

The Monitor Man: A Story of Stunning Discoveries and Charismatic Creatures*

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Abstract: On the occasion of Prof. Dr. Wolfgang Böhme's retirement from curatorship of the herpetology section at the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK) in Bonn, Germany after 39 years, we summarize his many achievements and contributions to the study of systematics and diversity of the extant members of the lizard family Varanidae. For the last 25 years, monitor lizards of Africa and Southeast Asia have been one of his main research activities which have resulted in nearly 80 publications about monitor lizard, including the descriptions of 15 new monitor taxa (viz., two subspecies, 12 species and one subgenus). Due to these decade-long taxonomic investigations of monitors, the herpetological section at ZFMK now houses one of the most important and most complete collections of monitor lizards both in terms of type material (including 12 primary type specimens and paratypes of four additional monitor species) as well as the total number of species represented. Today, 58 different *Varanus* species are housed in the ZFMK collection, representing nearly 80% of the global monitor lizard diversity. Without doubt, Wolfgang Böhme has played an important role in the advancement of monitor research and belongs to the most successful students of the systematics and taxonomy of extant monitor lizards.

The monitor man: how everything started

On the occasion of Prof. Dr. Wolfgang Böhme's (Fig. 1) retirement from the position as deputy director and curator of herpetology at the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK) in Bonn, Germany after 39 years, we summarize

his achievements and contributions to the study of systematics and diversity of the extant members of the lizard family Varanidae. For the last 25 years, monitor lizards of Africa and Southeast Asia have been one of his main research activities.



Fig. 1. Wolfgang Böhme in August 2006. Photograph by **André Koch**.

As early as 1974 (*i.e.*, three years after he had taken up the post as curator of amphibians and reptiles at the ZFMK), Prof. Dr. Hans-Georg Horn, Sprockhövel, drew the attention of Wolfgang Böhme to the fact that specimens of *V. panoptes* from New Guinea were morphologically distinct from their Australian conspecifics. At that time, a shipment of juvenile and subadult specimens from Merauke, southern New Guinea reached Germany. However, the lack of an adult specimen prevented the description of a novel taxon until 1988 when Böhme (1988a) finally erected the new allopatric subspecies *V. panoptes horni*, which was dedicated to his colleague and friend Hans-Georg Horn, with whom he would initiate and organize three consecutive “Multidisciplinary World Conferences on Monitor Lizards” between 1989 and 2005 (see below). This taxonomic description was the beginning of a most fruitful series of further monitor lizard discoveries which still continues today.

The “TV monitor” and other amazing discoveries

Many people may think that in order to find fascinating new species, scientists must survey poorly-explored regions of the globe such as mountainous areas, rainforests, or remote islands. Sometimes, however,

extraordinary discoveries are made under somewhat different circumstances. It was indeed an unusual circumstance in 1985 that began the long series of novel monitor lizard discoveries by Wolfgang Böhme and colleagues, when he sat comfortably at home watching a television documentary about the Arabian Republic of Yemen. After viewing images of Yemen’s landscapes, he was much surprised to see a large monitor lizard climbing up a tree, because no monitor species was hitherto known from northern Yemen. To get a hold of this undetermined species, Wolfgang Böhme first contacted the author of the documentary to obtain information about the exact locality where this monitor specimen had been filmed. Next, in early 1986, he sent out two students to the same locality to find and secure this monitor lizard for further investigations (Böhme *et al.*, 1987). Despite three months of intense efforts, not a single specimen could be found. However, during the rainy season half a year later, Beat Schätti, from the Zoological Museum in Zurich, traveled to the area again and encountered eight specimens of the unknown monitor lizard. For further taxonomic comparisons, they were exported to Switzerland and Germany, where the live specimens were displayed in the vivariums of the Berne Zoo and the ZFMK, respectively. Finally, the investigations culminated in the description



Fig. 2. *Varanus yemenensis*, the new monitor species Wolfgang Böhme discovered by watching a TV documentary, in the arms of his eight-year old son Peter. Photograph by **Wolfgang Böhme**.

of *V. yemenensis* (Fig. 2), the Yemen monitor (Böhme *et al.*, 1989). Due to its extraordinary discovery many colleagues still fondly refer to this species as the “TV monitor”.

