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.

KLAUS WESIAK[1] AND ANDRÉ KOCH[2]

[1] *Schöffenstr. 1-3, D-65933 Frankfurt a. M., Germany*
E-mail: boaklaus@web.de

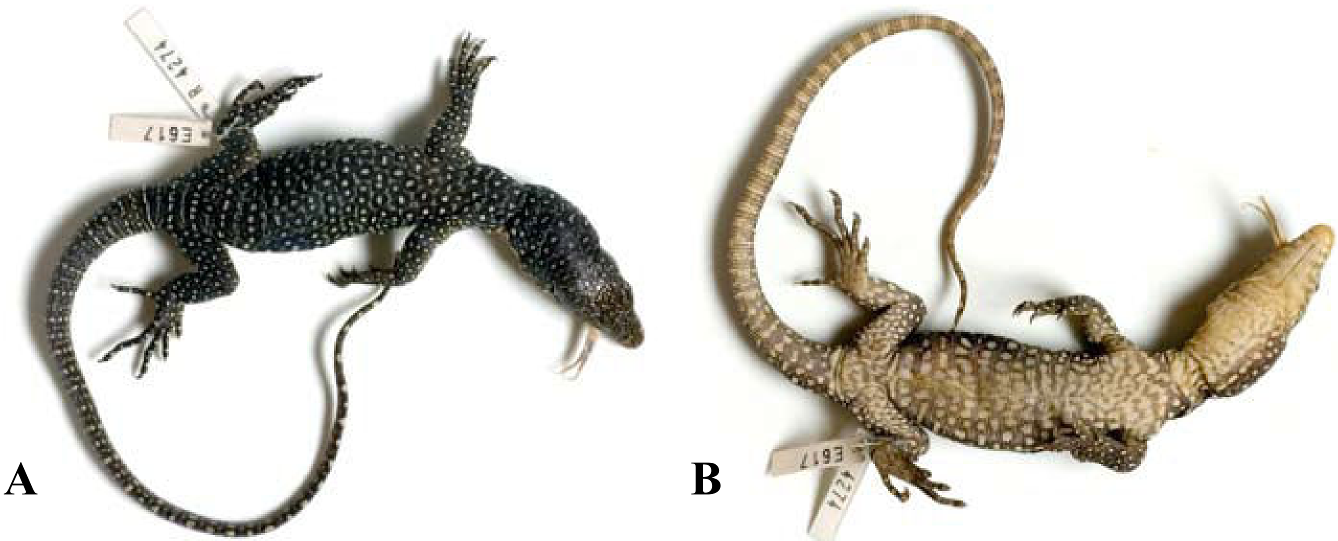
[2] *Zoological Research Museum A. Koenig, Department of Herpetology*
Adenauerallee 160, D-53113 Bonn, Germany
E-mail: andrepascalkoch@web.de

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



A B

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

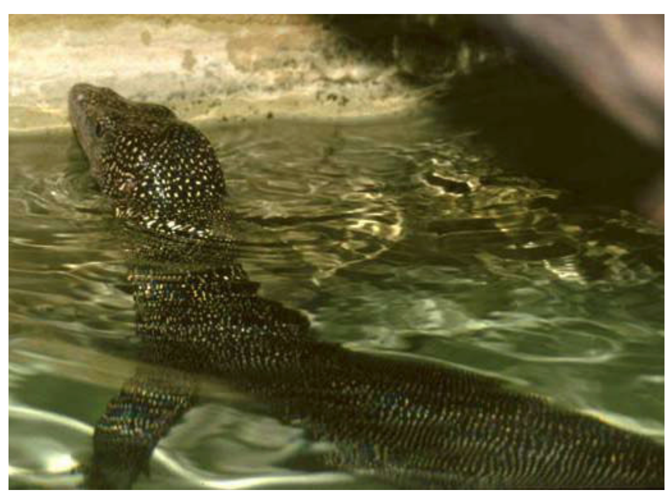


Fig. 10. *Varanus juxtindicus* frequently used the water feature for swimming and diving. Photograph by **Klaus Wesiak**.

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**.

