The highest number of sightings occurred in the Jhuwani area of Bachhauli VDC ward numbers 7 and 9, with five individuals observed (Table 1). Most were observed in agricultural land which is close to the Dhure Khola (river). Similarly, Kumroj village is located adjacent to Chitwan National Park and Kumroj Community forest, which lies between two rivers, Dhumre Khola and Icharni Khola, and also provided suitable habitat for the species. Four individuals were sighted from the Kumroj area. Single individuals were observed in the study sites of Ratnanagar and Bharatpur Municipality. Most of the *V. flavescens* were recorded from the forest and agricultural land near water sources.

Conservation Attitude

From the questionnaire survey findings, among 54 respondents out of 64 randomly selected households, a high proportion of respondents (90.9%) affirmed the occurrence of *V. flavescens* in the area. However, 4% were unaware of its presence and 5.1% responded that it was absent in the study area. As per the responses, two species of monitor lizard are found in the area, *Sun Gohoro* and *Bhaise Gohoro* in local dialect. *Sun Gohoro* refers to *V. flavescens*, with a light brown dorsum with a reddish hue, and a fairly distinct pattern of alternating transverse bars of reddish brown to dirty yellow on the back and tail (Fig. 2). *Bhaise Gohoro* refers to *V. b. bengalensis*, with a brown to olive dorsum usually marked with blackish spots; the spots are most numerous upon the throat (Fig. 3).

All respondents from Bachhauli and Kumroj confirmed sightings of *V. flavescens* in their area. *Varanus flavescens* sightings were recorded from different habitats within the study sites. Forty seven percent of respondents had noticed the species in cropland, followed by 29% in forest, 14% in wetland, and 10% from grassland. Seven percent of respondents had observed juvenile *V. flavescens*, signifying a breeding population in the area. Local people held favorable attitudes towards *V. flavescens* conservation with 73% of respondents indicating positive intent towards *V. flavescens* conservation, while 23% answered ‘no’ and

Table 1. Details of *Varanus flavescens* observations at Chitwan, 2008.

Block	Area	Location	Altitude (m)	Sightings (N)	Monitor Size Class		Main Habitat type
					Adult	Juvenile	
Bachhauli	Jhuwani	27º35’04.6”N 84º31’51.1”E	160	2	1	1	Agricultural land
	Nayabasti	27º35’04.7”N 84º31’51.2”E	172	1	1	0	Grassland
	Simaltandi	27º34’45.1”N 84º31’31.1”E	172	2	1	1	Agricultural land
Kumroj	Harnari	27º34’27.7”N 84º31’19.2”E	173	2	1	1	Forest/agricultural land
	Bairiya	27º34’26.9”N 84º31’49.4”E	182	2	2	0	Agricultural land
Ratnanagar	Chitrasari	27º35’45.0”N 84º20’19.6”E	182	1	1	0	Agricultural land
	Tikauli	27º37’45.7”N 84º28’42.6”E	214	1	1	0	Forest
Bharatpur	Gauriganj	27º36’49.5”N 84º25’20.2”E	175	1	1	0	Agricultural land
	Beesh Hajari Lake	27º37’05.5”N 84º26’15.7”E	209	1	1	0	Forest

Fig. 2. *Varanus flavescens* from Jhuwani, Chitwan.

4% answered ‘no opinion’.

Seventy percent of respondents generally believed that observations of *V. flavescens* were decreasing in the area. The other 24% claimed the population to be stable, but 6% believed the population is increasing.

Discussion

Information on the current conservation status of *V. flavescens* in Chitwan was obtained through multiple field surveys and via interviews with local people. Interviewees were representative of multiple ethnic groups and castes, with the Tharu people being the dominant community among the areas. Tharu communities are found closer to the forest and are primarily dependent on the natural resources. The Bachhauli and Kumroj areas contain the largest populations of Tharus, where farming and fishing are the major activities of these people. These areas have four bodies of water adjacent to the village: Dhure Khola, Icharni Khola, Budi Rapti and Rapti Khola. Most of the *V. flavescens* were sighted in forests and croplands near these bodies of water. *Varanus flavescens* is also very common in rice fields. It prefers swamps, but is also found in forests and cultivated lands (Shah and Tiwari,

Fig. 3. *V. bengalensis bengalensis* from Gyalchok, Gorkha, Nepal. 715 m elev.

Figs. 4 and 5. An adult *V. flavescens* killed by local people.

2004).

Overall, our survey results possibly suggest that sightings of *V. flavescens* have been decreasing. Several threats to *V. flavescens* were noted in our surveys including poaching and nuisance killing (Figs. 4 and 5). Poaching has been undertaken to enable consumption of meat for purported medicinal value. Respondents believed that eating the meat of monitor lizards increased human health and acts as a deterrent or possible cure for tuberculosis, leprosy, asthma, and piles (Shah and Tiwari, 2004). The skin of *V. flavescens* is also used to make different local products including drums and belts. Nuisance killing is known to occur, in part due to the burrows dug by *V. flavescens,* which inadvertently damage man-made water channels used for irrigating crops. Furthermore, local people regard *V. flavescens* as highly poisonous, resulting in retribution killings.

Conservation Recommendations

Human population growth in Chitwan will continue to put pressure on wild animals including *V. flavescens*. Much of the habitat for all animals is located outside the protected areas of Nepal. Hence, local community-based approaches for conservation are advocated. We envisage that a multi-stakeholder approach among the Department of National Park and Wildlife Conservation, non-governmental organizations (NGOs), research institutes, and local communities would benefit this lizard alongside other species in these areas of Nepal. Poaching for skin and meat, habitat degradation, and heavy use of pesticides could be reasons for declining populations, though determining the exact causes of declining populations will require more intensive study.

Acknowledgements – We would like to thank the Oregon Zoo Foundation and Columbus Zoo and Aquarium for providing financial support for this study. We are very much grateful to Himalayan Research and Conservation Nepal for the continuous support throughout the study period. We are thankful to Prakash Dhungana and Deepak Shah for their assistance in the field.

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Biawak, 3(4), pp. 106-121

Successful Husbandry and First Breeding of *Varanus juxtindicus* Böhme et al., 2002, with Remarks on the Development of Juveniles of this "Rarely-Kept" Endemic Solomon Monitor Species

*The main part of this article is a translation of the recent report by K. Wesiak (2009): Terrareinhaltung und Erstnachzucht des Pazifikwarans *Varanus* (*Euprepiosaurus*) *indicus* (Daudin, 1802), mit einigen Bemerkungen zur Entwicklung der Juntiere. Elaphe 17(1): 44–55. However, some modifications, corrections and additions became necessary when the real identity of the monitors was recognized.

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Abstract: Today, we know that new species are frequently available through the international pet trade before they are recognized as new to science and prior to their formal description. In recent years, this has also been the case in some monitors of the *Varanus indicus* and *V. prasinus* species groups (i.e., *V. melinus* Böhme and Ziegler, 1997; *V. yuwonoi* Harvey and Barker, 1998; *V. macraei* Böhme and Jacobs, 2001; *V. boehmei* Jacobs, 2003), which due to their colorful appearance and mostly moderate size, are focal species of monitor enthusiasts worldwide.

Here, we can add another monitor lizard to this list of formerly unrecognized species. More than ten years before *V. juxtindicus* was originally described by Böhme et al. (2002), three adult specimens (allegedly traded as *V. indicus*) came into the possession of one of the authors (KW), but due to close phenotypic similarity with *V. indicus* their real taxonomic identity remained unrecognized until very recently. Between 1991 and 1995, ten clutches were produced resulting in eight hatchlings. Detailed information is provided about the conditions for the first successful breeding of *V. juxtindicus* in captivity. Moreover, the development of the juveniles is documented with emphasis on the ontogenetic change in color pattern.

Introduction

Currently, *Varanus juxtindicus* is only known from the type locality Rennell Island, Solomon Islands (Böhme et al., 2002). There, *V. juxtindicus* is the only monitor species known to inhabit the island, and is called "te hokai" by the locals of Rennell Island (Wolff, 1955). Until the present report about this endemic Solomon monitor species, only the information from the original description by Böhme et al. (2002) and five voucher specimens (one juvenile [see Fig. 1], three subadults, and one adult male [see Böhme et al., 2002]) of the type series collected by the Danish Noona Dan Expedition in 1962 were known. They are housed in the Zoological Museum of the University of Copenhagen (ZMUC), Denmark, and the Zoologisches Forschungsmuseum

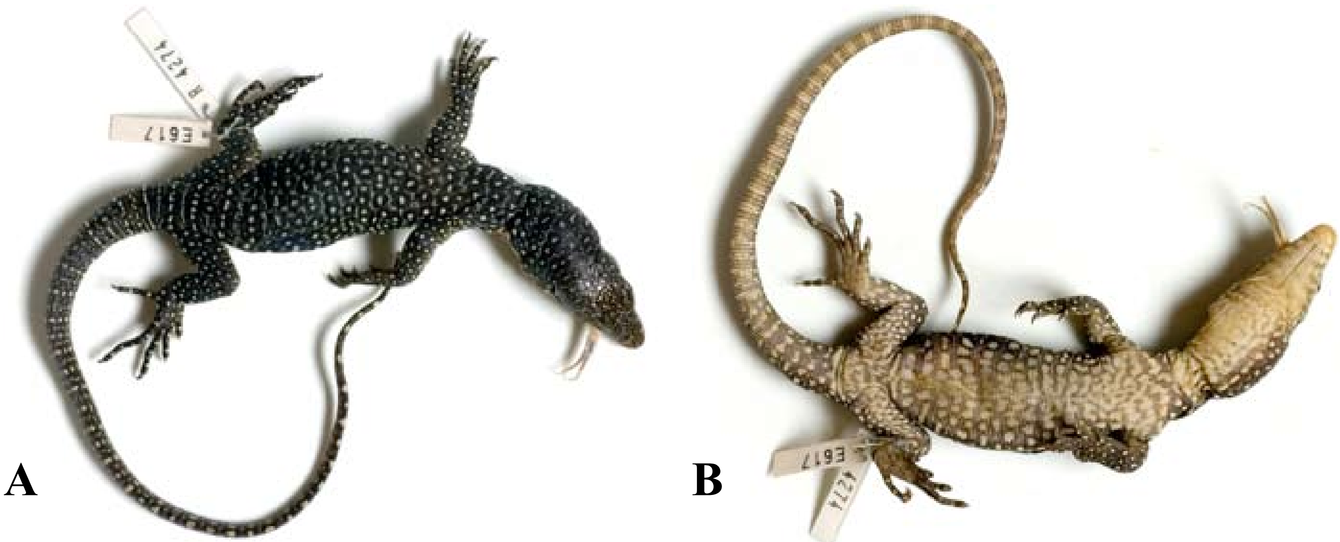

Fig. 1. Juvenile paratype of *Varanus juxtindicus* (ZMUC E617), dorsal (A) and ventral side (B). Photographs by **Mogens Andersen**.

Alexander Koenig (ZFMK), Bonn, Germany (Böhme et al., 2002). Thus, *V. juxtindicus* has to be regarded as one of the least known and rarest monitor species of the world (Böhme et al., 2004). Due to its assumed close relationship and phenotypic similarity with the widespread mangrove monitor (*V. indicus*) consisting of a dark background coloration mottled with numerous yellow scales, *V. juxtindicus* obtained its scientific species name (from Latin *iuxta* = "next to" or "close to"). The species is distinguished from all other members of the *V. indicus* species group (*V. caerulivirens, V. cerambonensis, V. doreanus, V. finschi, V. indicus, V. jobiensis, V. lirungensis, V. melinus, V. rainerguentheri, V. yuwonoi*, and *V. zugorum*) by its tail shape (Fig. 2), which is roundish in its first third and lacks a differentiated double keel on its dorsal ridge (Böhme et al., 2002).

Fig. 2. Characteristic for *V. juxtindicus*: the tail lacks a distinct dorsal double keel. Photograph by **André Koch**.

A photograph of a juvenile *V. juxtindicus* (Fig. 3) taken by Gunther Köhler (Frankfurt) from the offspring of Klaus Wesiak (KW) was published more than ten years ago in Bennett (1996: 203; 1998: 191) and again in Eidenmüller (1997: 64). In Bennett (1998: 124), another specimen bred by KW is shown at the age of one and a half years (photograph by Felix Hulbert). Remarkably, the color pattern of this specimen is very bright yellowish-green (Fig. 4). While the lack of the characteristic dorsal double keel as typical for *V. juxtindicus* is hardly visible in the juvenile specimen mentioned above, the tail of the adult specimen is obviously roundish and not laterally compressed. However, this confusion seems to have not

Fig. 3. Juvenile *V. juxtindicus*. Photograph by **Gunther Köhler**.

Fig. 4. Subadult captive-bred *V. juxtindicus* at the age of one and a half years. Note the very bright yellowish-green pattern of this specimen. Photograph by **Felix Hulbert**.

been recognized by any reader of Bennett's (1998) book since the publication by Böhme et al. (2002).

In light of these findings, photographs of real mangrove monitors (*V. indicus* sensu stricto) in the varanid literature are indeed quite rare. The real identity of these specimens has been unrecognized for so long (actually since at least 1962) due to the high degree of external similarity between *V. indicus* and *V. juxtindicus*, its sibling species from the Solomon Islands.

After several new descriptions within the *V. indicus* species complex during the last several years, the taxonomic identity of the monitors had to be checked. Wolfgang Böhme and AK (both ZFMK) identified the species based on photographic evidence and two specimens (Figs. 2 and 5) from the private collection of Florian Wagner (Frankfurt), which were said to be offsprings of KW's monitors. Both of these specimens were donated to the Museum Alexander Koenig in Bonn shortly after their death in 2009. In addition to the relatively brief report about the first offspring of *Varanus* (*juxt*)*indicus* (Wesiak, 1993a, b), some basic data are provided in the present paper in retrospect about the eight-fold successful breeding of *V. juxtindicus* between 1993 and 1996.

Structure of the Breeding Group

In summer 1989, KW purchased an adult female *V. juxtindicus* of about 100 cm total length from the pet trade, legally imported from the Solomon Islands. After treatment for parasitic nematodes and flagellates of the intestinal tract, the initial condition of the monitor changed for the best and it grew to a total length of 110 cm within the next year.

In autumn 1990, five adult specimens that had been illegally imported and confiscated by the German customs were conveyed to KW by the Bundesamt für Ernährung und Forstwirtschaft (Federal Office for Nutrition and Forestry). One male and two females of about 100 cm total length each showed differences in color and pattern towards the previously-received female, but were similar in their appearance among each other. The two remaining males of 100 and 130 cm total length (Fig. 6), respectively, were identical in their habitus with the female (Figs. 7 and 8). All five monitors were in poor condition; their feces were thin and ensanguined caused by various endoparasites. The two latter males showed advanced symptoms. After multiple treatments for nematodes, cestodes, flagellates, and *Entamoeba invadens* by Dr. G. Köhler, Offenbach, their physical condition and behavior had normalized. No parasites were detected in all fecal samples.