Untangling the underestimated diversity of Indo-Australian monitor lizards

After this promising opening, Wolfgang Böhme’s focus shifted from African to Indo-Australian monitor lizards. Although he never set foot in Southeast Asia, this presented hardly any obstacles for him to significantly enhance knowledge about the monitor diversity of this tropical region. For instance, by comparing the original type specimens Böhme (1991) showed that *V. karlschmidti* Mertens, 1951 is a junior synonym of *V. jobiensis* Ahl, 1932, and thus did not have nomenclatorial priority over the latter name. So, *V. jobiensis* was resurrected and is still in use today for the peach-throated monitor from New Guinea.

Until the 1990s, Indo-Australian monitor lizards comprised only seven long-recognized species. These were the infamous Komodo dragon *V. komodoensis* Ouwens, 1912 from the Lesser Sunda Islands, the widespread water monitor *V. salvator* (Laurenti, 1768) (with several subspecies) inhabiting continental Southeast Asia, the Greater and Lesser Sunda Islands, Sulawesi, and the Philippines (see Koch *et al.*, 2007), the polytypic emerald tree monitor *V. prasinus* (Schlegel, 1839) (with four allopatric subspecies), the crocodile monitor *V. salvadorii* (Peters & Doria, 1878), the peach-throated monitor *V. jobiensis* Ahl, 1932, and the mangrove monitor *V. indicus* (Daudin, 1802) (with three different subspecies), all of which inhabit New Guinea and adjacent islands, and *V. timorensis* (Gray,

1831) (likewise polytypic) from Timor, New Guinea and northern Australia (Böhme, 1988b, 1997; see also Mertens, 1963).

Again it was Prof. Dr. Hans-Georg Horn, an attentive monitor lizard keeper and successful breeder for many decades (*e.g.*, Horn, 1977, 1991), who got the ball rolling. As early as the 1970s, he observed significant differences between certain *V. indicus* forms with a dark versus a light tongue (Horn, 1977). The latter, very beautifully-colored specimens were referred to as *V. indicus* “kalabeck” by pet traders. In the first step of a thorough revision towards a resolved taxonomy of the seemingly variable mangrove monitor lizards, Böhme *et al.* (1994) examined the traceable, original type specimens of all available names, and then revalidated the taxon *doreanus* A. B. Meyer, 1874 (Fig. 3) for the light-tongued and blue-tailed monitors from New Guinea. This decision was corroborated by Böhme’s (1991) earlier findings, which had revealed differences in hemipenial morphology between both forms. At the same time, Böhme *et al.* (1994) described *V. doreanus finschi*, a new allopatric subspecies from the Bismarck Archipelago, which differed from typical *V. doreanus* by an unpatterned, bright throat and the lack of blue pigmentation on the tail. Later, this taxon was elevated to species status due to the confirmed sympatric occurrence of both taxa on New Guinea and northern Australia (Ziegler *et al.*, 1999a, 2001)

In their note on the synonymy and taxonomy of the *Varanus bengalensis* complex, Böhme & Ziegler (1997a) clarified the complicated and confusing nomenclatural situation caused by the descriptions of *V. irrawadicus* Yang & Li, 1987 and *V. vietnamensis* Yang & Liu, 1994. *Varanus irrawadicus* was already synonymized with *V. b. bengalensis* by Auffenberg (1994), but some



Fig. 3. The blue-tailed monitor *V. doreanus* remained long unrecognized but was resurrected from synonymy of *V. indicus* by Böhme *et al.* (1994). Photograph by Amir Hamidy.

misspellings and other errors still caused considerable confusion. Thus, the nomenclatural discussion and first revisionary action of Böhme & Ziegler (1997a) towards the correct spelling *irrawadicus* summarized that this taxon and the spellings *irrawardicus*, *irriwadicus*, and *irriwardicus* are in fact synonyms of *V. b. bengalensis* (Daudin, 1802). Böhme & Ziegler (1997a) also showed that *V. vietnamensis* has to be regarded as a synonym of *V. bengalensis nebulosus* (Gray, 1831). In addition to this assessment, the authors provided new evidence to reevaluate the taxonomic status of the two formal subspecies of *V. bengalensis*. Based on well-known differences in scalation (undifferentiated versus differentiated supraocular scales, number of oblique ventral scale rows) in combination with new genital morphological findings, Böhme & Ziegler (1997a) showed that the populations of *bengalensis* and *nebulosus* have achieved a divergent status surpassing the subspecies level. Besides the morphological evidence for a distinct specific rank of *bengalensis* and *nebulosus*,



Fig. 4. Wolfgang Böhme with a specimen of the colorful quince monitor *V. melinus*. Photograph by **Thomas Ziegler**.

the authors also demonstrated for the first time that the distribution ranges of these taxa, which were formerly considered to be allopatric, are parapatric and, in part, even sympatric. However, Böhme & Ziegler (1997a) closed their note with the challenge for more detailed distribution analyses at the geographical borderline between both taxa in order to document sympatry - with or without hybridization - also in other localities.