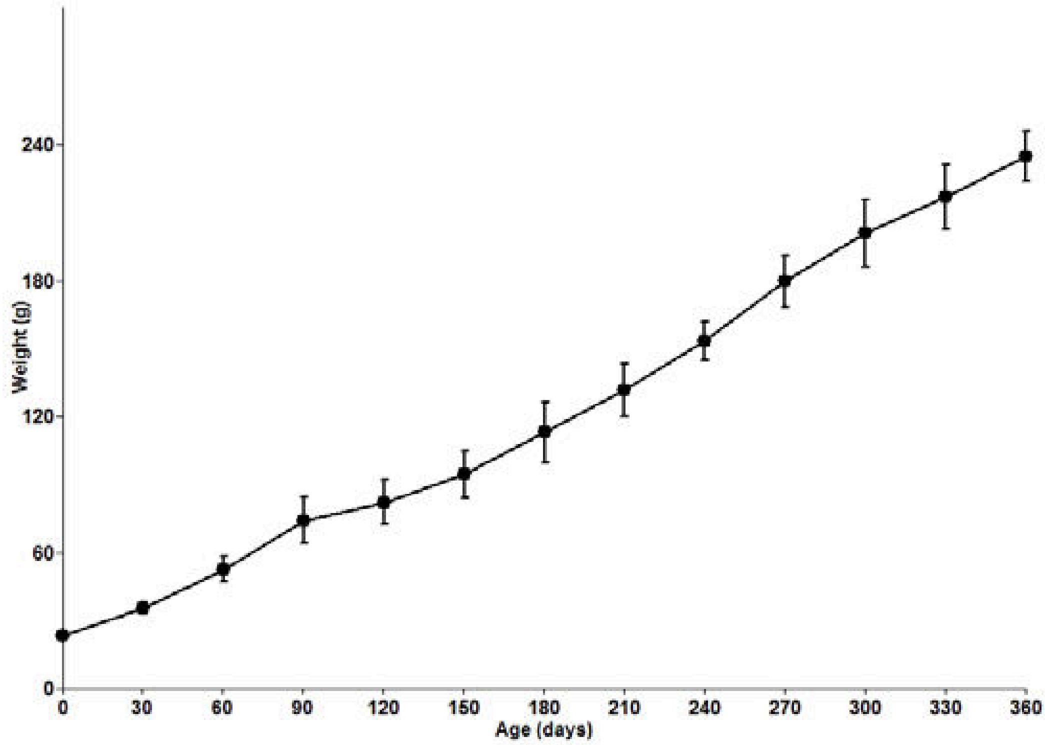


Diagram 1. Mean weight gain (g) of *V. juxtindicus* offspring (n = 8) during the first year.