After all monitors had been kept together for some weeks, the three specimens with differing color and patterns were passed on to a monitor keeper colleague (the male specimen is depicted in Eidenmüller [2003: 31, 76]). Unfortunately, they did not breed there. Both large males quickly grew to 135 cm and 140 cm total length, respectively, and were brought together permanently with the suitable female in February 1991.

Fig. 5. Portrait of *V. juxtindicus*, which is said to be from the offspring of KW's monitor specimens. Photograph by **André Koch**.

Fig. 6. An adult male *V. juxtindicus* climbing on a branch. Photograph by **Klaus Wesiak**.

Fig. 7. Female monitor leaving the box after egg deposition. Note the specimen's dark anterior third of the tongue. Photograph by **Klaus Wesiak**.

Fig. 8. The adult female *V. juxtindicus* with intensive yellow mottling. Photograph by **Klaus Wesiak.**

Housing

The long-term and species-appropriate keeping and breeding of medium-sized to large monitor species is a fixed element in herpetoculture in most zoos and some private households. Recent advances in light and heating technique as well as knowledge about dietary requirements, particularly nutrition supplements, and comprehensive veterinary support are the basis for a healthy and long life in captivity. For a comprehensive overview on published breeding results we refer, for instance, to Horn & Visser (1989, 1997) as well as to the references in Bennett (1996, 1998), Kirschner et al. (1996), and Eidenmüller (1997, 2003).

The respectable body dimensions of *V. juxtindicus* together with their strength and activity disallow the use of standard silicon terraria made of glass. Instead, the spacious terrarium has to be ordered or home-made following an elaborate concept. With respect to the individual structural elements of the apartment, the terrarium required a lightweight construction of robust, non-corrosive materials such as breeze blocks and aluminum profiles to fix the glass plates (Fig. 9). The walls and flooring were covered with plaster cement and synthetic resin (for a detailed description we refer to Wesiak [1996] and Wilms [2004]). Sliding glass doors are unsuitable, lockable glass doors are preferable. The more entries the terrarium has, the more effective it is to work inside. A large water feature was mounted at the bottom of the terrarium. A water inlet and waste pipe (leading directly into the sewer) was operable from outside the terrarium. A second, smaller terrarium with the same structure was indispensable to separate the females during gestation, egg deposition, and directly afterwards for recovery. The terrarium built in the corner of the room was pentagonal with a an area of about 3.75 m^2 including the water feature and a height of 1.1 meters in front and 1.25 meters in the rear areas.

Fig. 9. Terrarium in the former collection of KW for keeping large monitor species like *V. juxtindicus*. Photograph by **Klaus Wesiak.**

Geographically relevant data about climate was taken from literature sources (e.g., Brockhaus 1982). *Varanus juxtindicus* was kept perennially at high temperatures (27° to 30° C air temperature, water temperature not below 27°C) and high relative air humidity. Water temperature did not decrease at night, because these monitors often used the water pond to sleep. A thermostat-regulated freezer protection of 400 W placed below the terrarium was used to warm the terrarium's ground, air and water. The temperature sensor was supsended from the ceiling and inaccessible for the monitors.

The enclosure's artificial lighting was provided by four fluorescent lambs (36 W) which corresponded to the natural spectrum of sunlight. In addition, the monitors needed a place to warm-up, with local temperatures of 40° to 45°C combined with an UV ray lamp because they regularly spent long periods under the radiation source (Horn in Sauer et al., 2004; Böttcher, 2007; Lehmann, 2007). One 120 W spot (from Osram) provided light and heat all day, while a 300 W Ultra Vitalux spot (also from Osram) was added two times per day for 45 min each in the morning and the afternoon. All electrical components and connections were out of reach from the monitors.

Initial Quarantine

Like other members of the *V. indicus* species group, which forage in mangrove swamps and rainforests (Philipp, 1999, Ziegler et al, 2001, Philipp et al., 2007), *V. juxtindicus* is probably an opportunistic predator and is probably infested with parasites in the juvenile phase. Inadequate conditions by ruthless exporters and stress during transportation impair the health of monitors. Nematodes and protozoans (primarily *Entamoeba invadens*) in the intestinal tract, and nematodes and pentastomes in the lungs cause severe inflammations of the organs as secondary infections, generally with fatal consequences. These parasites are highly infectious and can achieve epidemic proportions.

Recently imported monitors were placed separately in quarantine. For feeding and cleaning, each terrarium had its own set of tools. Newspaper was used as substrate; excrement was immediately removed and the newspaper replaced. After working in a quarantine terrarium, hands and tools were thoroughly washed and disinfected. Water taps and the soap dispenser were only touched with the elbows. These surgical hygienic procedures always accompanied veterinary treatments such as the analysis of multiple fecal samples. After treatment with anti-parasitic medication, the monitors remained in quarantine for a minimum eight week period. For better control, several fecal samples were reanalyzed some weeks later. Procedures for wild caught monitors were the same irrespective of whether they were recent imports or long term captives.

Against nematodes, Panacur® (active substance is Fenbendazole, dose: 70 mg/kg) from Hoechst AG, now Aventis S.A., was given once orally. Treatment was repeated after two weeks. Against cestodes, Droncit® (Praziquantele, dose: 15-20 mg/kg) was given according to the medication as explained before. Against flagellates, Duodegran® (Ronidazol, dose: 10 mg/kg each day, not available anymore, today's equivalent is Ridzol®, same active substance from the company Dr. Hesse Tierpharma GmbH & Co. KG) was dissolved with water and administered daily with a stomach tube over a period of 10 days. Against *Entamoeba invadens*, Resochin® (active substance Chloroquin) was provided over a period of 8 days according to the following protocol: First day 0.6 ml/kg (equivals 18 mg/kg), second day 0.8 ml/kg (equivals 24 mg/kg), third day same dose as previous day, fourth day 1.0 ml/kg (equals 30 mg/kg), fifth day same dose as previous day, sixth day 0.8 ml/kg, and seventh day 0.6 ml/kg again. After this treatment, a test for antibiotic resistance was conducted. As a result, bacterial infections were medicated with Vibramycin® (Doxycycline). Nothing was done against pentastomes in the hope that these parasites of the respiratory system would not cause any complications. Eggs were only detectable in the feces of both male specimens. Medications outlined above refer to Frank (1985) and Köhler (1993, 1996).

Behavior in the Terrarium

Kept under optimal spatial and climatic conditions, healthy specimens of *V. juxtindicus* quickly lost their initial nervousness and displayed their amazing energy and potential speed. Therefore, it was advantageous to arrange several strong branches in the terrarium and to cover the back wall with artificial rockwork. The monitors used every space of the terrarium, either by climbing or by regular swimming and diving (Fig. 10). The water feature (190 x 105 x 40 cm deep) of the large terrarium was regularly used daily by the monitors.

During their activity period, adult *V. juxtindicus* were surprisingly sociable. Both of the large male specimens mentioned above lived together with the female for many years in the same terrarium. Conflicts were never observed. Even during several consecutive reproductive periods, the males remained calm and showed no conspicuous aggressive behavior. During a seven year period, a single case of aggressive behavior was observed between two females. The quarrel lasted for some days and was confined to aggressive postures and chasing through the terrarium. Injuries did not occur.

Feeding

In contrast to everyday life, *V. juxtindicus* had to be carefully observed during feeding. The monitors lunged quickly at the food offered and often bit around without control. After having prepared food and before opening the terrarium, hands should be thoroughly washed to ensure that the monitors could not discern the scent of eggs, fish, mice or other potential prey. Long tweezers were suitable for feeding. When fed small mammals like mice, the monitors displayed pronounced greediness and snapped at the heads of conspecifics. Once, a monitor keeper colleague reported that a specimen of *V. indicus* died from severe head injuries as the result of aggressive biting during feeding with mice. The only correct and secure procedure was to separate the monitors before feeding. Due to this procedure, none of the *V. juxtindicus* in KW's collection were ever injured during feeding. Before the monitors were brought together again, their heads were rinsed with water to remove food remains

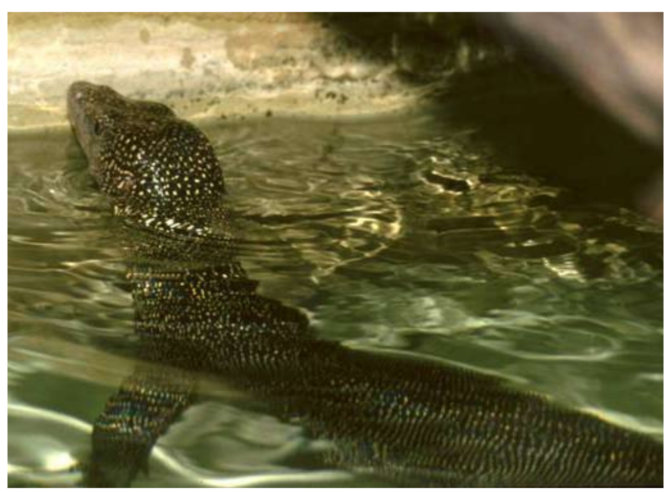

Fig. 10. *Varanus juxtindicus* frequently used the water feature for swimming and diving. Photograph by **Klaus Wesiak**.

and olfactory traces. In addition, it is recommended to wait until the monitors are completely at ease. This took about 10 minutes each time.

The high energy demand of the monitors could not be met by feedings only insects. High quality food with adequate calorie content had to be provided. In addition to large insects, subadult mice and rats, boiled eggs, crabs, and saltwater fish were provided two to three times per week. Despite the daily UV exposure, it was necessary to enhance the food with vitamins and mineral supplements. Biweekly, higher-concentrated multivitamin doses (Multi Mulsin® from Mucos Pharma, now discontinued) were provided. The dose of the supplements used should be 600 I.E. for vitamin A and 100 I.E. for vitamin D_3 per kg/body mass and week. The calculation of vitamin D_3 dose has priority if the concentration of both vitaminsare not balanced (G. Köhler, pers. comm.).

Reproduction in Captivity

After two months, first copulations were observed between 30 March 1991 and 6 April 1991 (Fig. 11). The female only mated with the smaller male which always alternated use of both hemipenes. While approaching, the male regularly bit the female's neck which in some cases was quite fierce. To date, this behavior has not been observed in any other monitor species kept by KW.

Matings always followed the above described behaviors. The mean time span between the last mating and oviposition was 40 days. The female regularly frequented a sunken box with removable cover to deposit the clutches. The female's tendency to eat the eggs after deposition persisted. Even the decision, from January 1995 onwards, to induce oviposition by the application of Oxitocin® (3 I.E/kg body mass intramuscular [Köhler 1996]), could not solve this problem. The number of eaten eggs was always verified by the partly digested eggs in the female's feces (see Fig. 13).

The first eggs were laid on 15 May 1991 (Fig. 12). Immediately after deposition (Fig. 8) the female ate three of the four eggs (Fig. 13). The fourth egg proved to be unfertilized when incubated artificially. By April 1993, the female had deposited two further clutches (29 October 1992 and 18 January 1993) which only contained five and six unfertilized eggs, respectively.

Between April 1993 and April 1995, the female laid another seven clutches. In total, 54 eggs were deposited (of which 24 were eaten) with ten fertilized eggs, eight of which were successfully incubated. Initially, Vermiculite was used as substrate, but was switched to Perlite for later clutches due to its looser grain. However, no advantage was recognized.

The first *V. juxtindicus* hatched in captivity on 28 September 1993 (Figs.14 to 16). All eight hatchlings, without exception, opened and left their eggs independently. A summary of the fertilized clutches between 1993 and 1995 (denoted as I to VII) and data on the first phase of live juveniles are provided in Table 1.

Fig. 11. Mating of the small male and the female *V. juxtindicus*. Photograph by **Klaus Wesiak**.

Fig. 12. Clutch of four eggs of *V. juxtindicus*; below an unfertilized egg. Photograph by **Klaus Wesiak**.

Fig. 13. Partly digested eggs from the feces of the female. Photograph by **Klaus Wesiak**.

Table 1. Summary of reproduction data for *V. juxtindicus* between 1993 and 1995.

Clutch	I	II	III	IV			V	VI			VII
Hatchlings	spec. 1	-	-	spec. 2	spec. 3	spec. 4	-	spec. 5	spec. 6	spec. 7	spec. 8
Eggs											
Deposition Date	06.04.1993	24.07.1993	10.10.1993	13.06.1994	13.06.1994	13.06.1994	20.11.1994	19.01.1995	19.01.1995	19.01.1995	05.4.1995
Oxytocin donated	no	no	no	no	no	no	no	yes	yes	yes	yes
Number of Eggs	5	5	7	6	6	6	6	5	5	5	5
Fertilized Eggs	2	-	?	3	3	3	?	3	3	3	2
Dead in Egg	1	-	-	-	-	-	-	-	-	-	1
Hatch Date	28.09.1993	-	-	18.11.1994	20.11.1994	20.11.1994	-	04.07.1995	04.07.1995	04.07.1995	22.09.1995
Eggs Eaten by ♀	3	1	7	3	3	3	6	1	1	1	-
Incubation											
Duration (days)	174	-	-	158	160	160	-	166	166	166	170
Temperature (°C)	28.5	-	-	30	30	30	-	29.5	29.5	29.5	29.5
Substrate	Vermiculite	-	-	Vermiculite	Vermiculite	Vermiculite	-	Vermiculite	Vermiculite	Vermiculite	Perlite
Hatch Duration (h)	24	-	-	36	36	24	-	12	12	24	24
Growth											
Umbilicus Closed After (h)	36	-	-	48	36	48	-	24	24	48	36
First Feedings After (days)	3	-	-	3	4	3	-	4	3	3	4
Days Since Hatch Date	46	-	-	39	38	37	-	38	36	33	42
1. Sloughing	13.11.1993	-	-	27.12.1994	28.12.1994	27.12.1994	-	11.08.1995	09.08.1995	06.08.1995	03.11.1995
Difference (days)	68	-	-	64	78	68	-	71	68	73	68
2. Sloughing	20.01.1994	-	-	02.03.1995	17.03.1995	06.03.1995	-	21.10.1995	16.10.1995	18.10.1995	12.01.1996
Difference (days)	85	-	-	91	79	87	-	84	86	85	87
3. Sloughing	14.04.1994	-	-	01.06.1995	04.06.1995	01.06.1995	-	15.01.1996	12.01.1996	13.01.1996	08.04.1996
Difference (days)	159	-	-	159	161	156	-	160	161	158	161
4. Sloughing	20.09.1994	-	-	07.11.1995	12.11.1995	04.11.1995	-	23.06.1996	21.06.1996	19.06.1996	16.09.1996

Fig. 14. First hatchling of *V. juxtindicus* in captivity, 28 September 1993. Photograph by **Klaus Wesiak**.

Fig. 15. Portrait of the first hatchling *V. juxtindicus*. Photograph by **Klaus Wesiak**.

