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# ARTICLES

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## First F2 Breeding of the Quince Monitor Lizard *Varanus melinus* Böhme & Ziegler, 1997 at the Cologne Zoo Aquarium

THOMAS ZIEGLER<sup>1,\*</sup>, NORBERT RÜTZ<sup>1</sup>,  
JOHANNES OBERREUTER<sup>1</sup> and SIMONE HOLST<sup>1</sup>

<sup>1</sup>Cologne Zoo  
Riehler Straße 173  
D-50735 Köln, Germany

\* Corresponding author  
E-mail: ziegler@koelnerzoo.de

**Abstract -** We report the first breeding of the quince monitor lizard *Varanus melinus* in a European Zoo, which at the same time represents to our knowledge the first F2 breeding of the species in general. In June 2009, a clutch containing nine eggs was produced at the Aquarium of the Cologne Zoo by a *V. melinus* pair received seven years earlier as offspring from a private breeder. Two of these eggs showed no development and one egg contained dead conjoined twins. Six offspring with weights of 33-35 g (mean 34 g) and total lengths of 266-281 mm (mean 274 mm) finally hatched in December 2009 from eggs measuring 47.1-58.6 mm (mean 54.0 mm) x 32.0-36.0 mm (mean 34.2 mm) in size, after 164–166 (mean 164.8) days of incubation at 29° C. A second clutch comprised of five eggs was laid in September 2009, about three months after the deposition of the first clutch. Two of these eggs showed no development and one egg contained a dead, slightly malformed embryo. Two *V. melinus* subsequently hatched from this second clutch in February 2010 after 164–165 days of incubation at 29° C. We compare our data with previously published information on the successful breeding of the species. All eight *V. melinus* hatched at the Cologne Zoo are developing well, and some will be subsequently provided for conservation breeding projects. Because this attractive species seems to play an important role in the international animal trade, and due to only very few husbandry and breeding reports available, we herewith intend to encourage the conservation breeding of this monitor lizard and to add to the scarce knowledge of the natural history of this beautiful species through both ex situ zoo breeding efforts and in situ population research, to finally contribute to improved conservation measures.

### Introduction

The quince monitor lizard (*Varanus melinus*) was described thirteen years ago by Böhme & Ziegler (1997) based on pet trade specimens originating from the Sula-Archipelago, Moluccas, Indonesia. The discovery of *V. melinus* might have been correlated with the disastrous

forest fires in Indonesia in 1997, because new collecting areas had to be found to replace traditional, known collecting sites. Ziegler *et al.* (2007b) summarized the islands of Banggai, Bowokan, Mangole, Sanana, and Taliabu as being inhabited by *V. melinus*. However,

recent investigations by Weijola & Sweet (2010) could only prove an occurrence of *V. melinus* with certainty for Mangole and Taliabu Islands.

*Varanus melinus* is a representative of the mangrove monitor group (*V. indicus* species group), which currently comprises the following 13 species (in chronological order, see Koch et al, 2009; Ziegler *et al.*, 2007a; 2007b; Weijola & Sweet, 2010): *V. indicus*, *V. doreamus*, *V. jobiensis*, *V. finschi*, *V. melinus*, *V. yuwonoi*, *V. caerulivirens*, *V. cerambonensis*, *V. juxtindicus*, *V. zugorum*, *V. rainerguentheri*, *V. lirungensis*, and *V. obor*. *Varanus melinus* is medium-sized, with a maximum total length surpassing 128 cm. Characteristic is its yellow ground coloration in adults, with a more or less discernible dark reticulated pattern on the body, neck, limbs and tail base. Hatchlings are black with a light yellow pattern consisting of transverse rows of yellow ocelli on the dorsum. With age, the dark coloration of the head and neck region is gradually replaced by the yellow ground coloration seen in sub-adults and adults (Ziegler & Böhme, 2004).