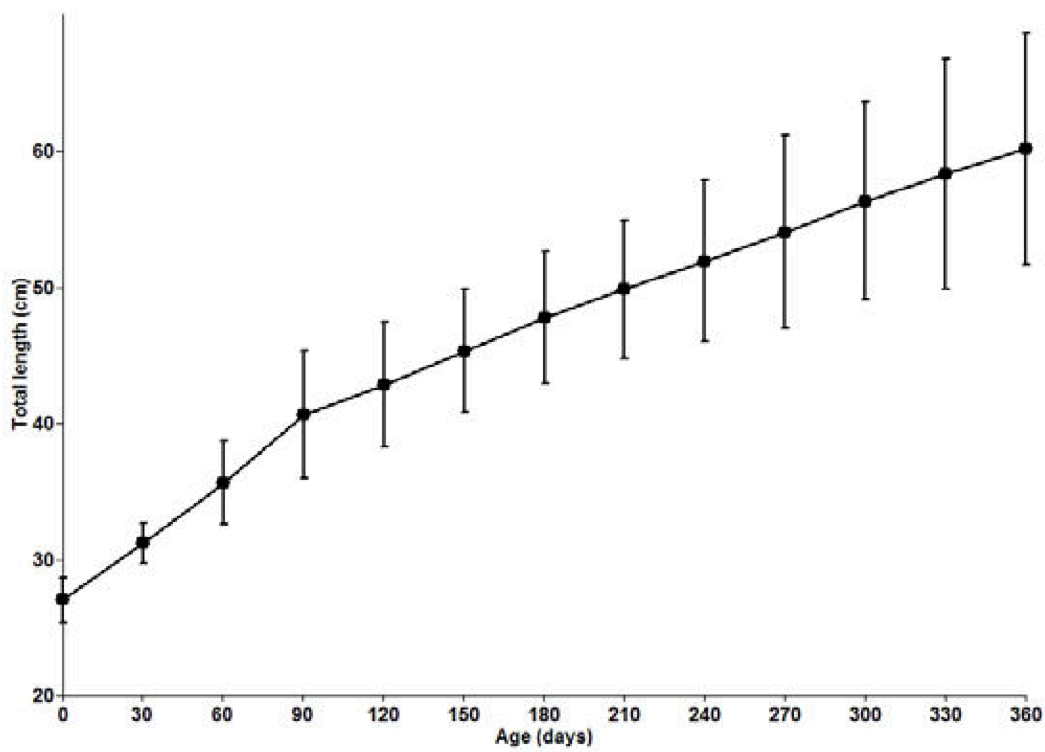


Diagram 2. Mean increase in total length (TTL) of *V. juxtindicus* offspring (n = 8) during the first year.

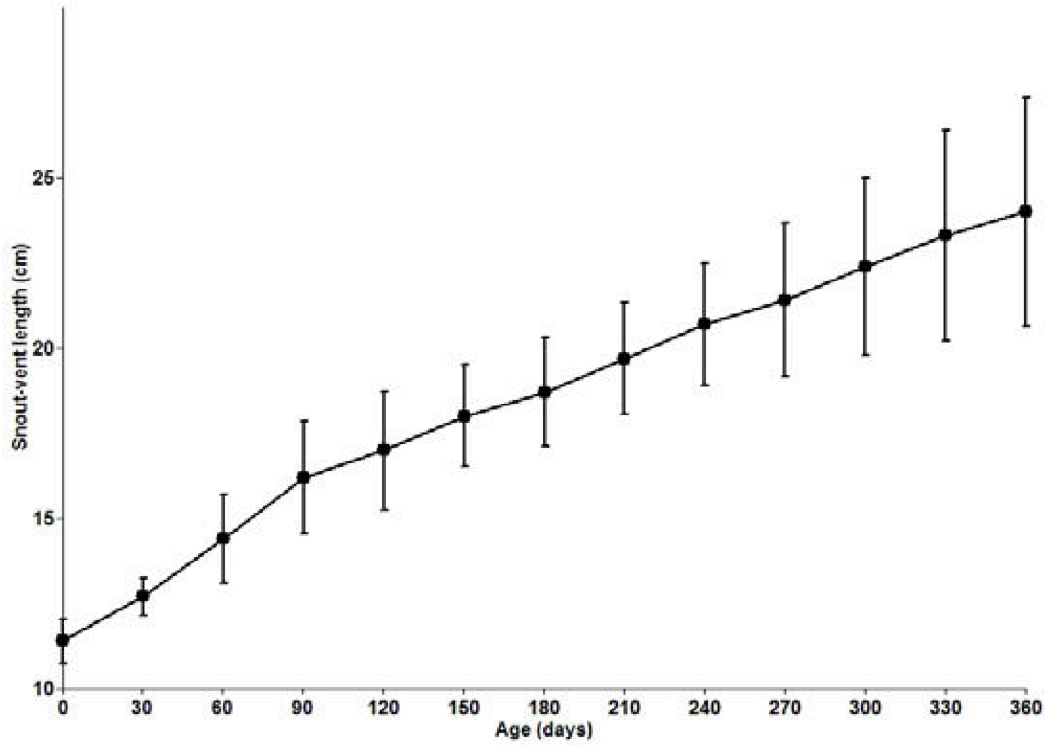


Diagram 3. Mean increase in snout-vent length (SVL) of *V. juxtindicus* offspring (n = 8) during the first year.