Raising of the Juveniles

The umbilicus closed after 24-48 h and neonates began eating after 3-4 days. The juveniles shed their skin for the first time after 33-46 days, and again at approximately 4, 6, and 12 months of age (Table 1).

During the first few days, the hatchlings were housed separately in plastic terraria (ca. 45 x 25 x 30 cm high), each heated by a heating lamp. The terraria had a shallow water basin on a bottom covering of slightly humid blotting paper to avoid infections of the umbilicus opening which was not yet closed. When the juveniles regularly accepted insects as food, they were kept in glass terraria (ca. 130 x 70 x 90 high), with simple and easy to clean furnishings. The largest part was occupied by the water basin with a water depth of ca. 10 cm. The ground consisted of several large stones which poked out above the water level. Several branches served as climbing structures. The climate corresponded to the conditions in the terraria of the adult monitors.

Fig. 16. Ventral pattern of hatchling. Photograph by **Klaus Wesiak**.

The juveniles were offered larger insects such as grasshoppers, house crickets, *Zophobas* and rose chafer larvae. In addition, pieces of fish and naked mice were also offered. The latter were clearly preferred by the juveniles. Initially the lizards were fed daily, after four months they were fed four days per week. During the first six months, the food was regularly supplemented with a balanced vitamin and mineral product (Korvimin ZVT® from WDT). Later, concentrated multivitamins (see above) were provided. The dosage was calculated as for the adult specimens (see above). Specimens No. 1 and No. 8 were each housed separately, the remaining six specimens of clutches IV and VI were kept together for several months in a terrarium. In this situation it

Fig. 17. Two juveniles in their terrarium at the age of ca. six months. The color pattern consists of distinct ocelli. Photograph by **Klaus Wesiak**.

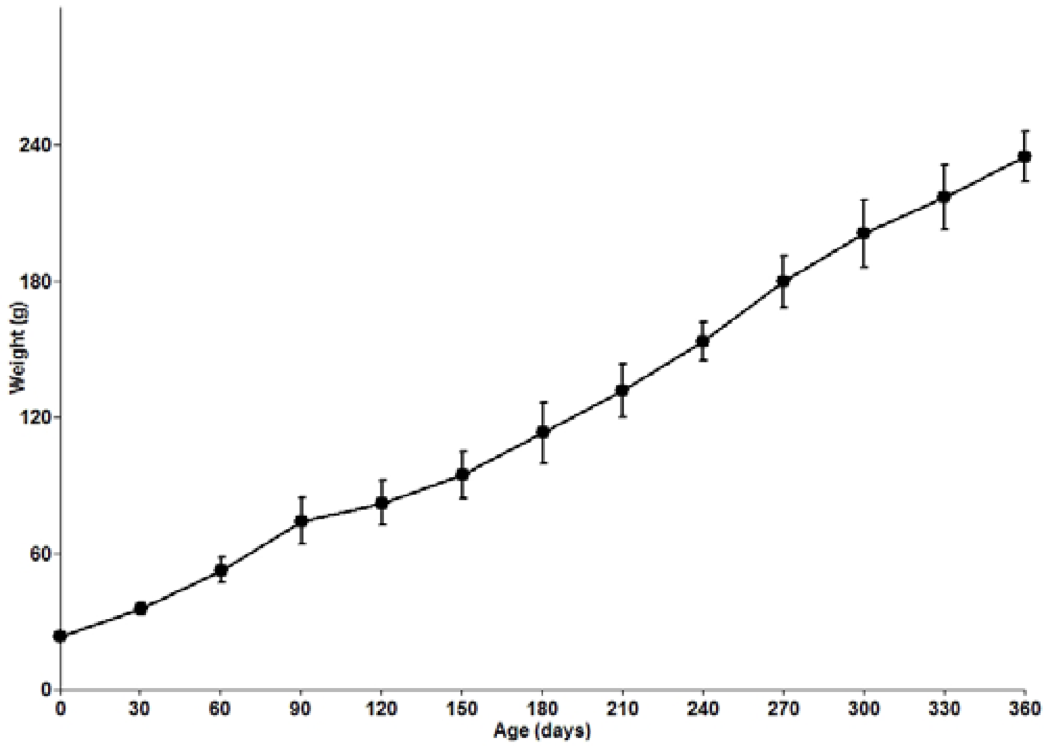

Diagram 1. Mean weight gain (g) of *V. juxtindicus* offspring (n = 8) during the first year.

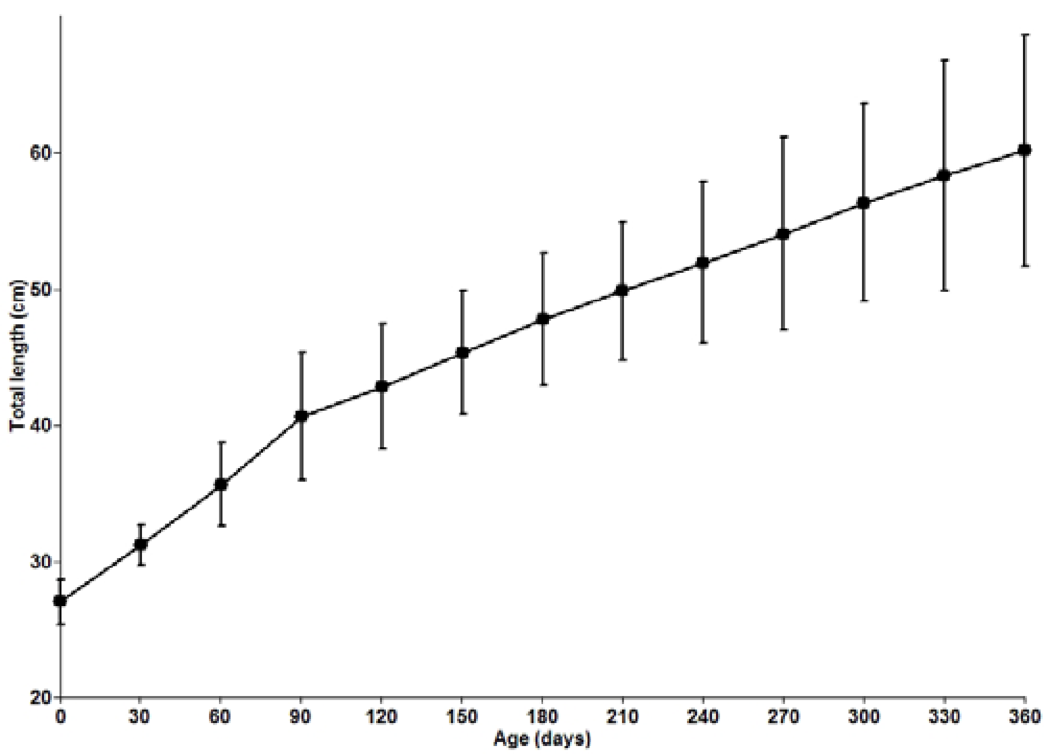

Diagram 2. Mean increase in total length (TTL) of *V. juxtindicus* offspring (n = 8) during the first year.

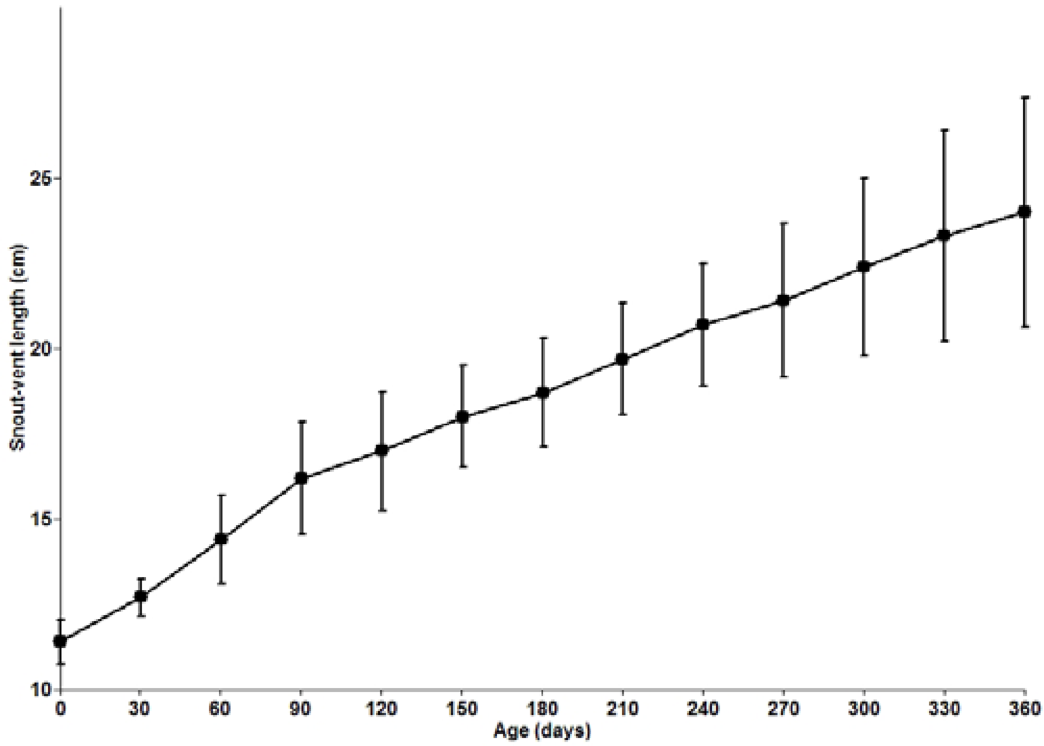

Diagram 3. Mean increase in snout-vent length (SVL) of *V. juxtindicus* offspring (n = 8) during the first year.

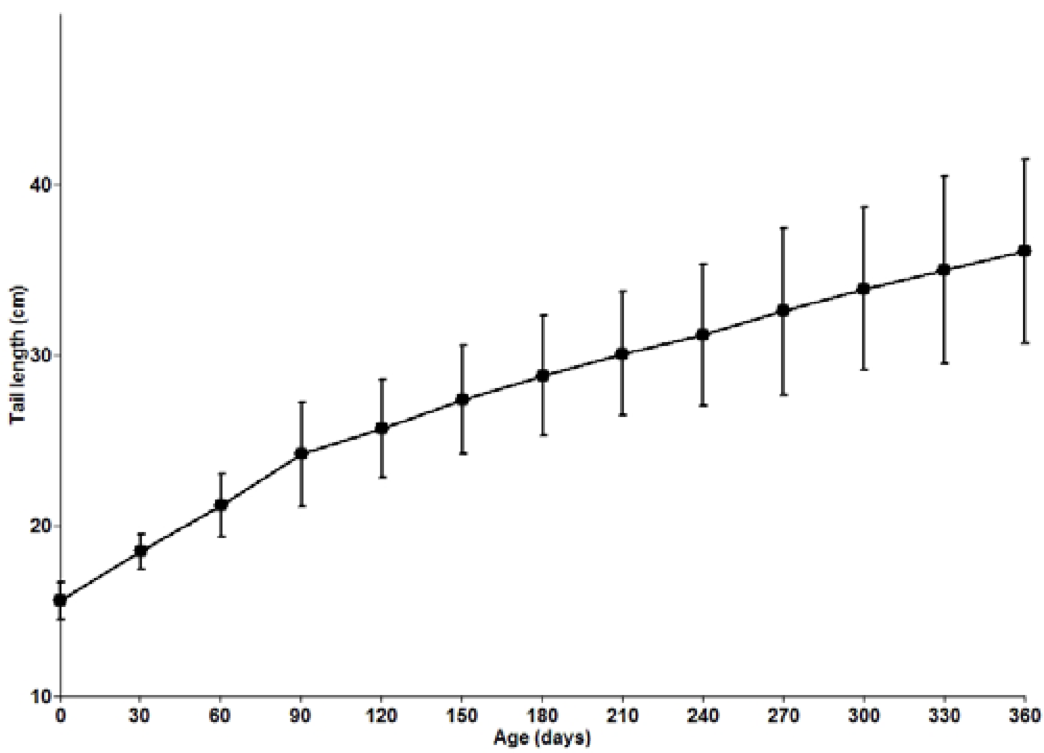

Diagram 4. Mean increase in tail length (TL) of *V. juxtindicus* offspring (n = 8) during the first year.

was important to control the feeding because juvenile *V. juxtindicus* can hurt each other severely. If necessary, the young monitors were fed separately.

Development of the Juveniles

Body Proportions and Weight

The development of the juveniles during the first year is documented in Diagrams 1 through 5. As expected, the increase in body mass showed the highest values (Diagram 1). While the hatchlings weighed 23.1 g on average at birth, after a year their weight had increased by a factor of 10. The values of the increase in snout-vent length in all specimens were similar (Diagram 3), probably because the quantitatively and qualitatively equal food allowance enabled a similar development. After one year, snout-vent lengths varied between 20.7 and 27.4 cm (mean = 24.0 cm). In contrast, the growth in tail lengths shows a noticeably divergent progress (Diagram 4), a physiological feature which is apparently genetically fixed and thus not affected by targeted feeding. In addition, variation in growth rates may be related to the sex of the specimens, but this information was not available. Correspondingly, the clearly divergent values of the total length are foremost the result of the individually divergent increase in tail lengths (see Diagram 2). Regarding the relation between snout-vent length and tail length, juveniles of *V. juxtindicus* hatch with relatively short tails – common among all monitor species studied on this variable (Mertens, 1942; Horn and Visser, 1991). The development of the head and body with the essential organs claims the maximal space in the egg (Horn and Visser, 1991).

Within the first weeks, the relation of snout-vent to tail was clearly shifted in favor of tail length (Diagram 5). At six months, the highest relative values loomed and, at the same time, the highest discrepancy between absolute maximal and minimal amount. Up until the first year, the relative tail length decreased again marginally, while maximal and minimal values approximated strongly (Diagram 5). At that time, the tail length was approximately 1.5 times the snout-vent length. This proportion between tail length and snout-vent length is also found in other monitor species (e.g., *V. indicus* and *V. salvator*), which are predominantly terrestrial or aquatic, while arboreal species have much longer tails and desert species often have shorter tails (Mertens, 1942; Horn and Visser, 1991).