Ziegler & Böhme (2004) also summarized what is currently known about the natural history of *V. melinus*, which in most instances derives from captive conditions. Only scarce data are known from the natural habitat. Bayless & Adragna (1999) reported *V. melinus* to inhabit interior tropical lowland forests on Taliabu, which are characterized by a high density of dipterocarp trees; however, these authors never set foot on the original habitat of the species. Based on actual field observations, Weijola & Sweet (2010) recently stated that *V. melinus* seems to prefer more open habitats away from the immediate mangrove zone. Weijola & Sweet (2010) also commented that the colorful and highly sought-after *V. melinus* has, according to the local animal trader on Mangole, experienced a serious population decline, resulting in the removal of more than 10,000 animals in the past decade.

Although this attractive species seems to play an important role in the animal trade, unfortunately very few husbandry and breeding reports have been published to date. To our knowledge, zoo breedings of this species are known only from the Wildlife Conservation Society's (WCS) Bronx Zoo and from the Fort Worth Zoo, both located in the United States (e.g., see Biawak 2008: 2(1): 6-7). The first, and to our knowledge the only breeding report of *V. melinus* in captivity appeared ten years ago from a private facility (Dedmar & Böhme, 2000), the offspring of which built up the breeding stock at Cologne Zoo. Thus, with the current breeding report, which is to our knowledge the

first breeding of the species in a European zoo as well as the first F2 breeding of the species in general, we intend to encourage further breeding and to add to the scarce knowledge of this beautiful species, which is likely threatened by extinction in its natural habitat.

### Breeding Pair

On 15 March 2003, Cologne Zoo received six yearling *V. melinus* from a private keeper in Germany. These animals originated from clutches that hatched on 3 March and 16 April 2002, respectively. Two of these animals made up the breeding stock of Cologne Zoo. In May 2010, at an age of more than eight years, the female measured 395 mm in snout-vent length (SVL) and had a tail length (TL) of 550 mm, whereas the male measured 500 mm SVL and 780 mm TL. All specimens were undoubtedly members of the *V. indicus* group, and assignable to the species *melinus* based on their lack of tail prehensility, with tails laterally compressed towards the tail tip, in combination with a yellow ground colouration with more or less developed dark marbling, the lack of any turquoise or blue colouration, a light pink-colored, tongue, and a low (124-133) midbody scale count (Ziegler & Böhme, 2004; Ziegler *et al.*, 2007).

### Housing

For quarantine, we housed the juvenile *V. melinus* individually in large 100 x 50 x 60 cm (length x width x height) glass terraria. The substrate consisted of pine bark. Besides drinking vessels, the quarantine terraria also contained cork pieces and cork tubes for climbing and hiding. Light was provided by fluorescent tubes in combination with basking lamps (60 W) which also supplied ultraviolet light. Photoperiod was approximately 12:12 (light:dark). Ambient temperatures ranged between 26.5 and 32.5° C, with a maximum temperature of up to 40° C directly beneath the basking lamps.

Following the quarantine period, during which one of the juveniles died, the remaining five *V. melinus* were kept in groups of two and three individuals under similar conditions in two 150 x 90 x 80 cm (l x w x h) terraria. During this time, we did not observe any conflicts between the animals.

At the same time, we constructed a large enclosure in the visitor's area of the Cologne Zoo Aquarium (Fig. 1) measuring ca. 300 x 180 x 250 cm (l x w x h). The background and the side walls were covered in a rough and climbable rock surface with elevated resting areas.



Fig. 1. *Varanus melinus* exhibit at the Cologne Zoo Aquarium (2 May 2005). Photograph by **Thomas Ziegler**.

This public enclosure was further equipped with large branches, some plants (*Pandanus*, *Ficus*), cork tubes, and a wooden nesting box for refuge, sleeping, and egg deposition. The substrate consisted of rough pine bark atop a base layer of gravel. The enclosure further provided a large water basin, with a maximum diameter of 120 cm and a depth of 80 cm, for swimming and diving. Light was provided by one HQI basking lamp (400 W), one Osram Ultravitalux basking lamp (300 W), and four Repronox basking lamps (160 W) which also supplied ultraviolet light, together with four fluorescent tubes. Ambient temperatures in the terrarium ranged from 26.5–33.5° C with a maximum temperature of up to 45° C directly beneath the basking lamps. The minimum water temperature was 27° C; water changes were regularly conducted.