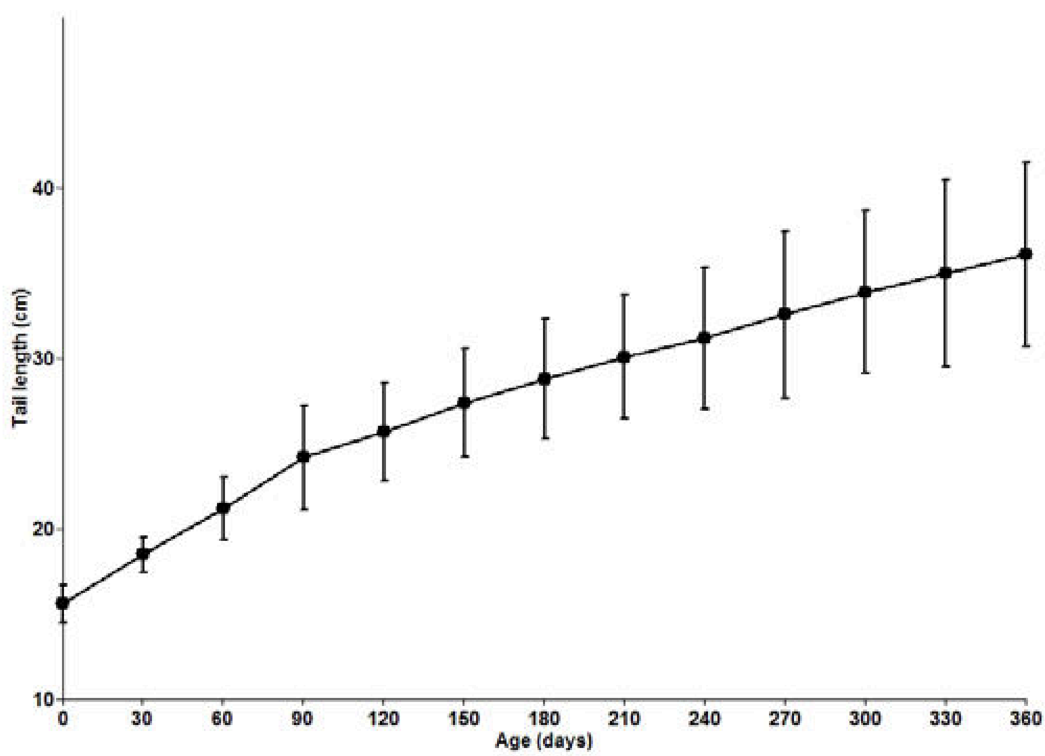


Diagram 4. Mean increase in tail length (TL) of *V. juxtindicus* offspring (n = 8) during the first year.