Change in Color Pattern

Dorsally, hatchlings of *V. juxtindicus* show a dense pattern of small and large whitish spots arranged in

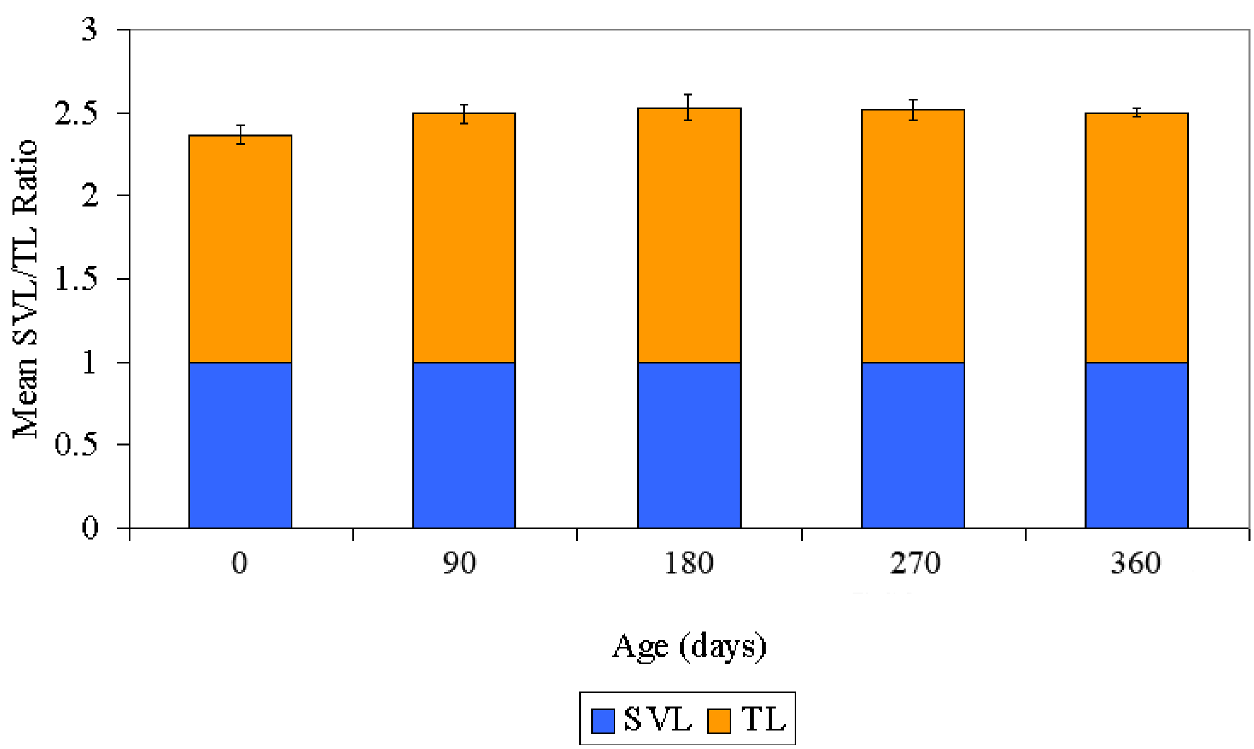

Diagram 5. Increase in mean SVL:TL ratio of *V. juxtindicus* offspring (n = 8) during the first year.

irregular transverse rows on a dark background. On the tail, the spots form a regular pattern of alternating transverse rows of larger and smaller spots respectively (Figs. 3 and 14). After the first molting at about two months, the spots become yellowish on the body. Laterally on the tail, some scattered ocelli are formed (Figs. 18A and B). Between the second and third molting, at about six months, the yellow coloration on the head, neck and limbs is intensified. On the back and tail, the smaller yellowish spots changed to a faint pattern of turquoise lines and distinct ocelli (Figs. 1, 18C and D). The underside of the body also showed distinct ocelli (Fig. 17). After the fourth molting at the age of about one year, the head, neck, and limbs still exhibit the brightest colors. The dotted color pattern has changed into a reticulated yellowish-green pattern interspersed with black markings (Figs. 19A and B). At the age of about two years, the juveniles of *V. juxtindicus* resemble the adults. The original color pattern of large whitish spots has dissolved into a homogenous and dense mottling of yellowish-green and orange small dots on a dark background. Only along the tail do the small dots still form thin and short transverse bars. The limbs are covered with yellow scales which have dark margins (Figs. 19C and D).

A significant ontogenetic change in color pattern from juveniles to adults within the same species is a rather common phenomenon in monitor lizards (Mertens, 1942). The occupation of different ecological niches during specific life stages within the same habitat may be responsible for the phenomenon. For instance, juveniles of *V. komodoensis* Ouwens, 1912 and *V. bengalensis* (Daudin, 1802) exhibit a vivid pattern of spots. With this camouflaged coloration, juvenile monitors are predominantly arboreal until they grow up to avoid pressure by various predators – including adult conspecifics (Auffenberg, 1981; Karunarathna et al., 2008). In the case of *V. juxtindicus* however, no statement can be made at the present time for the process of color change due to a lack of field observations in the their natural habitat.

A study about ecological and spatial niche partitioning by Philipp (1999) showed that *V. indicus* on New Guinea is not a very specialized species. This close relative of *V. juxtindicus* inhabits mangrove swamps, costal forests, inland forests along rivers, and lower mountain forests. Niche partitioning into different microhabitats by distinct age groups could not be inferred in the study area on Irian Jaya, New Guinea (Philipp, 1999).

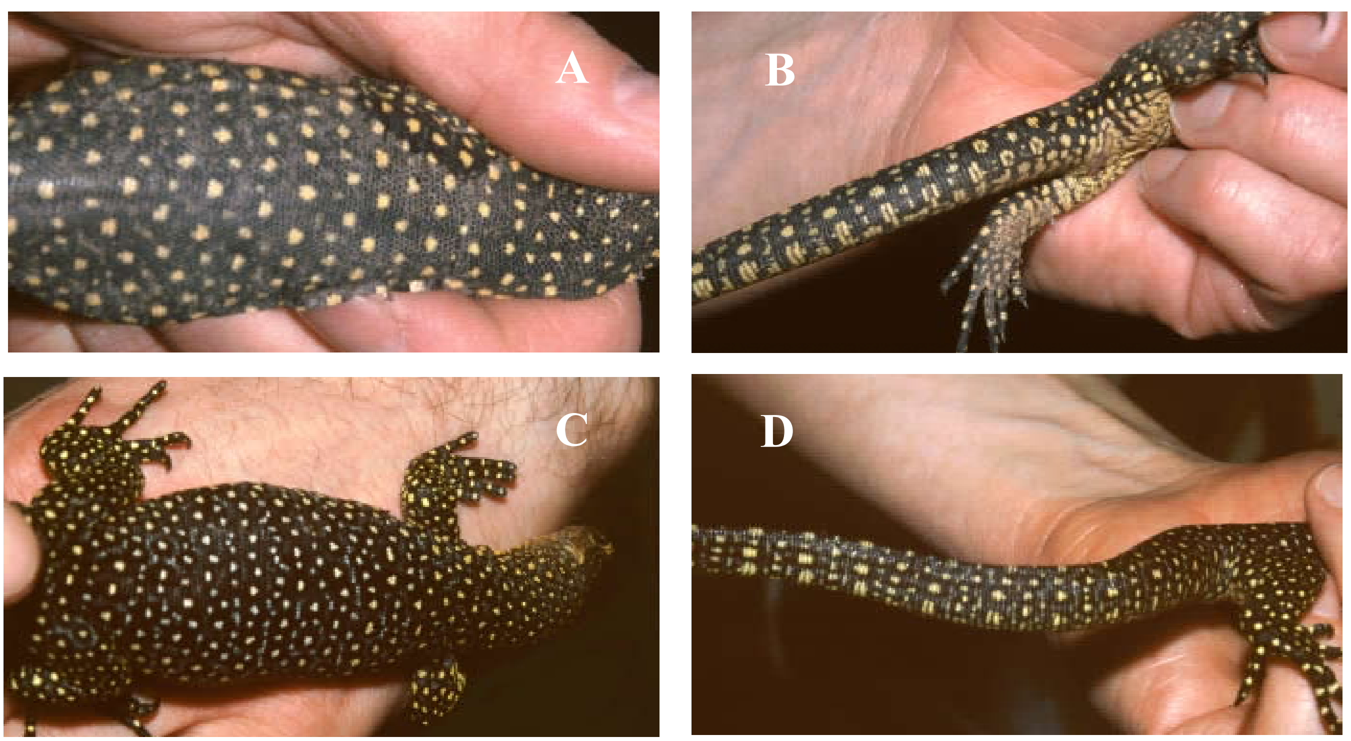

Fig. 18. Ontogenetic change in color pattern of dorsum and tail after two (A, B), six (C, D) months. Note the roundish base of the tail lacking a dorsal double keel as characteristic for *V. juxtindicus*. Photographs by **Klaus Wesiak**

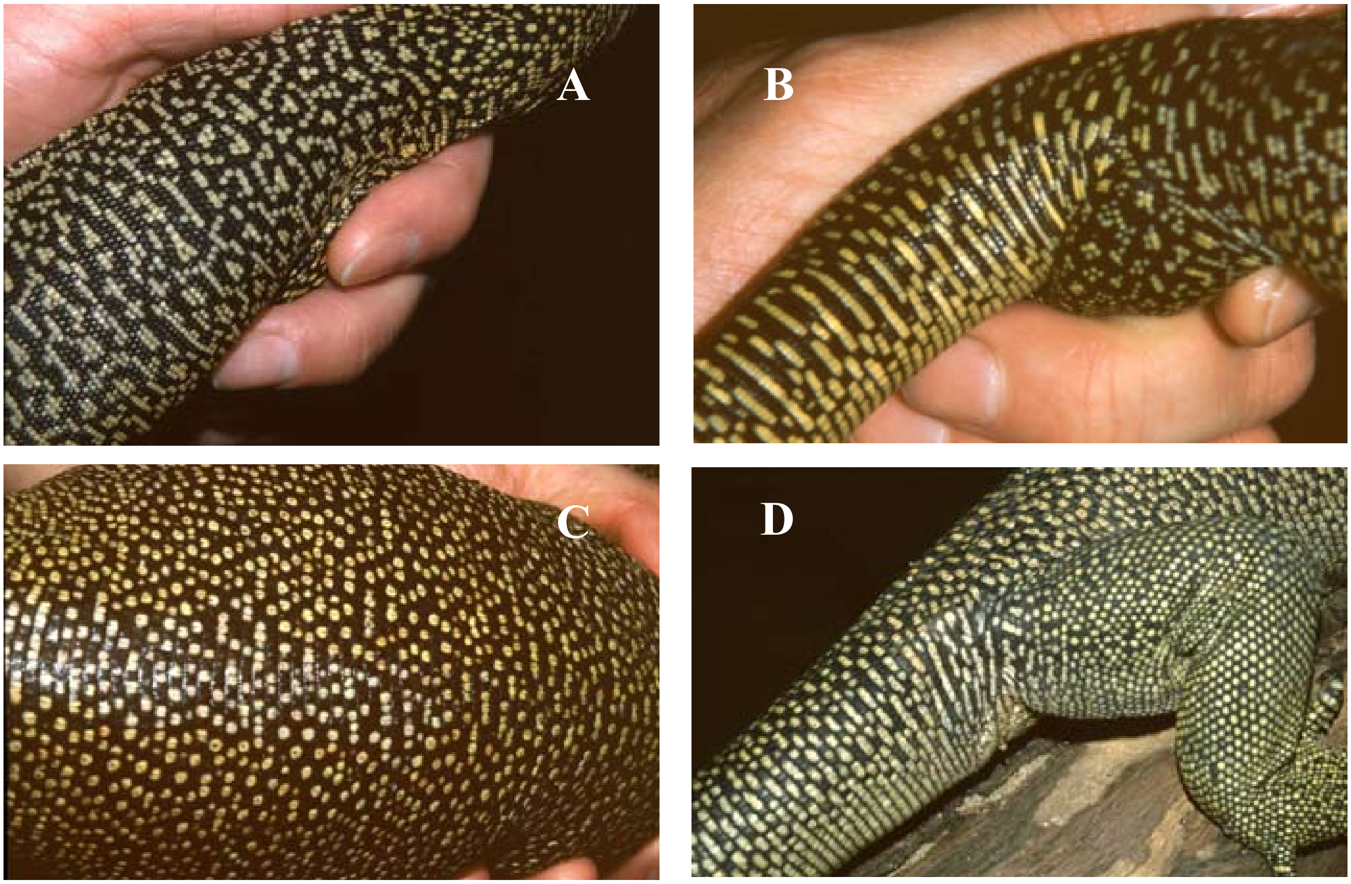

Fig. 19. Ontogenetic change in color pattern of dorsum and tail after twelve (A, B), and twenty-four (C, D) months. Photographs by **Klaus Wesiak.**

Outlook

Kok (1993) appears to have been the first person to breed *V. indicus* in captivity. He described his experiences in keeping and breeding this species successfully in two subsequent reports (Kok, 1995a, b). However, it has to be considered that the adult male specimen with unknown origin depicted by Kok (1995b) does not represent a real mangrove monitor (*V. indicus* s. str.) as defined by Philipp et al. (1999). It exhibits a thin bright temporal streak behind the eye, a black and white striped tail, and a vivid dorsal mottling of numerous bright scales on a dark background. This latter feature strongly resembles the color pattern characteristic for *V. juxtindicus*, which, however, lacks the first two characteristics – at least in adults (Böhme et al., 2002). In addition, the tail of Kok's male specimen seems to have a typical dorsal caudal keel as far as it can be determined from the photograph.

Besides the successful breeding of *V.* cf. *indicus* by Kok (1993), some further reports about keeping and breeding mangrove monitors in captivity have been published by McCoid (1993), Kukol (1993), Horn and Visser (1997), and Speer and Bayless (2000). While eggs obtained from captive *V. indicus* on Guam were incubated unsuccessfully by McCoid (1993), those reported by Kukol (1993) seemed not to be fertile. In addition, by reviewing reproduction data of monitor lizards in captivity, Horn and Visser (1997) reported the unpublished triple breeding success in *V. indicus* by two independent keepers (H. Biebl, unpubl. data; S. Irwin, unpubl. data). Lastly, Speer and Bayless (2000) documented the first case of mangrove monitor twins in what they considered to be *V. indicus*. In 1996, the first juvenile hatched (Speer, unpubl. data). Nothing is mentioned about the fate of this specimen. The following year, twin hatchlings pipped their egg on 13 July 1997, but did not succeed in emerging from the egg, and died shortly afterwards (Speer and Bayless, 2000). Both the adult specimens and the twin hatchlings were depicted in the short account by Speer and Bayless (2000). Similar to *V. juxtindicus* the male and female exhibit a fine color pattern of many bright scales scattered along the dorsum; the two hatchlings have bright tongue tips and lack a distinct caudal keel. For these reasons, we think that these monitors also belong to *V. juxtindicus*. Another alleged case of reproduction in *V. juxtindicus* occurred in

1999 but never reached publication (M. Bayless, pers. comm. to AK).

These few examples demonstrate that the “rarely-kept” *V. juxtindicus* seems to have been quite common in captivity during the 1990s, long before the taxonomic distinctness of this endemic Solomon monitor species was recognized (Böhme et al., 2002).

Due to far-reaching changes in the personal circumstances of KW, the keeping and breeding of *V. juxtindicus* were abandoned towards the end of 1996. His experiences with this species were very exciting and insightful. He believes that monitors can be kept and bred for a long time in captivity regardless of their size, providing the terrarium is of suitable size and design, and that the keeper is competent and has a sense of responsibility. Personally, KW would not avoid the energy or expense of keeping these magnificent and vivid monitors again.

Finally, we would like to encourage keepers of mangrove monitors and its allies, the so-called *V. indicus* species group (Ziegler et al., 2007), to publish their observations and experiences with these magnificent reptiles.