Upon completion of the public enclosure in April 2005, we transferred three of the then three year old *V. melinus* to this exhibit, keeping the remaining two individuals separately in the aforementioned glass terraria behind the scenes, inaccessible to the public. In the large public enclosure, it was obvious that the largest individual occupied the highest resting area. At the time, we also observed scattered aggression between this animal and the smaller inhabitants of the enclosure. On the morning of 18 May 2005, we found one dead *V. melinus* in the water basin of the public enclosure. It showed bite injuries on the head, body, and limbs. The postmortem analysis proved the existence of large cysts in the body cavity and pneumonia. At the time, we could not determine whether these injuries were inflicted on the animal while it was alive or once it was dead. Thus,

we transferred one of the two *V. melinus* kept behind the scenes to the public exhibit two months later on 23 July 2005. However, this move proved to be fatal, as this animal was found dead in the public enclosure, with similar, massive bite injuries after just two days. Another death, though not aggression-related, took place on 5 August 2005, unfortunately leaving just two of the six originally received *V. melinus* alive.

In early 2007, a large *V. melinus* pair was donated to the zoo. In May 2010, the male measured 510 mm SVL and 670 mm TL (Fig. 2); together with our breeding male (1280 mm total length), these two specimens currently represent the largest known individuals of the species. Due to the large size of the newly received *V. melinus* pair, we transferred our remaining pair from the public enclosure to a terrarium behind the scenes.

This terrarium, which could be separated into two halves if separation of the the pair was needed, measured 400 x 100 x 150 cm (l x w x h) and was constructed of laminated wood. The substrate consisted of pine bark and the enclosure was equipped with large branches, cork tubes and a 70 L water basin. Light was provided in each unit (200 x 100 x 150 cm) by two T 5 fluorescent tubes (80 W) and two basking lamps (160 W) which also supplied ultraviolet light. Ambient temperatures in the terrarium ranged from 26.5–33.5° C, with a maximum temperature of 45° C directly beneath the basking lamps. For egg deposition, we inserted a natural, hollow tree trunk nest box that measured 80 x 50 x 25 (l x w x h) cm and was half-filled with peat soil, leaves, and a layer of sphagnum moss.

Adults were fed vertebrate prey (mice, fish, or poultry)



Fig. 2. Tongue flicking, large male *V. melinus* (total length 1,180 mm) in the public exhibit depicted in Fig. 1. Photograph by **Rolf Schlosser**.

once a week, and invertebrates, locusts in particular, were usually offered in between weekly vertebrate feedings. Vitamins and minerals were occasionally supplemented by providing minced beef heart mixed with chicken eggs and powdered with Kalkamineral.

### **Courtship and Egg Deposition**

Matings were not seasonally related and took place year round. We observed copulation on the ground, in and on cork tubes, as well as directly underneath the basking lamps. Introducing the sexes together appeared to be the trigger for mating. We separated the male from the female around two weeks after observed copulations. Gestation was more noticeable by an increased and voracious appetite rather than observable increases in body volume.

Signs of egg deposition by the large *V. melinus* pair kept since 2007 in the public exhibit were initially determined by defecated egg shells. From a clutch which must have been laid in the public exhibit in

early 2008, we retrieved two eggs on 2 February 2008. However, these eggs showed no signs of development. Unfortunately, the large female kept on public exhibition died on 24 October 2008 at the age of 8.5 years from bacterial sepsis. Thus, besides the large male on exhibit, there remained just the pair received in 2003 housed off exhibit (Fig. 3). Since the large male on exhibit proved to be somewhat aggressive, we decided not to risk the life of our last remaining female by introducing it to this unrelated male. This proved to be the right decision, because the first successful egg deposition occurred roughly eight months later, on 20 June 2009. At that time, the parents were seven years and two months and seven years and three months old, respectively. The clutch comprised nine eggs (Fig. 4), and was deposited in the above described natural tree trunk half-filled with peat soil, foliage and a layer of sphagnum moss.