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

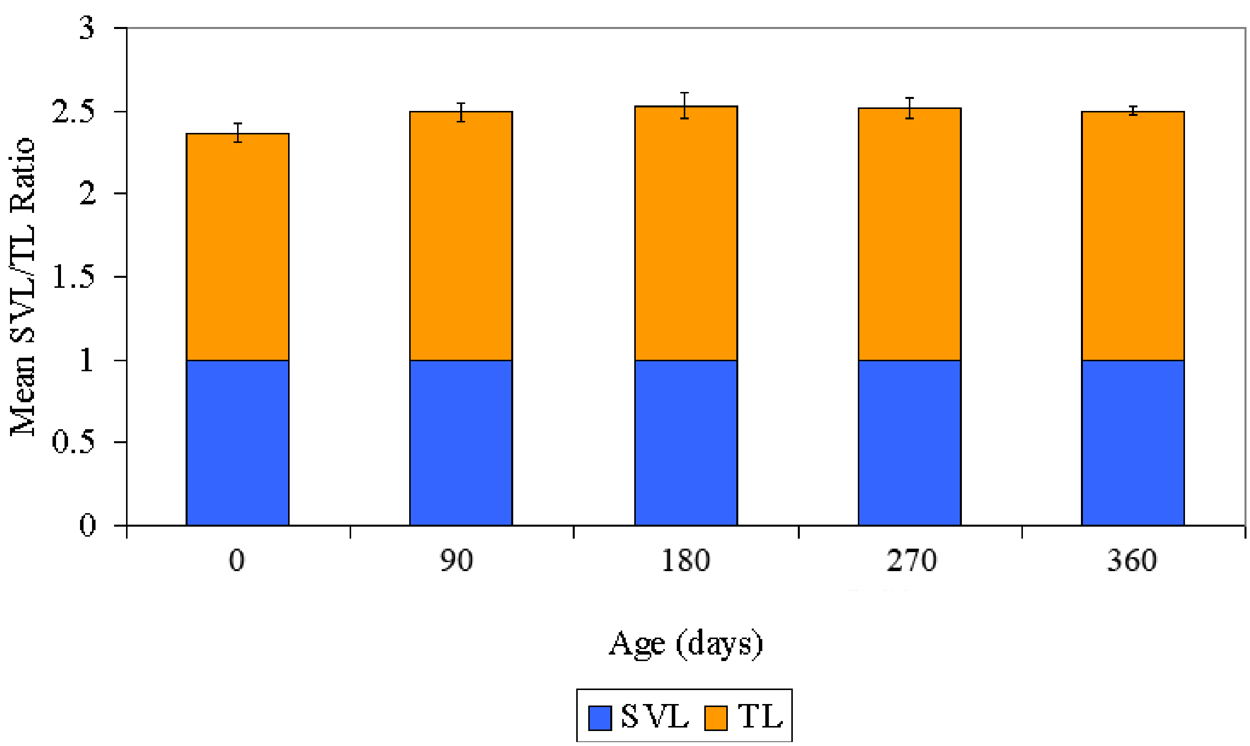


Diagram 5. Increase in mean SVL:TL ratio of *V. juxtindicus* offspring (n = 8) during the first year.

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).