While these initial investigations were based on the examination of voucher specimens housed in natural history collections, several subsequent discoveries of new Indonesian monitor lizards were real surprises because they were reptile trade-based. At first, some astonishingly yellow-colored monitors (Figs. 4 & 5), purported to have originated from Obi Island in the Moluccas, came to the attention of Wolfgang Böhme and his former student Thomas Ziegler from photographs taken by traders in Jakarta. Later, some live specimens reached Germany and were encountered in a pet store in Duisburg, North Rhine-Westphalia. One specimen, the subsequent holotype, was made available for further investigations and display in the vivarium of the ZMFK through the generous support of Horst Dintelmann, Bonn, a long-standing friend and supporter of the museum. This live individual, together with three additional voucher specimens served as the type series of the quince monitor *V. melinus* (Böhme & Ziegler, 1997b). Later, the pet-trade-based type locality Obi turned out to be an error and was corrected by Ziegler & Böhme (1999). Due to their colorful appearance, quince monitors are focal species of monitor enthusiasts all around the world. The first successful breeding of *V. melinus* was published by Dedlmar & Böhme (2000), and subsequently, the first F2 breeding by Ziegler *et al.* (2010a). However, still nothing is known about the biology of wild *V. melinus* populations.

Next to *V. melinus*, further hitherto unknown monitor lizards were regularly exported from Indonesia and appeared in the international pet trade towards the end of the last millennium. For instance, in 1998, another breathtakingly colorful monitor lizard, the tri-colored monitor *V. yuwonoi* (Fig. 6) from Halmahera Island, fascinated the international community of monitor lizard enthusiasts. A few years earlier, the first evidence for the existence of this third blue-tailed monitor species was collected by wildlife trader Frank Yuwono during an expedition to the Moluccan Islands. This time, however, the species was described by colleagues from the United States (Harvey & Barker, 1998). Confirmed assignment to the *V. indicus* species group was subsequently provided by Ziegler & Böhme (1999) based on synapomorphic



Fig. 5. *Varanus melinus* is one of the most colorful new monitor lizard species, and was discovered by Wolfgang Böhme and Thomas Ziegler through the pet trade in the 1990s. Photograph by **Thomas Ziegler**.



Fig. 6. When Wolfgang Böhme held *V. yuwonoi* in his hands, it had already been described by colleagues from the United States. Photograph by **Thomas Ziegler**.



Fig. 7. *Varanus caerulivirens* from the northern Moluccas was also discovered through the international pet trade. Photograph by **Kai Philipp**.

outer genital structures. The year 1999 was also very prolific for monitor lizard research because it saw the description of two new Indonesian species. Ziegler *et al.* (1998) had already published a photograph of a monitor specimen with a turquoise tinge and a light-colored tongue (Fig. 7), which could not be allocated to any known species of the *V. indicus* group. The following year, it was described as *V. caerulivirens* (Latin for turquoise) by Ziegler *et al.* (1999b) after a juvenile specimen with reliable locality data (Halmahera Island) had been found in the Senckenberg Museum, Frankfurt. The true identity of this historical voucher specimen had not been recognized by Robert Mertens. Only with the development of a new taxonomic concept of the widespread *V. indicus* (Böhme *et al.*, 1994; Philipp *et al.*, 1999; see also Koch *et al.*, 2009 a), could the underestimated diversity of these Pacific monitor lizards be revised.

The ninth member of the growing *V. indicus* group within the subgenus *Euprepiosaurus* was subsequently named *V. cerambonensis* from the Moluccan Islands of Ceram and Ambon, central Indonesia (Philipp *et al.*, 1999). In contrast to former studies, this time morphological data from voucher specimens collected by Kai Philipp (Baden Baden) on several Moluccan Islands and New Guinea were combined with specimens from various German and Dutch natural history museums. The systematic investigations revealed the sympatric existence of two distinct monitor lizard species on Ambon, the type locality of *V. indicus* (Daudin, 1802). Therefore, Philipp *et al.* (1999) designated a neotype for Daudin's taxon in order to allocate the species

epithet to a name-bearing voucher specimen for future investigations.