Just three months after deposition of the first clutch, a second clutch consisting of five eggs was laid on the 10 September 2009. Three months after the second clutch was laid, a third clutch must have been laid in

mid December 2009, evidenced by four discarded egg shells.

### Egg Incubation and Hatching

For incubation, eggs were removed from the terrarium and carefully placed in plastic boxes which were half-filled with an incubation medium of vermiculite and sand at a ratio of 2:1 by volume (Table 1). The eggs

were not turned, and were placed on the surface of the vermiculite. To guarantee saturated air humidity, we covered the opening of the incubation boxes with plastic sheeting, which also protected the eggs from intrusive pests such as flies and cockroaches. For ventilation, the plastic sheeting was removed at least once a week. Two eggs from the first clutch showed no signs of development, and were discarded after a few days. Of the remaining seven eggs, one showed a conspicuous,



Fig. 3. The breeding pair of *V. melinus* that produced the F2 offspring: A) sire (total length 1,280 mm); B) female (total length 945 mm). Photographs by **Detlef Karbe**.

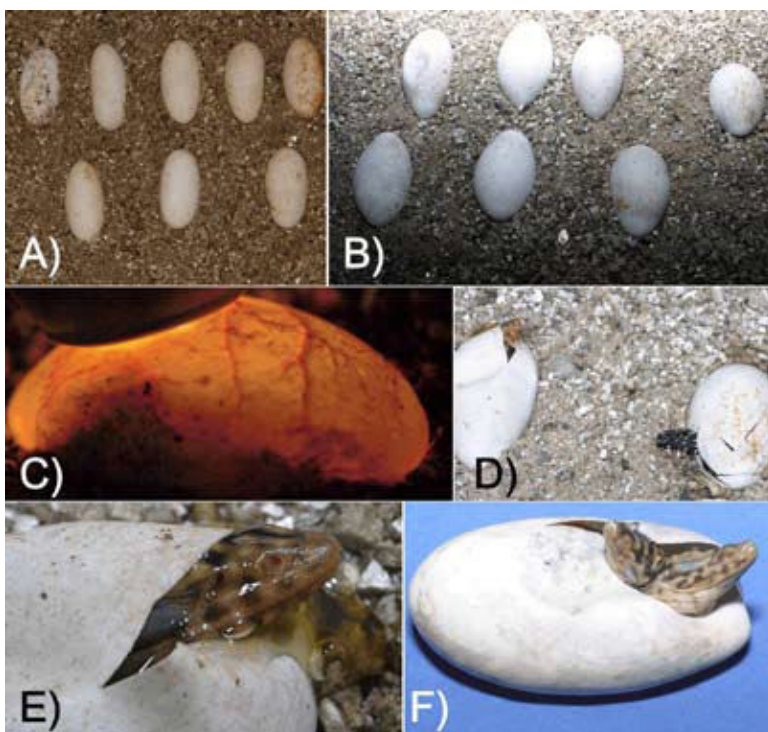


Fig. 4. Eggs and hatchlings of *V. melinus* at the Cologne Zoo Aquarium: A) eggs four days after deposition (24 June 2009). Photograph by **Detlef Karbe**; B) eggs few days before hatching. Photograph by **Thomas Ziegler**; C) candled egg at 157<sup>th</sup> day of incubation (24 November 2009). Photograph by **Detlef Karbe**; D) hatchlings on 30 November 2009. Photograph by **Thomas Ziegler**; E) close up of hatchling (30 November 2009). Photograph by **Thomas Ziegler**; F) conjoined twins (1 December 2009). Photograph by **Thomas Ziegler**.

Table 1. Egg measurements of the first six successfully hatched *Varanus melinus* immediately before hatching.

Egg Length (mm)	Egg Width (mm)
54.0	35.0
56.3	36.0
58.6	34.0
47.1	34.0
52.9	32.0
55.3	34.0

persistent dent on 26 November 2009.