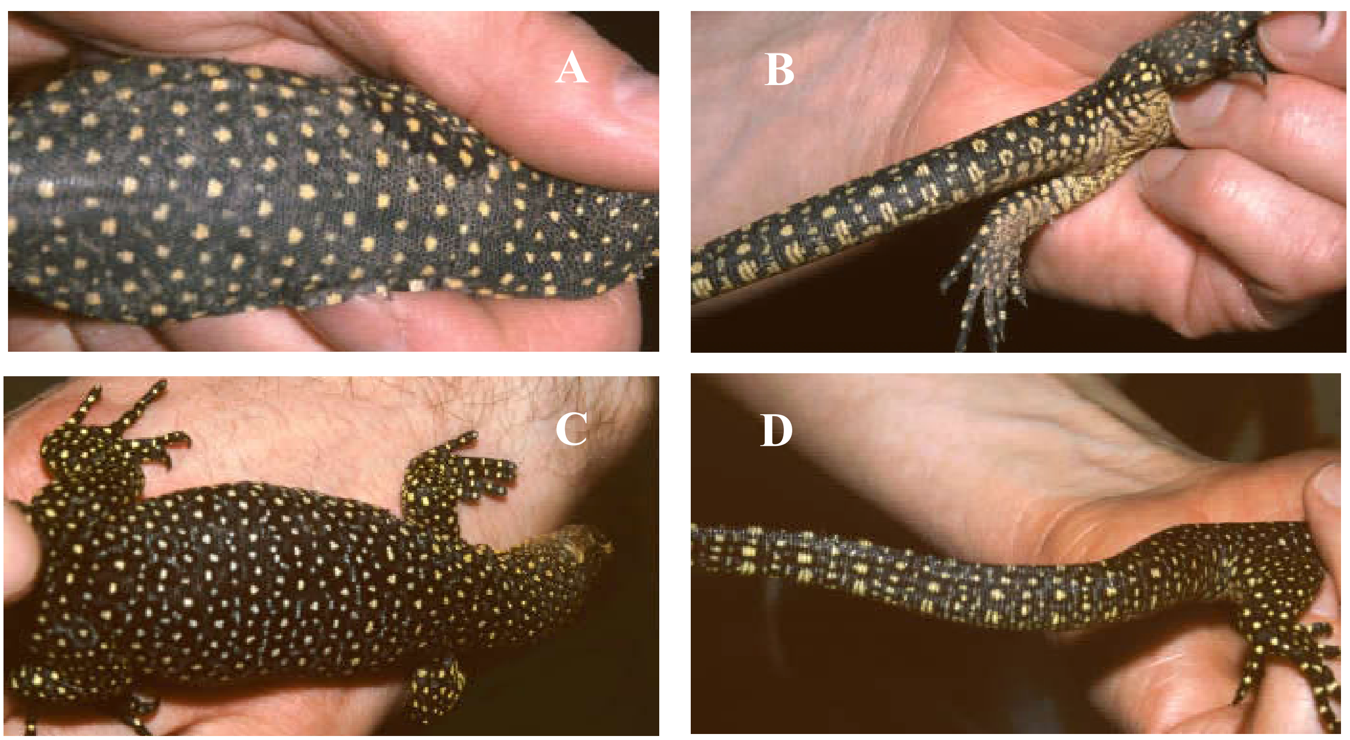


Fig. 18. Ontogenetic change in color pattern of dorsum and tail after two (A, B), six (C, D) months. Note the roundish base of the tail lacking a dorsal double keel as characteristic for *V. juxtindicus*. Photographs by **Klaus Wesiak**