The next new monitor species of considerable size was found by Wolfgang Böhme during a visit to his late friend and colleague Jens B. Rasmussen at the Zoological Museum in Copenhagen, Denmark. This time, a series of specimens identified as *V. indicus* and collected in 1962 by the Danish Noona Dan Expedition on Rennell, a remote islet of the Solomon Islands, did not exhibit the typical dorsal double keel along the tail. Apart from this unique feature, the new species, named *V. juxtindicus* (Figs. 8 & 9) due to its phenetic resemblance with the mangrove monitor *V. indicus*, is characterized by a vivid pattern of many small yellow dots (Böhme *et al.*, 2002). Until recently, *V. juxtindicus* was known only from the type specimens in the Copenhagen museum. Wesiak & Koch (2009), however, demonstrated that this "rare" monitor species was already kept and bred unrecognized in captivity more than 10 years before its formal description in 2002. The morphological similarity of both species together with the lack of a taxonomic concept of true *V. indicus* at that time inhibited identification (Wesiak & Koch, 2009).

Another unexpected discovery took place in summer 2002, when Wolfgang Böhme visited his colleague George Zug at the US National Museum of Natural History (USNM), Smithsonian Institution in Washington D.C., which maintains one of the largest amphibian and reptile collections in the world. Among its numerous *V. indicus* specimens, Wolfgang Böhme recovered a peculiar specimen from Halmahera Island, Moluccas, which showed no traces of a color pattern.



Fig. 8. Wolfgang Böhme holds the adult holotype of *V. juxtindicus*. Photograph by **Kai Philipp**.

It was subsequently named *V. zugorum* by Böhme & Ziegler (2005) in gratitude for George Zug and his wife. Until today, this single voucher specimen, which had been collected in the early 1980s, remains the only known example of this species.

It was also during this visit to the USNM that Wolfgang Böhme discovered a specimen of *V. spinulosus* (USNM 120886) which had likewise escaped the attention of herpetologists for nearly sixty years because it had been misidentified as *V. indicus* (Böhme & Ziegler, 2007). This voucher specimen from the island of Bougainville represented the first country record of *V. spinulosus* for Papua New Guinea (PNG) and expanded its known range by almost 400 km. At the same time, two specimens of true *V. indicus* (USNM 120161, -62) with the same locality and collecting data documented sympatry, and possibly even syntopy, of both species on Bougainville (Böhme & Ziegler, 2007).

These discoveries of novel monitor lizard species in natural history museums impressively demonstrated the importance of historical herpetological collections and the need for further taxonomic investigations into Indo-



Fig. 9. Until recently, *V. juxtindicus* was only known from the historical type specimens. Photograph by **André Koch**.

Australian monitor lizards. In 2007, a third new monitor species from Halmahera Island in the northern Moluccas was described. *Varanus rainerguentheri* was dedicated to Rainer Günther, the former curator of herpetology at the Museum für Naturkunde in Berlin (ZMB), at the occasion of his retirement (Ziegler *et al.*, 2007).

Despite the description of *V. rainerguentheri*, the year 2007 experienced no increase in species numbers of the growing *V. indicus* group. Based on the examination of the hemipenes, *V. spinulosus* (Fig. 10), originally described by Mertens (1941) as a subspecies of *V. indicus*, was excluded from the *V. indicus* species group (Böhme & Ziegler, 2007). Due to unique features in genital morphology and scalation, *V. spinulosus* is now not even considered a member of the subgenus *Euprepiosaurus*. Therefore, this monitor species from the Solomon Islands is currently treated *incertae sedis*, and probably represents a distinct subgenus of its own (Böhme & Ziegler, 2007).

When Wolfgang Böhme looked for another student to conduct a project on Indonesian monitor lizards of the *V. salvator* complex, it was the senior author who traveled to Sulawesi and adjacent islands in order to collect new voucher specimens and data representing this taxonomically unresolved monitor group. It was a biogeographic surprise when no members of the *V. salvator* complex were encountered while surveying the remote Talaud Islands in the very north of Sulawesi, but rather an undescribed species of the *V. indicus* group (Koch *et al.*, 2009b). Named after the village of Lirung on Salibabu Island where it was found, *V. lirungensis* has one of the smallest distribution ranges of all known



Fig. 10. Originally described as a subspecies of *V. indicus*, recent hemipenial investigations of *V. spinulosus* have shown that this Solomon Island monitor species does not belong to the subgenus *Euprepiosaurus*. Photograph by **Quetzal Dwyer**.

monitor lizards (Koch *et al.*, 2009a,b). It represents the most northwesterly occurrence of a Pacific monitor lizard species.