Acknowledgements - We are grateful to Florian Wagner (Frankfurt) who was the first to draw our attention to the real identity of the monitor specimens under his care, which in the end turned out to be *Varanus juxtindicus*. Robert Mendyk (New York, USA) pointed our attention to further reports about reproduction of *V.* “*indicus*” in captivity. AK is thankful to the late Mark Bayless who sent him a draft about the successful breeding of what he thought was *V. juxtindicus*. KW would like to thank Prof. Dr. Hans-Georg Horn (Sprockhövel) and Bernd Eidenmüller (Frankfurt) for helpful comments on the draft that was published in Elaphe. B. Eidenmüller (Frankfurt) also helped to digitally edit some older slides for the former Elaphe publication. Gunther Köhler (Senckenberg Museum, Frankfurt) and Felix Hulbert (Eltville) provided some slides of KW’s offspring of *V. juxtindicus*. Ulla Bott (ZFMK, Bonn) kindly scanned them for publication. KW is also grateful to Prof. Dr. Wolfgang Böhme (ZFMK, Bonn) who kindly helped to elucidate the identity of his monitors. We would like to stress that Prof. Böhme never saw all pictures of the monitors, nor did he ever see KW’s specimens, until two adult *V. juxtindicus* were generously donated to the Museum Alexander Koenig by Florian Wagner.

We apologize for any confusion caused and hope that this translated and corrected version of the original article by Klaus Wesiak (2009) will help prevent future misidentification of *V. juxtindicus*. Mogens Andersen (Zoological Museum of the University of Copenhagen, Denmark) kindly provided photographs of the juvenile paratype of *V. juxtindicus* for comparisons with the monitor offspring bred by Klaus Wesiak. Finally, we thank Wolfgang Böhme (ZFMK), Robert Neal (Brisbane, Australia), and three reviewers for improving the English language and for helpful comments on earlier drafts.

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First Captive Breeding of the Blue Tree Monitor *Varanus macraei* Böhme & Jacobs, 2001 at the Plzen and Cologne Zoos

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Abstract - The blue tree monitor, *Varanus macraei*, was described in 2001 from Batanta Island off Irian Jaya, Indonesian New Guinea. Only scarce information is available on its natural history, and breeding reports thus far have only been published from private holdings. The first successful breedings from within zoological gardens, at the Plzen and Cologne Zoos, are herein reported. Altogether, 37 eggs were laid and 24 juveniles have hatched to date. Furthermore, this data are compared with previously published information on the successful breeding of the species, and for the first time, proof of an individual recognition system for *V. macraei* based on neck patterns is provided.

Introduction

Varanus macraei was only recently described by Böhme and Jacobs (2001) and is known only from Batanta Island, northwest of the Vogelkop Peninsula of Irian Jaya, Indonesian New Guinea. The species belongs to the emerald tree monitor (*V. prasinus*) group, which is currently comprised of nine species: *V. prasinus*, *V. beccarii*, *V. kordensis*, *V. bogerti*, *V. keithhornei*, *V. telenesetes*, *V. macraei*, *V. boehmei* and *V. reisingeri* (Ziegler et al., 2007). *Varanus macraei* is a large, slender tree monitor with smooth, unkeeled nuchal scales and a unique dorsal color pattern consisting of numerous oblique, irregular rows of blue ocelli on a black ground color. Maximum size is 110 cm in total length, with a maximum snout vent length (SVL) of 36 cm in males and 31.3 cm in females (Böhme & Jacobs, 2004). *Varanus macraei* is a diurnal, highly specialized tree monitor, as are the other members of the *V. prasinus* group. Because the size of Batanta Island is only 455 km², with a maximum length of 61 km and a maximum width of 13 km, *V. macraei* has one of the smallest distributions among *Varanus*, and virtually nothing is known about its habitat and natural history (Böhme & Jacobs, 2001; 2004). The first breeding of *V. macraei* in captivity was published by Jacobs (2002). Further breeding successes in private facilities were subsequently published by Dedlmar (2007) and Moldovan (2008). Moreover, Mendyk (2007) reported on dizygotic twinning in *V. macraei* and Dedlmar (2008) on a two-headed hatchling. However, to our knowledge, there have been no documented zoo breedings of this rare and certainly endangered species. Thus, the first successful zoo breedings of *V. macraei*, at the Plzen and Cologne Zoos are herein reported.

Breeding Pairs

On 21 January 2004, the Plzen Zoo received a subadult pair of *V. macraei*, which was sent from Jakarta and subsequently confiscated at Prague airport. In April 2009, the female specimen measured 300 mm SVL and 620 mm tail length (TL) (920 mm in total length), the male measured 330 mm SVL and 660 mm TL (990 mm in total length). Three years later, in January 2007, Cologne Zoo received a confiscated pair of adult *V. macraei* from the Wildtier- und Artenschutzstation e.V. Sachsenhagen in Germany. On 28 April 2009, the female specimen (Fig. 1) measured 275 mm SVL and 575 mm TL (850 mm in total length), the male measured 290 mm SVL and 640 mm TL (930 mm in total length).

Both wild-caught pairs made up the unrelated breeding stocks of the Plzen and Cologne Zoos. Both breeding pairs from Plzen and Cologne are undoubtedly members of the *V. prasinus* group and assignable to the species *macraei* due to their prehensile tails which are roundish in cross section, in combination with unkeeled, smooth neck scales, dorsal patterns consisting of transversal rows of blue ocelli, and tails bearing alternating blue and black bands (Ziegler et al., 2007).

Housing

Cologne Zoo

The confiscated pair of *V. macraei* was placed together in a glass terrarium measuring 200 x 100 x 70 cm (L x W x H). The breeding pair was kept behind the scenes, inaccessible to the public. The enclosure was equipped with massive branches, cork tubes, and live plants (e.g., *Ficus* sp.) for climbing and hiding. The substrate consisted of pine bark. Light was provided by two fluorescent tubes (54 W) and two basking lamps (100 W) which also supplied ultraviolet light. Photoperiod was approximately 13:11 h (light:dark), however some lights were regularly turned off to simulate natural cloud cover, controlled by timers. Ambient temperatures of 29-32 °C were provided by light sources with a maximum temperature up to 40 °C directly beneath the basking

Fig. 1. The confiscated wild-caught female *Varanus macraei* after one year at Cologne Zoo (12 Jan. 2008). Photograph by **Thomas Ziegler**

lamps. A wooden nesting box was located in one corner of the enclosure and a clay nesting box was located in the middle of the rear of wall of the enclosure. The nesting boxes were accessible by a small hole and were filled with humid sphagnum moss, sand, and leaf litter at a ratio of 1:1:1, providing a beneficial microclimate due to the emerging compost heat. The enclosure further provided a water basin measuring 64 x 68 x 11 cm (L x W x H). Ambient humidity was around 70 % due to the water basin and daily misting.

The pair was predominantly fed live insects such as locusts, dusted with calcium (CALC Mineral) and/or vitamin powder (Korvimin ZVT) up to five times a week. Dead baby mice were offered supplementally, as well as chopped-up day-old chicken and fish occasionally.

The monitors were relatively shy and often disappeared when approached. Because of the particularly nervous behavior of the male early on in its captivity, it often collided with the glass panes of the enclosure and resulted in snout injuries and subsequent deformations.

Plzen Zoo

The breeding pair was housed in a terrarium measuring 100 x 100 x 150 cm (L x W x H). The side and rear walls were constructed with wooden panels (OSB) and the front consisted of a glass door. Three round ventilation holes (10 cm in diameter) covered by wire mesh were situated under the door and an additional ventilation hole measuring 10 x 100 cm was located on the rear wall 20 cm down from the ceiling. The terrarium was equipped with plastic plants, two wooden shelves, and some branches. The walls and furniture could be used for climbing, allowing the entire space of the terrarium to be utilized. Wood chips were used as substrate. Light and heat was provided by a white fluorescent tube (18 W) measuring 60 cm in length, a Sera UV 5 light tube (18 W) and a T-Rex Active UV Heat (100 W), controlled by a thermostat and switched off at temperatures above 30°C. A water dish measuring 50 x 25 x 20 cm was used for water supply. Additionally, the terrarium was sprayed with water twice a day (in the morning and in the afternoon); thus ambient humidity ranged between 70 and 90%. A wooden box with one side made of glass was used for egg-laying. It measured 25 x 25 x 30 cm and was filled with a 5-6 cm deep layer of peat. The box provided an entrance hole (6 cm in diameter) situated 3 cm from the top and was mounted on the upper third of the enclosure's rear wall.

Animals were fed crickets twice a week and mice twice a week. Occasionally, mice were replaced by 5-6 locusts. Vitamins were initially supplemented with NUTRIMIX for poultry and eventually replaced by PLASTIN with Amino Rep F.

Mating and Gestation Period

Cologne Zoo

As an indication of the mating season (e.g., the female's receptivity) the female was observed approaching the male. During this time, the pair was often seen resting close to each other. Copulations were observed several times before deposition of the clutches. The time between observed copulations and egg depositions ranged from 25 to 35 days. Vertical copulatory positions as reported by Moldovan (2008) and photographed by Dedlmar (2007) could not be observed. Copulations always took place in a horizontal position on the cork tube; however, this may be reliant on the structure and general shape of the terrarium. Observed copulations lasted at least 5-6 min.

Concordant with Dedlmar's (2007) statements, the female was observed frequenting basking sites with UV lights during gestation. During this time, the female was also restless and almost always in motion, which may be due to the increasing food demand. However, a few days before oviposition, the gravid female refused food. Digging or other physical cues indicating gestation or forthcoming oviposition, such as the swelling of the abdomen, were not observed.

Plzen Zoo

After observing initial copulation attempts, keepers always limited their visits to the animals. Consequently, copulation was never observed. Approximately three weeks after perceived copulation attempts, the male was always separated from the female because of increasing aggression by the female. Two weeks after egg deposition, the female became less aggressive and the male was returned to the enclosure.

Egg Deposition and Incubation

Cologne Zoo

Egg deposition by *V. macraei* occurred three times at Cologne Zoo. Six months after their confiscation, on 17 June 2007, the adult pair laid eggs for the first time, approximately four to five weeks after observed mating behavior. In total, four eggs were laid in the wooden nesting box. Eggs were not buried, but deposited on top of the nesting substrate. For incubation, eggs were removed and carefully placed in plastic boxes which were half-filled with vermiculite and sand at a ratio of 2:1 as incubation substrate. Eggs were not turned, and were placed on the surface of the vermiculite. The plastic boxes measured 20-22.5 x 12-14 x 14 cm (L x W x H) and contained two eggs each. For incubation, the plastic boxes were placed inside a large medicinal incubator.

The first clutch was incubated at a temperature of 29.3°C with a substrate humidity of 97 % (Table 1). From the four eggs, four juveniles hatched after 154-158 (156±1.8) days of incubation between 17 and 21 November 2007. Several days before hatching, the egg shells showed a red marbling and denting, which disappeared shortly before the hatching process. Because one egg (egg no. 3 in Table 1) developed further dentations and a stronger red marbling than observed in both previously hatched eggs, it was decided to manually open it to ease the hatching process. Because the juvenile was in good condition, the fourth egg was not opened and hatched one day later on 21 November. Egg shells measured 42-50 x 23-25 mm after hatching. The hatching process began with longish slits made at the head end of the egg. The snout of the hatching juvenile protruded for some hours and hatching was usually completed within 24 h (Figs. 2-4).

Nearly eight months after deposition of the first clutch, the same pair laid eggs again on 5 February 2008. Four eggs were immediately found, and remains of a fifth egg were found in faeces in the enclosure several days later. Although egg deposition and incubation did not change, three of the four incubated eggs were disposed of after 2-3 weeks because they did not show signs of development and began to decay. The remaining egg hatched on 13 July 2008 after 160 days of incubation.

A third clutch was laid by the confiscated wild-caught female in March 2009, but this time the father was an approximately two year old male offspring of the wild-caught breeding pair at the Plzen Zoo. This far-calmer male replaced the aforementioned wild caught male at Cologne Zoo in February 2009. Three eggs were laid on 20 March 2009, approximately 39 days after the pair was introduced and 25 days after copulation had been observed. Two eggs measuring 45-46 x 18-19 mm were found in a cork tube that provided relatively humid conditions due to increased misting at that time. The third egg must have been eaten again by one of the parents, because the shell was found in faeces inside the terrarium. The remaining two eggs did not show signs of development and began to decay.

Plzen Zoo

At the Plzen Zoo, six clutches of *V. macraei* eggs

Table 1. Egg incubation for *V. macraei* at Cologne Zoo. Egg shells were measured after hatching; * artificial hatching (egg was opened); ** measured 5 days after egg deposition.

N°	Egg Deposition (date)	Clutch Size (eggs)	Egg Shell Size (mm)	Incubation Temperature °C	Substrate Humidity	Hatching (date)	Incubation Period
1	17 Jun 07	4	49 x 23	29.3	97%	17 Nov 07	154
2	17 Jun 07	4	50 x 23	29.3	97%	18 Nov 07	155
3	17 Jun 07	4	42 x 25	29.3	97%	20 Nov 07*	157
4	17 Jun 07	4	48 x 25	29.3	97%	21 Nov 07	158
5	5 Feb 08	5	48-50 x 19-21	29.3	97%	13 Jul 08	160
6	5 Feb 08	5	48-50 x 19-21	29.3	97%	Dead	-
7	5 Feb 08	5	48-50 x 19-21	29.3	97%	Dead	-
8	5 Feb 08	5	48-50 x 19-21	29.3	97%	Dead	-
9	20 Mar 09	3	46 x 18**	29.3	97%	Dead	-
10	20 Mar 09	3	45 x 19**	29.3	97%	Dead	-

Fig. 2. At early hatching stage, only the snout of the juvenile *V. macraei* is protruding (16 Nov. 2007). Photograph by **Thomas Ziegler**

Fig. 3. Hatching *V. macraei* (16 Nov. 2007). Photograph by **Thomas Ziegler**

Fig. 4. The juvenile *V. macraei* depicted in Figs. 2-3 upon hatching (17 Nov. 2007); the prehensile tail of the first hatchling in the Cologne Zoo is already well discernible. Photograph by **Thomas Ziegler**

have been laid within a two year period. The eggs of the first clutch laid on 15 June 2006 were measured and their sizes ranged between 50-55 mm (52.5±2.4) in length and 14-18 g (15.3±1.9) in weight.

All eggs laid up until now have been incubated in plastic boxes filled with moist vermiculite in a Jäger FB 80 incubator. Incubation temperatures ranging from below 28 °C to 31 °C were tested with different clutches and failed to demonstrate any correlation between temperature and sex of hatchlings (for details see Table 2). Both sexes hatched at low and high temperatures. At temperatures below 28 °C all embryos died. Because of these attempts, eggs are currently incubated at 29 °C.