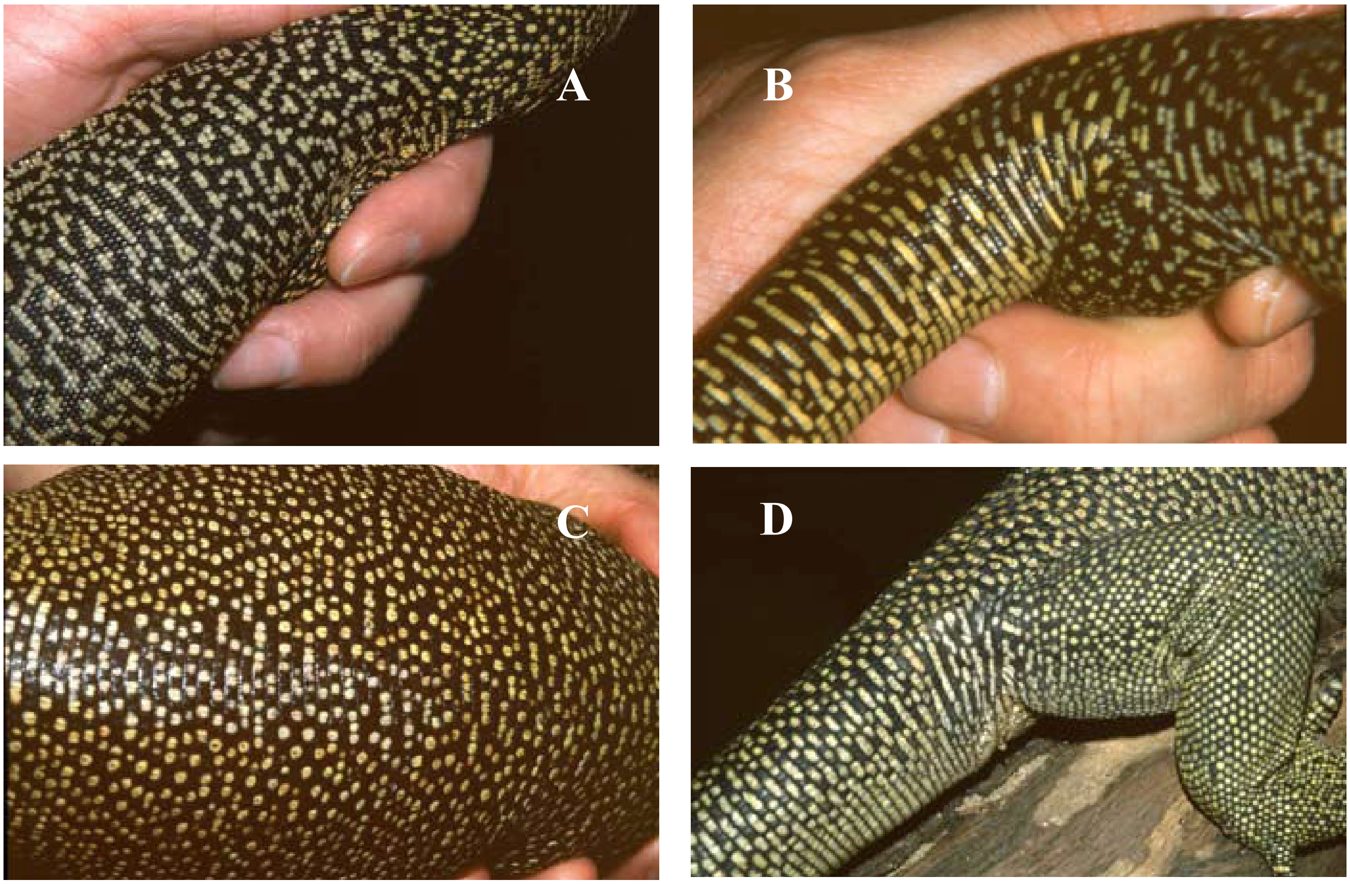


Fig. 19. Ontogenetic change in color pattern of dorsum and tail after twelve (A, B), and twenty-four (C, D) months. Photographs by **Klaus Wesiak.**

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.

References

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

Bennett, D. 1996. Warane der Welt, Welt der Warane. Edition Chimaira, Frankfurt/Main, 383 pp.

Bennett, D. 1998. Monitor Lizards. Natural History, Biology and Husbandry. Second edition, Edition Chimaira, Frankfurt/Main, 352 pp.

Böhme, W., K. Philipp and T. Ziegler. 2002. Another new member of the *Varanus* (*Euprepiosaurus*) *indicus* group (Sauria, Varanidae): an undescribed species from Rennell Island, Solomon Islands. Salamandra 38(1): 15–26.

Böhme, W., K. Philipp and T. Ziegler 2004. *V. juxtindicus*. pp. 193–196 in Pianka, E. R. & D. R. King (Eds.): Varanoid lizards of the world. Indiana University Press, Bloomington & Indianapolis.

Böttcher, M. 2007. Die Versorgung von Reptilien in der Terrarienhaltung mit ultraviolettem Licht. Elaphe 15(1): 32–37.

Brockhaus 1982. Länder und Klima (Asien, Australien). Brockhaus, Wiesbaden, 240 pp.

Eidenmüller, B. 1997. Warane - Lebensweise, Pflege, Zucht. Herpeton, Offenbach, 157 pp.

Eidenmüller, B. 2003. Warane - Lebensweise, Pflege, Zucht. Herpeton, Offenbach, 2. Edition, 176 pp.

Frank, W. 1985. Amphibien und Reptilien. pp. 162–402, In: Isenbügel, E. & W. Frank (Eds.): Heimtierkrankheiten. Verlag Eugen Ulmer, Stuttgart, 402 pp.

Horn, H.-G. 2004. Beleuchtung im Vivarium (Terrarium, Paludarium). pp. 168–253, in: Sauer, K., B. Steck, H. Schuchart & H.-G- Horn (Eds.): Praxis Ratgeber Vivarienbeleuchtung. Edition Chimaira, Frankfurt, 287 pp.

Horn, H.-G. and G.-J. Visser. 1989. Review of reproduction of monitor lizards *Varanus ssp*. in captivity. International Zoo Yearbook 28: 140–150.