On the morning of 30 November, we recognized the first slit on one of the non-dented eggs. Shortly thereafter, the snout and a leg protruded from the egg. By the afternoon of the same day, a total of three eggs showed slits, and the juveniles were occasionally seen circling inside their lacertated eggs. On the morning of 1 December 2009, after 164 days of incubation at a temperature of 29° C, the first juvenile emerged. The second hatchling emerged some hours later, during the night. The third emergence was observed in the morning of the following day. At that time we also carefully opened the conspicuously dented egg. Contained within this egg, which then measured 55.2 x 31.0 mm, were dead conjoined twins. The twins were well developed, and conjoined at the head and abdominal region. Two additional juveniles hatched after 165 days of incubation on the morning of 2 December 2009. The sixth and final juvenile of this clutch hatched one day later, on 3 December. All six juveniles proved to be healthy and strong (see Figs. 4-7, Table 3).

Concerning the second clutch (see Table 2), we removed two eggs which showed no development on 28 October and 20 December 2009. Of the remaining three eggs, the first hatched on 21 February 2010, after 164 days of incubation. The second emergence took place one day later, and the third egg, which measured 57.9 x 33.9 mm, was manually opened on 3 March 2010, and contained a well developed, but dead juvenile with an open abdomen (with protruding internal organs) and a slightly malformed cranium.

**Development**

The six juveniles from the first clutch were transferred to an upbringing terrarium measuring 60 x 100 x 75 cm (l x w x h). The two juveniles from the second clutch were transferred to a terrarium measuring 60 x 60 x 70 cm

Table 2. Egg shell measurements of the last two successfully hatched *Varanus melinus* (animals 7 and 8) immediately after hatching.

Egg Shell Length (mm)	Egg Shell Width (mm)
52.0	32.0
64.5	32.6

Table 3. Snout-vent length (KRL), tail length (TL), total length (ToL) and weight of the first six hatchlings of *Varanus melinus* measured shortly after hatching (3 December 2009).

SVL (mm)	TL (mm)	ToL (mm)	Weight (g)
115	157	272	33
112	158	270	34
111	165	276	33
109	157	266	34
116	163	279	35
115	166	281	35

(l x w x h). These upbringing terraria were constructed of glass and were equipped with several branches, cork and bamboo tubes, plants (e.g., *Ficus*) and drinking vessels. The substrate consisted of pine bark pieces, and misting with rain water was provided daily. Light was provided by T5 double fluorescent tubes and two basking lamps (160 W) which also supplied ultraviolet light. Ambient temperatures of 26.5-32.5° C were provided by light sources with a maximum temperature of up to 40° C directly beneath the basking lamps.

After four to five days, the hatchlings were first offered house crickets, which were refused until after the tenth day. A few weeks later, we offered baby mice. At this time, the diet consisted of invertebrates such as house crickets (*Acheta domesticus*), and locusts which were offered every other day, with baby mice offered from time to time. The juvenile *V. melinus* proved to be such voracious feeders that care was taken not to over-feed them. Thus, individuals were only fed with forceps to guarantee equal amounts of food. Nevertheless, some individuals grew somewhat faster than others, which may be related to sex or hierarchy.

On 18 May 2010, we transferred four juveniles from the first clutch at the age of about 5.5 months to an exhibit in the visitors area measuring 165 x 140 x 120 cm (l x w x h). Terrarium composition and climate was similar to the conditions previously described. By this stage,