Sexes of monitor lizards were determined through a combination of probing and palpation, and observation of noticeable sexual dimorphism (head size, tail base swelling). Sometimes, captured males spontaneously everted hemipenes which was used as evidence for male sex, and during some health assessments, radiography was used to check for genital mineralizations (visible in males due to mineralized hemibacula; not visible in females due to unmineralized hemibaubella; see, e.g., Ziegler and Böhme 1996, 1997). Males were usually recognized at a rate of 100%; sexing of females became reliable at an age of about one year (then, head shape and tail base swelling proved to be distinct indicators of sex). Another indicator of sex was behavior, with females more submissive and nervous than males.

Development

Cologne Zoo

The four juveniles from the first clutch had SVL of ca. 90 mm, and TL of 130-140 mm. Their weights two days after hatching were 10-11 g. Since the artificially-hatched juvenile was weighed with its remaining egg yolk, its weight was 14 g. Hatchlings from the first clutch were housed together for approximately two months in a glass terrarium measuring 60 x 85 x 60 cm (L x W x H). They were subsequently moved to individual enclosures as a result of increasing differences in size. The juvenile from the second clutch was solely kept in an exhibit measuring 50 x 80 x 60 cm (L x W x H) since hatching. All enclosures provided conditions similar to the enclosure of the breeding pair. Hatchlings began feeding on small migratory locusts within a few days after hatching. Further hatchling husbandry took place without complications. However, it is interesting to note that the juveniles developed different food preferences, e.g., for mice or locusts. Of the four hatchlings from the first clutch of *V. macraei*, one was unfortunately stolen

Fig. 5. Two hatchlings from the first *V. macraei* clutch at Cologne Zoo (20 Nov. 2007). Photograph by **Norbert Rütz**

Table 2. Egg incubation for *V. macraei* and sexes of hatchlings at the Plzen Zoo.

N°	Egg Deposition (date)	Clutch Size (eggs)	Incubation Temperature °C	Hatching (date)	Incubation Period	Sex
1	15 Jun 06	4	30	15 Nov 06	153	-
2	15 Jun 06	4	30	18 Nov 06	156	1.0
3	2 Dec 06	4	31	1 May 07	150	0.1
4	2 Dec 06	4	31	3 May 07	152	1.0
5	2 Dec 06	4	31	5 May 07	154	1.0
6	2 Dec 06	4	31	5 May 07	154	-
7	1 Apr 07	4	29	30 Sept 07	183	0.1
8	1 Apr 07	4	29	29 Sept 07	182	-
9	1 Apr 07	4	28.5	11 Dec 07	194	0.1
10	1 Apr 07	4	28.5	16 Oct 07	199	-
11	29 Jul 07	4	29.5	12 Jan 08	167	0.1
12	29 Jul 07	4	29.5	20 Jan 08	175	1.0
13	1 Nov 07	5	29.5	10 Apr 08	162	0.1
14	1 Nov 07	5	29.5	11 Apr 08	163	0.1
15	1 Nov 07	5	28.5	18 Apr 08	170	1.0
16	1 Nov 07	5	28.5	19 Apr 08	171	1.0
17	22 May 08	4	29.5	10 Nov 08	173	-
18	22 May 08	4	29.5	14 Nov 08	177	-
19	22 May 08	4	29.5	15 Nov 08	178	-

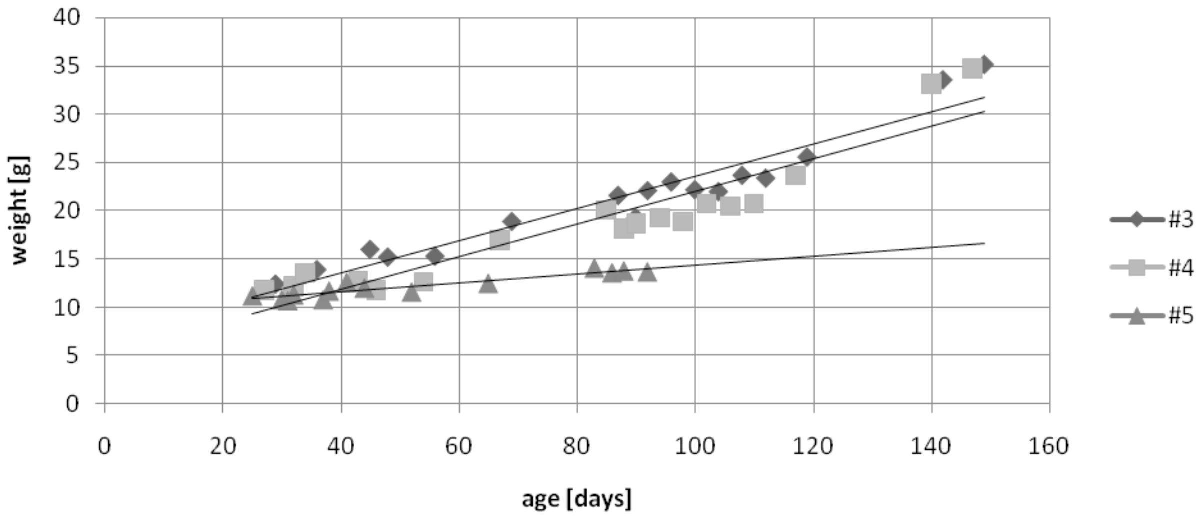

Fig. 6. Weight increases of *V. macraei* hatchlings during the first 5 months from the second clutch laid at the Plzen Zoo (eggs N° 3-5).

Table 3. Previously published data on the successful breeding of *V. macraei* in private facilities, after Jacobs (2002), Dedlmar (2007) and Moldovan (2008). Mean ± standard deviation are given in parentheses.

	Jacobs (2002)	Dedlmar (2007)	Moldovan (2008)
Number of Clutches	1	5	1
Number of Eggs (per clutch)	4	2-4 (2.8±0.8)	7
Number of Eggs (total)	4	14	7
Egg Size (mm)	43-45 x 20-21 (43.7±1.2 x 20.7±0.6)	47.1-52.5 x 20.3-22.3 (48.9±1.6 x 22.0±0.5)	-
Egg Weight (g)	9.0-10.0 (9.3±0.6)	-	-
Incubation Temperature °C	29.0-30.0	28.5	28.5
Incubation Period	159	206-240 (218.1±15.0)	169-177 (173.2±3.0)
Number of Hatchlings	2	7	5
Snout to Vent Length (mm)	95-100 (97.5±3.5)	-	88-91 (89.2±1.3)
Tail Length (mm)	140-150 (145.0±7.1)	-	125-130 (127,6±1,8)
Total Length (mm)	235-250 (242.5±10.6)	239-264 (250.0±10.0)	213-221 (216.8±3.0)
Weight (g)	12.0-13.0 (12.5±0.7)	11.9-14.3 (12.7±1.0)	11.0-12.0 (11.4±0.5)

(see below), one was exchanged with Plzen Zoo, and two remain at Cologne Zoo (Fig. 5). On 28 April 2009, they measured 230-240 mm SVL, 435-455 mm TL, 665-695 mm in total length and their weights were 170-180 g. The specimen exchanged with Plzen measured 240 mm SVL, 470 mm TL, 710 mm in total length, and weighed 151 g in May 2009.

Plzen Zoo

Juveniles primarily weighed between 13 and 15 g shortly after hatching. The two hatchlings of the first clutch which hatched on 15 and 18 November 2006 weighed 13 and 15 g respectively on 28 November. On 2 January 2007, their weight was 10 and 20 g. The declining weight of the first hatchling indicated its forthcoming death. The other juvenile was later transferred to Cologne Zoo. Weight increases of viable hatchlings from the second clutch (egg nos. 3-5) were measured during the first 5 months of life (Figure 6).

Hatchlings were kept in separate terrariums. Later, juveniles from the same clutch were placed together in groups. They were housed in glass terrariums measuring 125 x 80 x 55 cm (L x W x H). The terrariums were situated in a quiet location above the keepers' heads because young hatchlings proved to be stress-sensitive. Stress might lead to food refusal and weight decrease below 9 g, which seems to be lethal.

Comparisons with Breeding Successes in Private Facilities

In captivity, clutches of *V. macraei* may range in size from 2-7 eggs with a mean of 3.9±1.2 eggs per clutch (see Tables 1-3). Up to four clutches may be laid throughout the year (Mendyk, 2007). The shortest interval between subsequent clutches of the same breeding pair was 95 days, as was documented at the Plzen Zoo. However, most of the clutches (64.7%) were deposited during European winter time, from October to March. This may be due to the reduced amounts of rainfall experienced during this time of year in the natural habitat of *V. macraei*, as was documented by Moldovan (2008) for Sorong, Bird-head Peninsula. Copulations were observed from November until May, but most frequently from November until January. According to observations and data from the literature, the period between copulation and egg deposition takes about five to seven weeks. Egg size varied from 43 to 55 mm in length and 20 to 22.3 mm in width (Tables 1 and 3). In captivity, incubation

Table 4. Incubation period and hatchling size/weight of *V. macraei* in relation to incubation temperature. After own data (successful breeding at Cologne and Plzen Zoos) and data provided by Jacobs (2002), Dedlmar (2007) and Moldovan (2008); mean ± standard deviation are given in parentheses; 1 one of five hatchlings was weighted with egg yolk; 2 measured 4-7 days after hatching; 3 measured 25-29 days after hatching.

Incubation Temperature °C	Number of Eggs	Incubation Period	SVL (mm)	TL (mm)	TTL (mm)	Weight (g)
28.5	16	169-240 (195.4±24.1)	88-91 (89.2±1.2)	125-130 (127.6±1.8)	213-264 (236.2±18.7)	11.0-14.3 (12.2±1.1)
29	2	182-183 (182.5±0.7)	-	-	-	-
29.3	5	154-158 (156.8±2.4)	90	130-140 (135.5±7.1)	220-230 (225.5±7.1)	10.0-14.0 (11.25±1.9)[1]
29.5	7	162-178 (170.7±6.7)	-	-	-	-
29-30	2	159	95-100 (97.5±3.5)	140-150 (145±7.1)	235-250 (242.5±10.6)	12.0-13.0 (12.5±0.7)
30	2	153-156 (154.5±2.1)	-	-	-	13.0-15.0 (14.0±1.4)[2]
31	4	150-154 (152.5±1.9)	-	-	-	11.2-12.4 (11.8±0.6)[3]

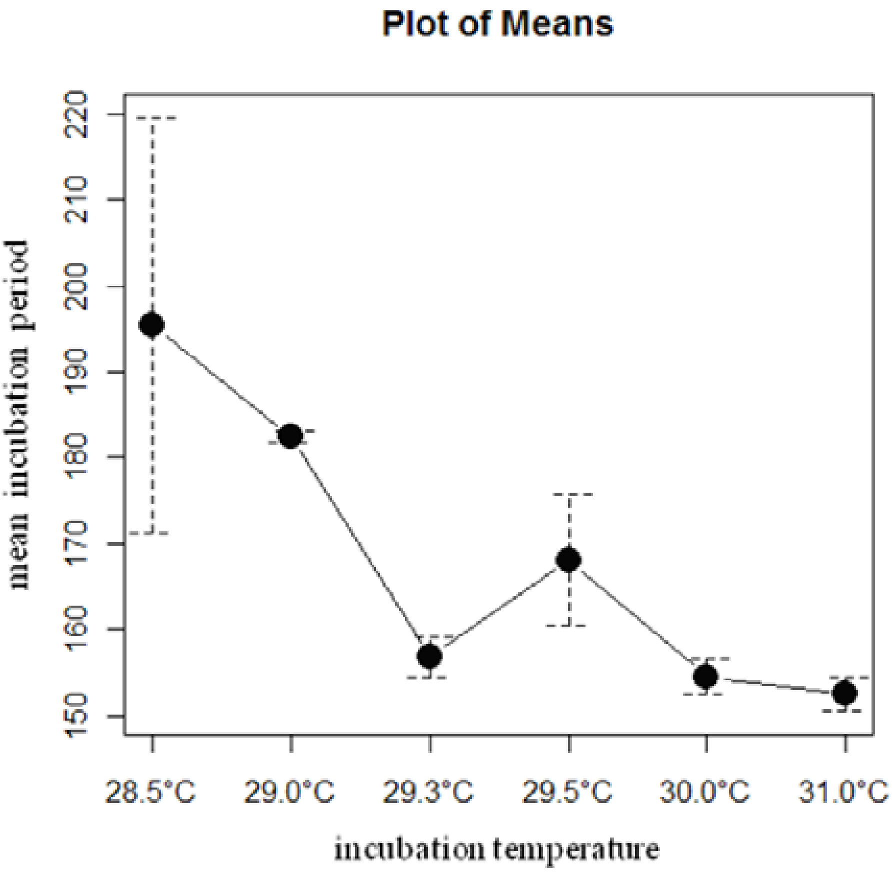

Fig. 7. Mean and standard deviation of incubation period for *V. macraei* in relation to incubation temperature; after own data (successful breeding at Cologne and Plzen Zoos) and data from Jacobs (2002), Dedlmar (2007) and Moldovan (2008).

temperatures varied from 28.5 to 31 °C, with 28.5 °C representing the most frequently used temperature for incubation. More than half of the incubated eggs of *V. macraei* (67%) hatched in all facilities independent of the incubation temperature. Most of the eggs which did not hatch proved to be infertile (21%). Incubation times ranged between 150 and 240 days, depending on the incubation climate. The incubation period generally declined with increasing incubation temperatures (Fig. 7, Table 4). Hatchlings measured 88 to 100 mm in SVL and 125 to 150 mm in TL (213 to 264 mm in total length). Eggs that were incubated at higher temperatures led to lower incubation periods and usually produced larger hatchlings (see Table 4). This trend suggests that higher incubation temperatures are more beneficial to the development of *V. macraei* clutches; however, this needs to be confirmed by further research. Sexual maturity seems to be reached by the age of about two years, as was shown by the male offspring from the Plzen Zoo which successfully copulated with the wild-caught female kept at Cologne Zoo. The age of this male was 26 months at the time of successful copulation and it measured 320 mm in SVL and 645 mm in TL at that time. The sexual maturity of *V. prasinus* is also reached at an age of about two years (Greene, 2004).

Individual Recognition

In 2008, one of the hatchlings from the first clutch of *V. macraei* at Cologne Zoo was stolen from an exhibit accessible to the public. Because the juvenile specimen was not yet microchipped, this gave reason to study a possible individual recognition system for this species. Photographs from all hatchlings were evaluated and compared with the grown-up specimens. For every specimen, a characteristic neck pattern was detected which allowed for proper identification even after about 1.5 years, as discernible by Fig. 8. Although the borders of individual dark neck patterns may slightly change or become intermixed by lighter scales over the years, it still allows for an individual's identification. Thus, as an alternative method for recognizing individual specimens, it is recommended to photographically document the pattern on both sides of the neck. The characteristic neck

Fig. 8. The neck pattern of *V. macraei* may serve for the recognition of individuals as is shown here for the specimen depicted on the top of Fig. 5; above: immediately after hatching (20 Nov. 2007, photograph by **Norbert Rütz**), and below: 16 months later (27 March 2009, photograph by **Thomas Ziegler**).

pattern (left side) of the stolen specimen, consisting of three dark ball-like structures at the lower neck, is well discernible from a figure published in Ziegler (2008: 10) and in the November issue (Vol. 2, No. 4:148) of this journal (available at http://varanidae.org/Vol2_No4.pdf).