Horn, H.-G. and G.-J. Visser. 1991. Basic Data on the biology of monitors. Mertensiella 2: 176–187.
Horn, H.-G. and G.-J. Visser. 1997. Review of reproduction of monitor lizards *Varanus ssp*. in captivity II. International Zoo Yearbook 35: 227–246.
Karunarathna, S., T. Amarasinghe and A. de Voss. 2008. Preliminary notes on the monitor lizards (Family: Varanidae) within the National Zoological Garden (NZG) Dehiwala, Colombo District, Sri Lanka. Biawak 2(3): 109–118.
Kirschner, A., T. Müller and H. Seufer.1996. Faszination Warane. – Kirschner & Seufer Verlag, Keltern-Weiler, 254 pp.
Köhler, G. 1993. Die Amöbiasis bei Reptilien – Hinweise zu Pathenogenese, Diagnose und Therapie. Elaphe 1(4): 15–17.
Köhler, G. 1996. Krankheiten der Amphibien und Reptilien. Verlag Eugen Ulmer, Stuttgart, 170 pp.
Kok, R. 1993. Gelungene Zucht des Pazifikwarans (*Varanus indicus*). Monitor 2(2): 31.
Kok, R. 1995a. Weitere Angaben zur wiederholten Zucht beim Pazifikwaran (*Varanus indicus*). Monitor 4(1): 39–40.
Kok, R. 1995b. Zur Haltung und Nachzucht des Pazifikwarans (*Varanus indicus*). Salamandra 31(3): 129–136.
Kukol, Z. 1993. Mangrove monitor, *Varanus indicus* (Daudin), 1802. Varanews 3: 5.
Lehmann, H.-D. 2007. UV-Bestrahlung im Terrarium – der Status quo. Elaphe 15(4): 20–30.
McCoid, M.J. 1993. Reproductive output in captive and wild mangrove monitors (*Varanus indicus*). Varanews 3: 4-5.
Mertens, R. 1926. Über die Rassen einiger indo-australischer Reptilien. Senckenbergiana 8(5/6): 272–279.
Mertens, R. 1942. Die Familie der Warane (Varanidae), Teil 1-3. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 462, 465, 466: 1–391.
Philipp, K.-M. 1999. Niche partitioning of *Varanus doreanus*, *V. indicus* and *V. jobiensis* in Irian Jaya: preliminary results. Mertensiella 11: 311–316.
Philipp, K.-M, W. Böhme, and T. Ziegler. 1999. The identity of *Varanus indicus*: redifinition and description of a sibling species coexisting at the type locality. Spixiana 22: 273–287.
Philipp, K.-M., T. Ziegler and W. Böhme. 2007. Preliminary investigations of the natural diet of six monitor lizard species of the *Varanus* (*Euprepiosaurus*) *indicus* Group. Mertensiella 16: 336–345.
Speer, R.J. and M. Bayless. 2000. The first report of mangrove monitor twins in captivity: the remarkable reproduction and disappointing result. Reptiles Magazine 8: 30-31.
Wesiak, K. 1993a. Eine gelungene Nachzucht von *Varanus indicus* (Daudin 1802). Monitor 2(2): 10.
Wesiak, K. 1993b. Über Haltung und Nachzucht von *Varanus* (*Euprepiosaurus*) *indicus indicus* (Daudin 1802). Herpetofauna 15(87): 21–25.
Wesiak, K. 1996. Zum Bau von Aquaterrarien für großwüchsige Warane. Sauria 18(1): 17–25.
Wesiak, K. 2009. Terrarienhaltung und Erstnachzucht des Pazifikwarans *Varanus* (*Euprepiosaurus*) *indicus* (Daudin, 1802), mit einigen Bemerkungen zur Entwicklung der Jungtiere. Elaphe 17(1): 44–55.
Wilms, T. 2004. Terrarieneinrichtung, Grundlagen, Materialien, Methoden. Natur und Tier-Verlag, Münster, 128 pp.
Wolff, T. 1955. Rennellese names of animals. pp. 59–63 in Wolff, T. (Ed.): The natural history of Rennell Island, British Solomon Islands. Vol. 1 (vertebrates). Danish Science Press, Copenhagen.
Ziegler, T., W. Böhme, B. Eidenmüller and K.-M. Philipp. 2001. A note on the coexistence of three species of Pacific Monitor Lizards in Australia. Bonner Zoologische Beiträge 50(1/2): 27–30.
Ziegler T., A. Schmitz, A. Koch and W. Böhme. 2007. A review of the subgenus *Euprepiosaurus* of *Varanus* (Squamata: Varanidae): morphological and molecular phylogeny, distribution and zoogeography, with an identification key for the members of the *V. indicus* and the *V. prasinus* species groups. Zootaxa 1472: 1–28.

Received: 28 October 2009; Accepted: 5 December 2009