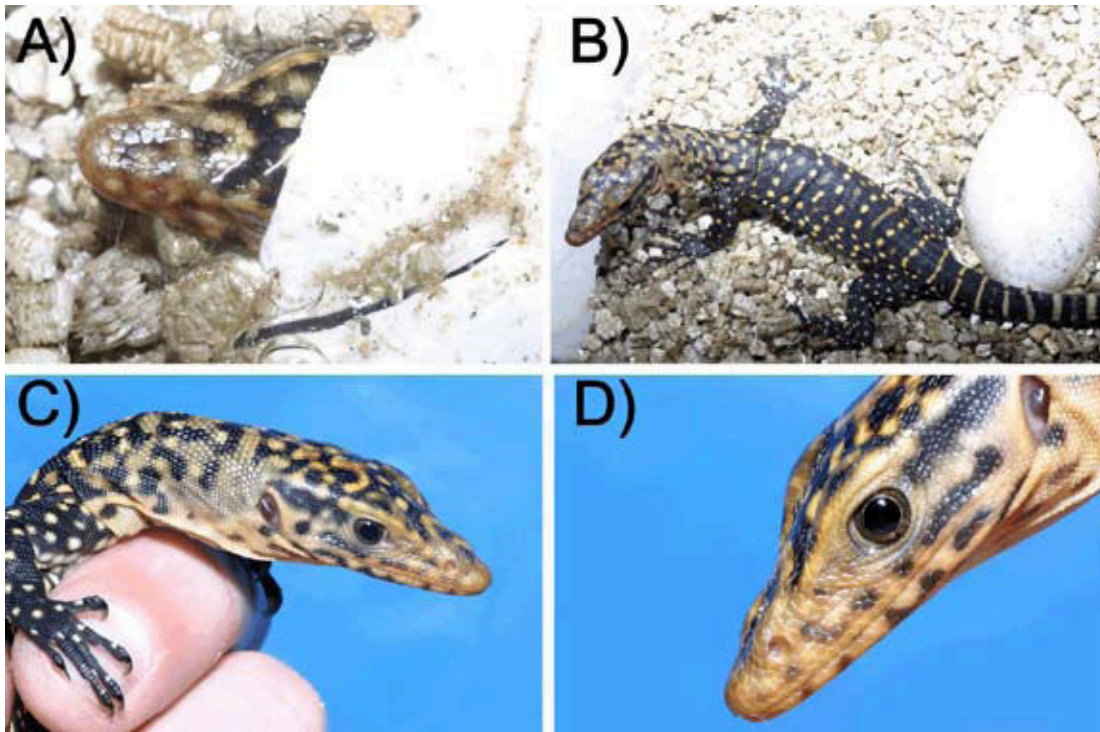


Fig. 5. First hatchling of *V. melinus* at the Cologne Zoo (1 December 2009) during A) hatching process (the egg tooth is well visible), and B-D) shortly after emerging from the egg. Photographs by **Thomas Ziegler**.