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Geographical Distribution and Regional Variation of *Varanus salvator macromaculatus* in Thailand

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Abstract: The geographical distribution of *Varanus salvator macromaculatus* in Thailand has not been accurately recorded in previously published literature, which has either concluded it is present throughout Thailand or absent only from northern-most Northern Thailand. Here, the geographical distribution is mapped out for Thailand and Laos using documented localities and the findings of this study. Our findings show that *V. salvator macromaculatus* is absent from most of Northern and nearly all of Northeastern Thailand; it is further described for adjacent countries. The geographical variation of *V. salvator macromaculatus* is recorded and discussed, which can be of aid to biologists and wildlife trade enforcement officials in order to protect the species from the illegal wildlife trade.

Introduction

Varanus salvator was described in 1768 by Austrian naturalist Josephus Nicolaus Laurenti. Today, this species has among the widest distribution of all varanids, ranging from Sri Lanka in the west through continental Southeast Asia, the Greater and Lesser Sunda Islands and the Philippines, finally reaching Sulawesi in the east. The form in Thailand was designated as the nominate form, *V. salvator salvator* until Deraniyagala wrote a paper in 1947 on the different races of *V. salvator* in which he described it as *V. salvator macromaculatus*. This subspecies epithet remained in synonymy with *V. s. salvator* until Koch et al. (2007), when *V. salvator* was reviewed; many subspecies were elevated to species status, *V. salvator macromaculatus* was raised again as a subspecies with Siam (Thailand) as *terra typica*. Another Thai form, the melanistic *V. salvator komaini* was placed as a synonym of *V. salvator macromaculatus* (Koch et al., 2007).

In Thailand, *V. salvator macromaculatus* is protected from hunting, collection and export without special permits by Thai Law (1992). This same protection also hinders research; therefore, this species has been neglected in study (Cota, 2009). Another reason why there has been little study of this species is because of the negative attitude brought by the species name in Thailand, which is considered the lowest and dirtiest animal in the culture. The name of this magnificent species, “hia”, has become a curse word in Thailand and a substitute word, “tua ngern tua tong”, has substituted it so this species can be talked about politely in public. Recently, the word “Varanus” was suggested as a substitute, but because a similar name is already in usage, it was the subject of protest and misunderstanding, which prompted a publication to educate the public (Chan-ard, 2009). Since it has been despised and subsequently neglected, no nation-wide study has been conducted on this species in the past. Its geographic distribution has been simply described as ‘throughout Thailand’ in all literature (Taylor, 1963; Cox et al. 1998 by implication; Nabhitabata and Chan-ard, 2005), except those which only recorded locality data, such as Nabhitabhata et al. (2000).

During field studies of *V. salvator macromaculatus*, a number of regional variations have been found. These variations are described along with the geographic locations that they can be found.

Geographical Distribution in Thailand

There have been a number of maps showing the geographic distribution of *V. salvator*. Every one of these maps has shown the entirety of Thailand (Bennett, 1998;

Gaulke and Horn, 2004; Koch et al., 2007) which might be based on the information in Taylor (1963) or all of Thailand with the exception of the northern- most extent of Northern Thailand (Eidenmüller, 2007; Eidenmüller and Philippen, 2008) as being the extent of natural geographic distribution for this species. To date, there is no field guide with distribution maps for the reptiles of Thailand. Descriptions of the geographic distribution of *V. salvator* have not been specific, either listing all of Thailand and citing Smith (1935) and Taylor (1963), or Southeast Asia, citing Mertens (1942) and Cox et al. (1998). Because of the enormous range of this species, it is possible that errors in the past may have been a result of an overestimation of geographical distribution in a species with one of the greatest distributions of all monitor species. The only publications that have dealt specifically with this species' geographic distribution in Thailand to date have been Taylor (1963), which claimed it was found throughout Thailand, albeit with no specific locality data in the areas this study shows them to be absent; Nabhitabhata et al. (2000), which was solely based on locality data and Lauprasert and Thirakupt (2001), which documented localities in Southern Thailand; Nabhitabhata and Chan-ard (2005) described distribution as all of Thailand, following past literature.

Although Thailand has a very large population of *V. salvator macromaculatus* due to their protected status and lack of predators, this species is mostly absent in the geographical/political region of Northern Thailand. As depicted in Fig. 1, the furthest northern extent of its range in Northern Thailand is a population in Sukhothai (this study). With the exception of a mountain range between Central and Northeastern Thailand (Nabhitabhata et al. 2000), *V. salvator macromaculatus* barely reaches the Korat Plateau, which makes up the topography of the geographical and political area known as Northeastern Thailand, also referred to as the Isaan Region (this study). It is most common in the flood plains of the Chao Phraya River flood basin, even into the middle of Bangkok where there are large thriving populations with large population densities and in the mangrove forests to the south of Bangkok (this study).

To the west of Thailand, it is absent from central Myanmar (Zug, pers. comm.), but has been recorded once, 130 years ago, in the north of Myanmar, in Bhato (Anderson, 1879 cited in Mertens, 1942) and again in the Kakhien (Kachin) Hills of Myanmar, which is in the same region (Boulenger, 1888, cited in Mertens, 1942). The areas of Bhato and the Kachin Hills represent the source of the Irrawady River. Could these localities be based on specimens obtained in markets, transported as food? Could these localities have been in error like many localities for *V. salvator* recorded in the mid to late 19th century, such as South Africa (Gray, 1845 cited in Mertens, 1942) and Cape York in Australia (Boettger, 1888 cited in Mertens, 1942) or had *V. salvator* dispersed up the Irrawady River north to its source and has not been recorded in the north since? The California Academy of Sciences (CAS) has conducted numerous surveys of Myanmar (Burma), but has not recorded *V. salvator* in central or northern regions of the country. To the north of Thailand, it is absent in northern Laos and is only recorded in southern and eastern Laos in the northern and central areas of the Annamite Mountains, which separate Laos and Vietnam. One record shows it in the plains west of the Annamite Mountains (Duckworth et al. 1999). To the east of Thailand in Cambodia, its geographic distribution extends to the southeast along the Cardamom Mountains following the coastal areas to eastern Cambodia, and is found in the hilly areas of northeastern Cambodia (Stuart, unpubl. data); it has also been found in Cambodia along the Mekong River (Bezuijen et al., 2009). South of Thailand, the geographical distribution is continuous south past the tip of peninsular Malaysia to Singapore and beyond into Indonesia, as described in historical literature (Mertens, 1942; Bennett, 1998; Gaulke and Horn, 2004; Koch et al., 2007; Eidenmüller, 2007; Eidenmüller and Philippen, 2008)

One can only speculate as to why *V. salvator macromaculatus* has not expanded its geographic distribution further north into Northern Thailand and Northeastern Thailand. One reason that they have not expanded further north and northeast could be due to the xeric habitats of these regions resulting from a dry climate during the cold season, from November to February, and the hot season, from March to June. During these seasons, large areas are without permanent water sources, which *V. salvator* is completely dependent. Even within its geographical distribution, *V. salvator macromaculatus* in Thailand is not found more than 200 m away from a water source, with the exception of torrential downpours during the rainy season (Cota, pers. obs.). Another reason that *V. salvator macromaculatus* may not have expanded its geographic distribution further north and northeast may be time constraints; it may not have had the time to disperse further inland from the time it appeared in Thailand. There are riparian habitats along the Ping River, Nan River and Yom River that *V. salvator macromaculatus* could exploit from its furthest distribution north in order to expand its range

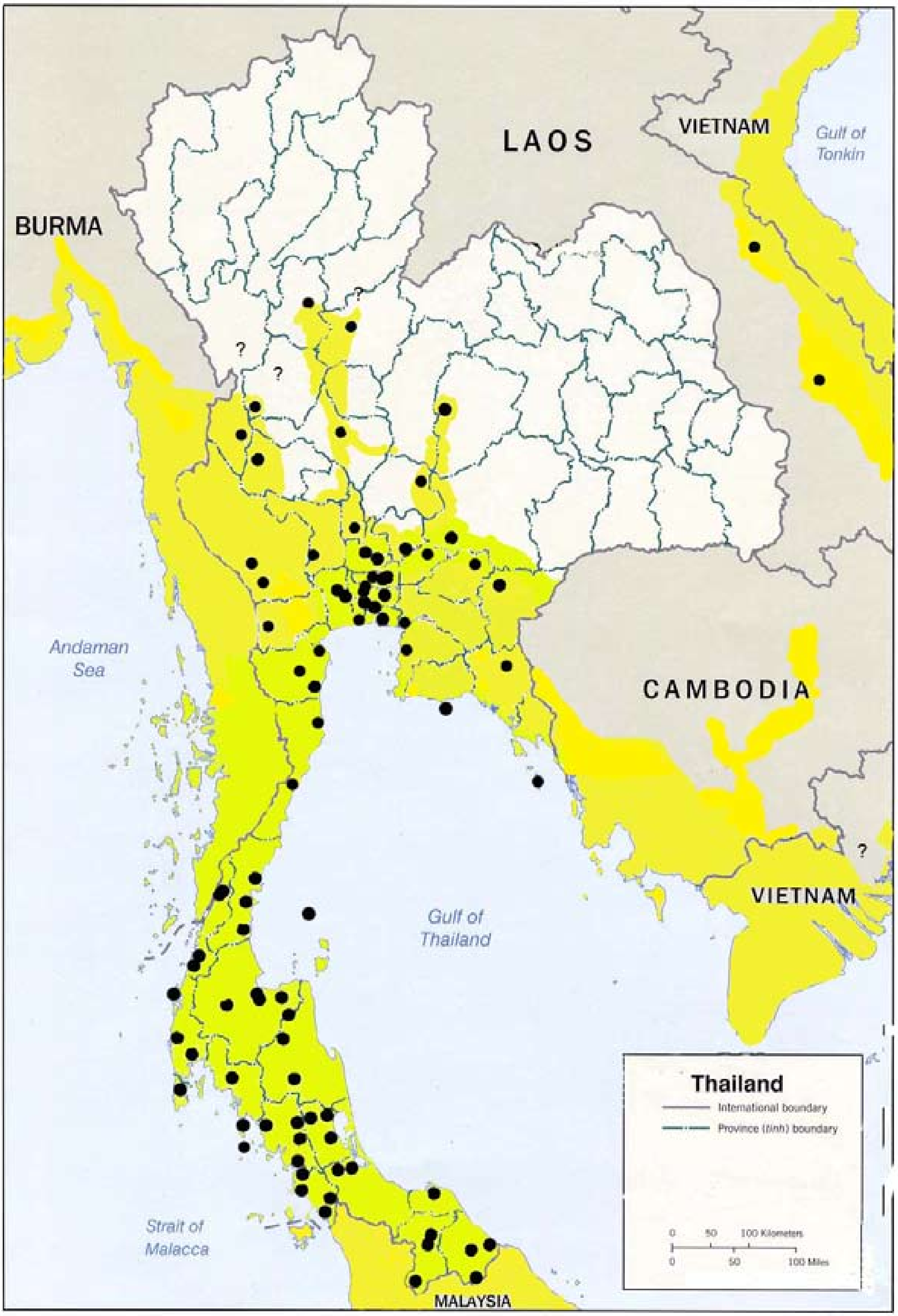

Fig. 1. Geographic distribution of *Varanus salvator macromaculatus*, based on locality data provided in Table 1.

deep into mountainous Northern Thailand, but it has not, as it had possibly done in the past along the Irrawady River in Myanmar and has already done up the Chao Phraya River in Thailand. It has also not exploited the riparian habitats up the Mekong River, along the border between Laos and Thailand. Although *V. salvator macromaculatus* is seen in the open sea, it is not often seen in the largest rivers in Thailand, like one would find *V. niloticus* in Africa (Cota, pers. obs.). Massive deforestation and habitat destruction for agriculture in Northeast Thailand that has taken place over the past decades ensures that *V. salvator macromaculatus* will not disperse into the Khorat Plateau, which makes up Northeast Thailand. Numerous interviews of the elderly in the northeast region of Thailand confirm that there was no historical *V. salvator* presence many decades ago when the entire area was forested and the only monitor lizard known was referred to as "Lan", which refers to *V. bengalensis nebulosus* in Lao and the Isaan (Northeast Thailand) dialect.

Examination of the true geographical distribution of the *V. salvator* complex, shows a continuous coastal and near the coast distribution. This geographical distribution becomes more broken up as one continues inland and necessarily so since the geographic distribution becomes tied to permanent water sources and riparian habitat. Where there are no permanent water sources, one will not find *V. salvator.*

Regional Variation

Before this study, specifically before Koch et al. (2007), there were two regional variations of *V. salvator* known in Thailand. This was the common variation found throughout Thailand and the form that was previously known as *V. salvator komaini*. During the conduct of this study, 5 different variations of *V. salvator macromaculatus* were identified primarily based on geography with one that may be based on habitat. These variations are strictly on the basis of pattern, no morphometric data has been taken or morphological differences studied to further separate them.

The most common geographical variation of *V. salvator macromaculatus* is found in central Thailand, throughout the Chao Phraya River basin and extends north in the mountains that separate Central Thailand from Northeast Thailand (Isaan); westward, its range extends over mountainous western area of Thailand and over the border with Myanmar; southward, it extends into peninsular Thailand. This form is boldly marked with bands of large ocelli, which represent the subspecies epithet and should be considered the *terra typica* form, as represented in the photograph showing *V. salvator macromaculatus* in Koch et al. (2007) and Fig. 2.