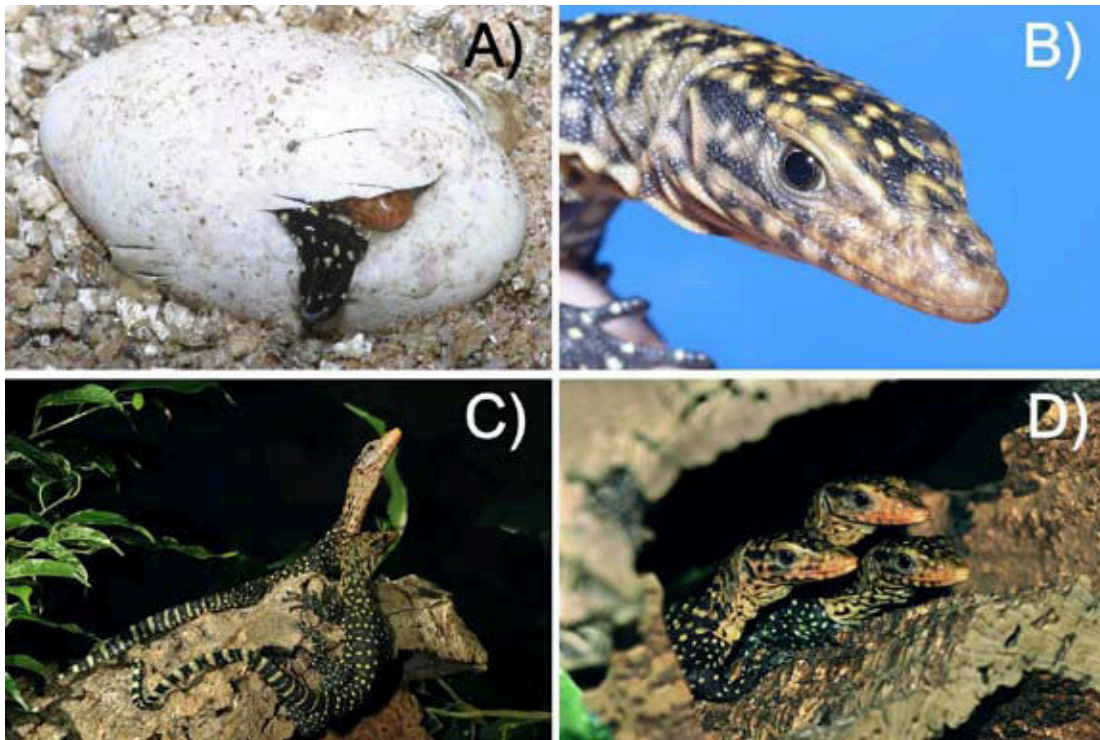


Fig. 6. A-B) Another hatchling of *V. melinus* (2 December 2009). Photographs by **Thomas Ziegler**; C-D) juvenile *V. melinus* at a few months old. Photographs by **Rolf Schlosser**.



Fig. 7. A-B) Juvenile *V. melinus*. Photographs by Rolf Schlosser.

the juveniles had noticeably grown, and were about 1/3 longer and heavier than at the time of hatching (Table 4). The typical color pattern change between juvenile and adult stages had also started (Figs. 8-9). The black dorsal pattern was reduced to thin markings surrounding the dorsal ocelli. These thin black borders around the ocelli further reduce with age and sometimes lead to irregular black reticulation patterns. We also observed that the head and neck regions on our 5.5 month old juveniles started to become distinctly yellow. At this stage, the venter was grey-brown, with numerous light ocelli. The throat pattern consisted of some elongate dark blotches, which were marginally fused in part to longish stripes.

Ziegler & Böhme (2004) indicated the lack of dark temporal stripes as one of the diagnostic features of adult *V. melinus*. However, due to our current knowledge based

on observations of a number of captive specimens, dark blotches behind the eyes that may be fused to a more or less temporal stripe-like shape may exist in some individuals.

**Discussion**

According to Lemm (1998), *V. melinus* females have cycled in captivity in both private collections and zoos, although eggs have been infertile. The first successful captive breeding of the species was reported by Dedlmar & Böhme (2000). To our knowledge, this remains the only published reproduction report for *V. melinus*. According to Dedlmar & Böhme (2000), one pair yielded four clutches consisting of 2-7 eggs each (mean 4.8) which were deposited at intervals of 3.5-8 months (mean 5.2). After 168-171 days of incubation (mean 170) at 28.5° C, five juveniles hatched from a single clutch containing six eggs measuring 65-67 mm (mean 66 mm) x 23-27.5 mm (mean 26 mm) in size. Hatchlings measured 210-225 mm in total length (mean 216 mm), with a weight of 21-23 g (mean 22 g).

In comparison with Dedlmar & Böhme (2000), the maximum clutch size of *V. melinus* at Cologne Zoo was slightly larger (9 versus 7). Maximum clutch sizes of up to 12 eggs are known for the species (Ziegler & Böhme, 2004). The incubation temperature at Cologne Zoo was 0.5° C higher than that used by Dedlmar & Böhme (2000), and thus, hatchlings at Cologne Zoo hatched 2-

Table 4. Total length (ToL) and weight of the first six hatchlings of *Varanus melinus* measured on 18.5.2010, at an age of about 5.5 months.

ToL (mm)	Weight (g)
370	46
375	50
395	55
375	45
370	41
380	47





Fig. 8. Young *V. melinus* 5.5 months after hatching (18 May 2010) with a total length of 370 mm and a weight of 46 g; the pattern is distinctly beginning to brighten up. Photograph by **Detlef Karbe**.



Fig. 9. Release of ca. 5.5 month old *V. melinus* into their public exhibit at the Cologne Zoo Aquarium (18 May 2010). Photograph by **Detlef Karbe**.