Another variant of *V. salvator macromaculatus* that is well known is the form previously known as *V. salvator komaini*, until Koch et al. (2007), made it a synonym of *V. salvator macromaculatus*. This form is found in the mangrove forests of the La-Ngu District of Satun Province and the islands off shore. It is occasionally found across the provincial boundary into Trang Province, but it rarely encountered there. There is no record of this form from south of the La Ngu District. This is the only completely melanistic population recorded for the

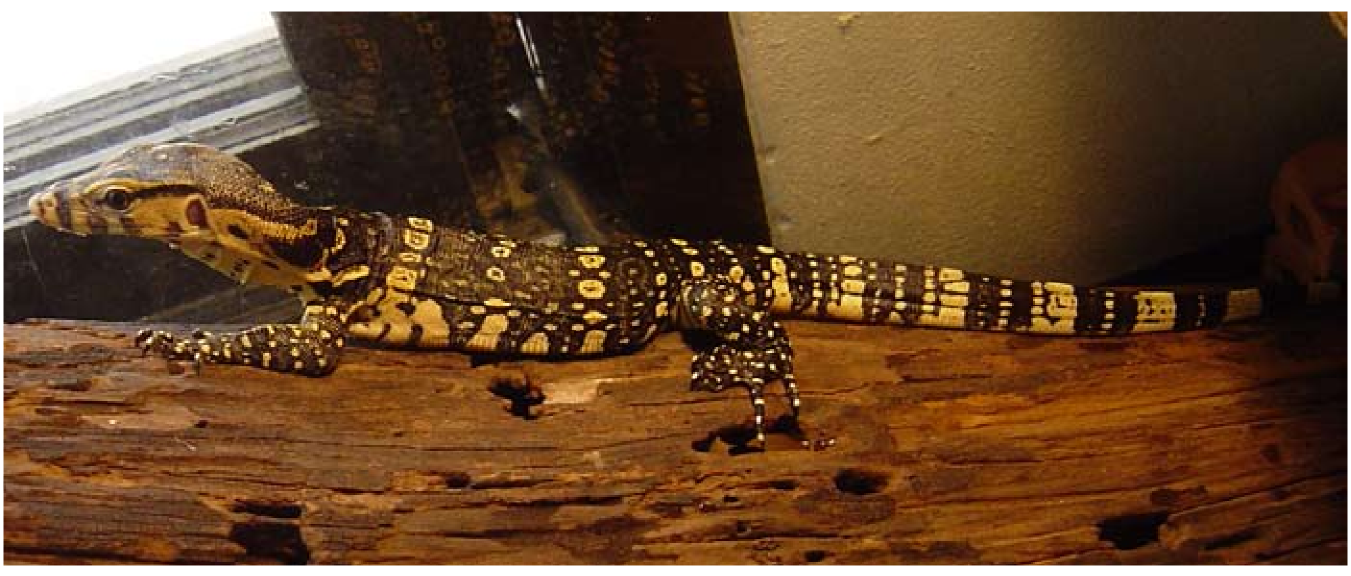

Fig. 2. Juvenile of *V. salvator macromaculatus* from the Chao Phraya River flood plain of central Thailand. Photograph by **Michael Cota.**

V. salvator species complex. It is completely melanistic and patternless from the time it hatches. This form is known as the Black Dragon from its *V. salvator komaini* description (Nutphand, 1987) and by the international pet trade on the occasions it has been smuggled out of Thailand (Cota, 2009) (Fig. 3).

In parts of southern peninsular Thailand, there is a form of *V. salvator macromaculatus* that is similar to that which is found more often in peninsular Malaysia and Singapore, which is gray in overall coloration with a subdued pattern. The pattern is bolder in juveniles, but becomes more subdued and gray as the monitor matures (Fig. 4).

Fig. 3. Adult of melanistic population of *V. salvator macromaculatus*, previously known as *V. salvator komaini*, from the La-ngu District, Satun Province of Southern Thailand. Photograph by **Michael Cota.**

In the mangrove forests of Thailand, there is a form of *V. salvator macromaculatus* that possesses an overall dark subdued pattern. It is similar to the most common geographical variation in Thailand, but the bright yellow markings are subdued with black to a point where it is hardly visible. Subadults are already nearly without a pattern. The common Thai geographical variant is also sometimes found in the mangrove forest, but the subdued mangrove form is only found in the mangrove forests or in geographical locations not too distant from mangrove forests (Fig. 5).

Eastern Thailand has a form of *V. salvator macromaculatus* which is similar to the more common form, but possesses smaller ocelli which make the black bands appear larger. In Eastern Thailand, the more common pattern also appears, but is exceptional (Fig. 6).

Saraburi Province has a variant that is quite possibly the most attractive of all variations in Thailand. This is a high yellow variant with solid yellow/white spots in the place of ocelli. The great amount of yellow in the pattern is possibly due to the arid climate, among the most arid in which *V. salvator macromaculatus* is to be found in Thailand (Fig. 7).

Fig. 4. Adult *V. salvator macromaculatus* from Phuket Province of Thailand. Photograph by **Suwit Punnadee** (Wild Animal Rescue Foundation of Thailand).

Fig. 5. Young adult *V. salvator macromaculatus* from the mangrove forest of Samut Prakarn Province of Thailand. Photograph by **Michael Cota**.

Fig. 6. Sub-adult of *V. salvator macromaculatus* from Khao Yai National Park, in the eastern part of its geographical distribution in Thailand. Photograph by **Michael Cota**.

Fig. 7. Juvenile of *V. salvator macromaculatus* from the arid area of Saraburi, Thailand, on the edge of its continuous geographical distribution within Thailand. Photograph by **Michael Cota**.

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Table 1. Documented localities of *Varanus salvator macromaculatus* in Thailand.

Province	District/Area	Source
Angthong		Flower, 1899, cited in Mertens, 1942
Ayutthaya	Pahang	Flower, 1899, cited in Mertens, 1942
Ayutthaya	Muang	Flower, 1899, cited in Mertens, 1942
Bangkok		Flower, 1899, cited in Mertens, 1942
Pattani		de Rooj, 1917, cited in Mertens, 1942
Surat Thani	Koh Tao	Cochran, 1930, cited in Mertens, 1942
Satun	La Ngu	Nutphand, 1987
Pang Nga	Khao Lak-Lam Ru MNP	Chan-ard et al., 1999
Nakhon Ratchasima	Khao Yai National Park	Chan-ard et al., 1999
Bangkok	Bang Khen	Nabhitabhata et al., 2000
Chaiyaphum	Khao Khieo NP	Nabhitabhata et al., 2000
Chumphon	Muang	Nabhitabhata et al., 2000
Chumphon	Sawee	Nabhitabhata et al., 2000
Chumphon	La Ma	Nabhitabhata et al., 2000
Chumphon	Mu Ko Phayam	Nabhitabhata et al., 2000
Nakhon Si Thammarat	Tai Rom Yen	Nabhitabhata et al., 2000
Nakhon Si Thammarat	Thung Son	Nabhitabhata et al., 2000
Narathiwat	Ruso	Nabhitabhata et al., 2000
Narathiwat	Tak Bi	Nabhitabhata et al., 2000
Narathiwat	Hala-Bala WS	Nabhitabhata et al., 2000
Pattani		Nabhitabhata et al., 2000
Phatthalung	Khao Pu Khao Ya NP	Nabhitabhata et al., 2000
Phuket	Khao Pra Taew WC	Nabhitabhata et al., 2000
Ranong	Kra Buri	Nabhitabhata et al., 2000
Ranong	Suk Sam Ran	Nabhitabhata et al., 2000
Sa Kaeo	Pang Sida NP	Nabhitabhata et al., 2000

Table 1. *continued.*

Province	District/Area	Source
Surat Thani	Phun Phin	Nabhitabhata et al., 2000
Surat Thani	Khao Sok NP	Nabhitabhata et al., 2000
Surat Thani	Kanchanadit	Nabhitabhata et al., 2000
Trang	Khao Pu Khao Ya NP	Nabhitabhata et al., 2000
Trang	Khao Chong WC	Nabhitabhata et al., 2000
Uthai Thani	Huay Kha Kaeng WS	Nabhitabhata et al., 2000
Yala	Bannang Sata	Nabhitabhata et al., 2000
Yala	Betong	Nabhitabhata et al., 2000
Pathum Thani	Rangsit	National Science Museum (TH), 2001
Krabi	Mu Ko Lunta MNP	Lauprasert and Thirakupt, 2001
Krabi	Khao Phanom	Lauprasert and Thirakupt, 2001
Narathiwat	Hala-Bala WS	Lauprasert and Thirakupt, 2001
Narathiwat	Sirindhorn Peat Swamp RNC	Lauprasert and Thirakupt, 2001
Pang Nga	Sri Nang Nga NP	Lauprasert and Thirakupt, 2001
Pang Nga	Ao Pang Nga MNP	Lauprasert and Thirakupt, 2001
Phatthalung	Khao Pu Khao Ya NP	Lauprasert and Thirakupt, 2001
Phatthalung	Thale Noi NA	Lauprasert and Thirakupt, 2001
Ranong	Lumnum Kraburi NP	Lauprasert and Thirakupt, 2001
Ranong	Mu Ko Payam MNP	Lauprasert and Thirakupt, 2001
Satun	Nong Prag Praya NA	Lauprasert and Thirakupt, 2001
Songkla	Ton Nga Chang WRS	Lauprasert and Thirakupt, 2001
Songkla	Hat Yai NWSC	Lauprasert and Thirakupt, 2001
Surat Thani	Muang	Lauprasert and Thirakupt, 2001
Trang	Had Chao Mai MNP	Lauprasert and Thirakupt, 2001
Phetchaburi	Ban Lat	Pauwels et al., 2003
Phetchaburi	Ban Laem	Pauwels et al., 2003
Chachoengsao	Bang Pakong	Sukprakarn, pers. comm.
Ayutthaya	Muang	This study
Ayutthaya	Pang Pa-In	This study
Ayutthaya	Wang Noi	This study
Bangkok	Dusit	This study
Bangkok	Lumpini	This study
Kanchanaburi	Muang	This study
Kanchanaburi	Sai Yok	This study
Krabi	Muang	This study
Lop Buri	Tha Wung	This study
Nakhon Pathom	Nakhon Chaisi	This study
Nakhon Pathom	Phuttamonthon	This study
Nakhon Pathom	Salaya	This study
Nakhon Sawan	Bueng Boraphet	This study
Nonthaburi	Bang Bua Thong	This study
Nonthaburi	Bang Yai	This study
Pathum Thani	Khlong Luang	This study
Pathum Thani	Muang	This study
Pathum Thani	Thanyaburi	This study
Phetchaburi	Cha-Am	This study
Phitsanulok	Kaeng Jed Kwae NP	This study

Table 1. *continued*

Province	District/Area	Source
Prachin Buri	Tablan NP	This study
Prachuap Khiri Khan	Ao Manao	This study
Prachuap Khiri Khan	Pranburi	This study
Ratchaburi	Suan Pueng	This study
Rayong	Koh Man	This study
Sing Buri	Prom Buri	This study
Saraburi	Muak Lek	This study
Sukhothai	Muang	This study
Tak	Huai Kha Kaeng WS	This study

Abbreviations used:

MNP	Marine National Park
NA	Non-Hunting Area
NP	National Park
RNC	Research and Nature Study Center
WC	Wildlife Conservation Development and Extension Center
WRS	Wildlife Research Center
WS	Wildlife Sanctuary

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Mending a Ruptured *Varanus acanthurus brachyurus* Egg

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Abstract: A *Varanus acanthurus brachyurus* egg ruptured during artificial incubation. To repair the egg, a small piece of eggshell was taken from a previously hatched *V. tristis tristis* egg and used to patch the hole in the ruptured *V. aacanthurus brachyurus* egg. After 106 days, the patched egg successfully hatched together with other eggs from the same clutch.

Reptile eggs that are artificially incubated in captivity are subject to various hazards and human error emergencies. During the course of egg incubation, the senior author encountered an emergency involving a ruptured *Varanus acanthurus brachyurus* egg. Other authors have reported ways of repairing incubating reptile eggs (Barnett, 1980). This report describes a method used to repair a *V. acanthurus brachyurus* egg and investigates possible causes for its rupture.

On 23 February 2009, the senior author dug up nine fertile eggs laid by a two year old female *V. acanthurus brachyurus* (Fig. 1). The pair of *V. acanthurus brachyurus* copulated for five days, and eggs were laid 19 days after copulation ceased. For incubation, a 'no substrate' method was used where the eggs were placed in a custom-made container, suspended above the incubation medium using a diffuser grid, with a bent wire frame used to keep the eggs in a stable position. The medium consisted of an unmeasured mixture of perlite and water, soaked, drained, and pressed down into the reservoir area of the incubation container.

Fig. 1. Unearthed clutch of *Varanus acanthurus brachyurus* eggs.

On 15 May, one egg was seen leaking albumen from its underside, which passed through the diffuser grid onto the surface of the substrate below. The egg was handled and a small V-shaped hole (ca. 2-3 mm) was noticed after the albumen was wiped away. Turning the egg back to its original placement, it began to leak again.

The junior author suggested covering the hole with a piece of eggshell from a *V. tristis tristis* egg which hatched previously that year. A dry, wrinkled *V. t. tristis* eggshell was chosen from a group of hatched eggshells the primary author had collected and saved. A 10 x 10 mm square piece of eggshell was cracked off of the *V. t. tristis* egg, and shaped by hand to form a patch. The patch was soaked in a small container of warm water for 20 min, softening it to the point of being pliable and rubbery. Once the perforated shell was wiped clean of albumen and any detritus, the patch was placed on top of the perforated shell surface and pressed lightly into place (Fig. 2.). There was no adhesive used other than the remnant albumen, which adhered the patch to the egg well. Within 24 h, the patch was firmly in place,

Fig. 2. Detail of eggshell patch on mended *V. acanthurus brachyurus* egg post-hatching.

staunching any further leakage of albumen from the egg.

It is believed that the underlying cause of the rupture was a rapid change in air pressure when opening the incubator door. Since the incubation container lacked ventilation holes and was kept inside an airtight, modified refrigerator incubator, this may have led to a pressure difference between the internal egg environment and the room's ambient conditions. To remedy the situation and prevent this occurrence from reoccurring, all egg container lids were removed, vented with two 4 mm holes, and then placed back onto the egg containers. No other eggs suffered from leaks.

On 9 June 2009, after 106 days of incubation, three eggs began to pip (Fig. 3), one of which was the mended egg. All hatchlings emerged by 11 June (Fig. 4) and continue to thrive at the time of this writing.

Fig. 3. Hatchling *V. acanthurus brachyurus* emerging from egg.

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Fig. 4. Recently-hatched *V. acanthurus brachyurus* off-spring.

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ERRATA

On page 86 of Shannon, R. and R.W. Mendyk. 2009. Aquatic foraging behavior and freshwater mussel (*Velesunio* sp.) predation by *Varanus panoptes panoptes* in central-western Queesnland. Biawak 3(3): 85-87., a large *V. p. panoptes* is erroneously estimated of measuring between 2- 2.25 m in total length. Accurate estimation of the individual's total length may have been affected by its activity within the water of the dam. Maximum lengths reported for *V. p. panoptes* (Christian, K. 2004. *Varanus panoptes*. Pp. 423-429. In Pianka, E.R. and D.King [eds.]. Varanoid Lizards of the World. Indiana University Press, Indianapolis.), suggest that the observed specimen was under 2 m in total length.

On page 74 of Volume 3 Number 3, a photograph depicting a juvenile *Varanus bengalensis nebulosus* in Central Catchment Nature Reserve in Singapore was erroneously credited to Shirly Ng. The correct photographic creditation is **Shirley Ng**.

In Stefani, M. 2008. Husbandry and reproduction of the peach-throated monitor *Varanus jobiensis* in captivity. Biawak 2(3): 124-130, photographs depicted in figures 7 and 8 are credited to **Mike Heinrich** http://amazontreeboa.org.

Varanus salvator macromaculatus. Captive male. Parque Reptilandia, Costa Rica.
Photograph by **Robert W Mendyk**.

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