7 days earlier. The minimal interval between clutches at Cologne Zoo was roughly three months (versus 3.5 months in Dedlmar & Böhme 2000); however, the clutch size after this three month interval at Cologne Zoo was distinctly smaller than that of the previous clutch (5 versus 9 eggs). Hatchlings at Cologne Zoo were also larger (mean total length 274 mm versus 216 mm) and heavier (mean weight 34 g versus 22 g) than those reported by Dedlmar & Böhme (2000), although the Cologne Zoo female was slightly smaller (total length 945 mm versus 950 mm).

With respect to the conjoined twins, twinning has

only been reported for nine species of varanid lizards, of which three (*V. indicus*, *V. kordensis*, and *V. macraei*) belong to the subgenus *Euprepiosaurus* (see overview in Mendyk, 2007). This represents the first case of conjoined twins in *V. melinus*, which will be dealt with in detail separately. Although we have contacted several experts, we failed to find an appropriate research method or technique to determine the cause of the conjoined twinning (e.g., genesis by chance versus inbreeding). Of course, it would have been better to pair together unrelated adults; however, due to the limited number of adult animals available at the time, and due to our

previous keeping record and loss of specimens (e.g., due to unfortunate pairings), we did not want to risk the health of additional specimens. At this time, we do not know cause for the conjoined twins or the dead, slightly malformed juvenile from the second clutch. Despite these problems, eight healthy juveniles emerged from both clutches at the Cologne Zoo Aquarium which are strong and developing well.

When further critically reviewing our breeding success, attention should be paid to removing eggs from the terrarium immediately after deposition, so that no damage to the eggs by the mother (e.g., ovophagy) can occur. Although Dedlmar & Böhme (2000) did not observe any aggressive behavior when introducing their breeding pair, we could show that the compatibility of animals should be tested and carefully observed. Of the six *V. melinus* received by the Cologne Zoo in 2003, only two survived. However, both remaining specimens proved to become a stable breeding pair which has produced eight sound offspring to date, all of which will hopefully mature and be able to contribute on their part to captive conservation breeding projects.

## Outlook

Of the nearly 70 currently recognized species of monitor lizard, ten have been discovered in just the past decade. Especially diverse are the mangrove and emerald tree monitor lizard groups, which are currently comprised of 22 species in total, of which 64% have been discovered in the past twenty years. Many of these species are known only from a few museum specimens, and virtually nothing is known about their natural history. Since we are only able to protect what is well known to us, there is a high demand for ecological research. Because many monitor species live in remote and difficult to access habitats, ex situ studies also become important. Thus, the zoo community can contribute towards a better understanding of the natural history of monitor lizards. Through captive husbandry and breeding, important data can be obtained for further captive conservation efforts. Building up a zoo population based on captive bred animals may also someday serve as a basis for reintroduction, particularly when species like *V. melinus* are concerned, which seems to have a very restricted geographical distribution. Thus, juvenile *V. melinus* will be raised at Cologne Zoo with some of them provided to other accredited zoos with reptile breeding/conservation projects for starting a captive breeding program.

It will be crucial to combine aforementioned ex

situ efforts based on sustainably-acquired, captive bred animals with in situ research, such as studies of the species' habitat requirements and estimations of the remaining population size. The trial of the German Federal Government to elevate the species to CITES Appendix I status was unfortunately dismissed (with the justification "data deficient") at the Nairobi CITES Conference some years ago.

Facing the recently published, alarmingly high numbers of wild-caught *V. melinus* (Weijola & Sweet, 2010), one really seriously wonders why such an enigmatic flagship species for beautiful, diversity-rich, and still largely unknown Indonesian island ecosystems is left abandoned to its fate.

It is really high time to conduct population analyses (and that such research is supported and commissioned, respectively). Given that the wild-caught numbers provided by Weijola & Sweet (2010) are affirmed in the near future and thus the natural population has in fact drastically declined, adequate conservation measures must urgently follow (i.e., habitat protection, strict export quotas, possibly population reinforcement), if it is not already too late.

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