Jewels in the jungle: the *V. prasinus* group

Another monitor lizard group, the colorful New Guinean tree monitors of the *V. prasinus* complex, experienced some astonishing discoveries in the new millennium. One of these spectacular new species was the light-blue and black *V. macraei* (Böhme & Jacobs, 2001), which, without a doubt, is one of the most colorful reptile species of the world (Fig. 11). *Varanus macraei* was successfully bred in captivity just one year after its scientific description (Jacobs, 2002); later, a reproducing zoo population was established (Ziegler *et al.*, 2010b).

Wolfgang Böhme's long-standing contributions to monitor lizard research were honored in 2003 when Hans J. Jacobs (Borchen, Germany), a good friend of Wolfgang and enthusiastic keeper of Indonesian monitors, named a novel species of tree monitor lizard *Varanus boehmei* (Jacobs, 2003). Specimens of the so-called golden-speckled tree monitor, endemic to Waigeo Island off the northwest coast of the Vogelkop (Doberai) peninsula of New Guinea, are still kept and displayed in the public vivarium exhibition of the ZFMK today (Fig. 12).

The Southeast Asian water monitors

The third Southeast Asian monitor group that saw a growing number of representatives were the

widespread water monitors of the *V. salvator* complex. In a first step, Koch *et al.* (2007) re-elevated the three traditionally recognized Philippine taxa *marmoratus* Wiegmann, 1834, *nuchalis* Günther, 1872, and *cumingi* Martin, 1838, as well as the Sulawesi taxon *togianus* Peters, 1872, to their original species status (they had been classified as subspecies of *V. salvator* by Mertens [1942c]). At the same time, the nominotypic subspecies *V. s. salvator* was restricted to the designated type locality of Sri Lanka, while the name *macromaculatus* Deraniyagala, 1944 was resurrected from synonymy for the populations of mainland Southeast Asia, as well as Borneo and Sumatra. The melanistic *komaini* Nutphand, 1987 from Thailand, however, was synonymized with the latter taxon.



Fig. 11. The beautifully-colored *V. macraei* from Batanta Island is one of the most spectacular monitor discoveries in recent years. Photograph by **André Koch**.



Fig. 12. *Varanus boehmei* was named in honor of Wolfgang Böhme's contributions to monitor lizard research in 2003. Today, this species is still displayed in the vivarium of the ZMFK in Bonn. Photograph by **Thomas Ziegler**.



Fig. 13. *Varanus palawanensis* from the Philippines was recently revealed to be specifically distinct from *V. marmoratus*. Photograph by **Ingo Langlotz**.

Recently, the Philippine members of the *V. salvator* complex were re-investigated, resulting in the taxonomic splitting of the polymorphic and disjunct *V. marmoratus* populations (Koch *et al.*, 2010a). Two new species, *V. palawanensis* (Fig. 13) from Palawan Island and *V. rasmussenii* from the Sulu Archipelago, were diagnosed as morphologically distinct species. Interestingly, the latter species is only known from two historical voucher specimens, which like the type series of *V. juxtindicus*, was also collected by the Noona Dan Expedition (see above). In addition, the attractive *V. cumingi* was shown

to be polytypic and a new subspecies of this popular monitor species, *V. cumingi samarensis*, was described from the islands of Samar, Leyte, and Bohol (Koch *et al.*, 2010a).

Even after these two comprehensive revisions of the systematics and diversity of Southeast Asian water monitor lizards, further taxonomic changes and additions are to be expected in the future from various islands of Sulawesi, the Moluccas, and the Lesser Sundas (Koch *et al.*, unpubl. data).

The Nile monitor and Africa's largest lizard

Discoveries of large, undescribed monitor species are not only to be expected from the many unexplored Indo-Australian and Pacific islands, but may also occur in Africa. In this regard, Böhme & Ziegler (1997c; see also Böhme, 1990) discussed the existence of a further giant monitor lizard species in addition to *V. ornatus* (the rainforest form of *V. niloticus*, which was elevated to full species status by Böhme & Ziegler [1997d]) from the rainforests of Cameroon and Gabon. They cited several independent reports by reliable scientists about a large, gray (monitor) lizard which, in contrast to the forest-dwelling *V. ornatus*, was said to taste delicious according to the local people. This interesting feature bares resemblance to the experience of Auffenberg (1988) and could indicate a frugivorous monitor in Africa, as is hitherto only known from the Philippine species *V. mabitang* and *V. olivaceus*. Until today, however, no specimen of such a mystery monitor lizard from Central Africa has been secured for science.

Regarding the question of what is Africa's largest lizard, the osteological herpetology collection at ZFMK houses the answer. Based on two skulls from the island of Bioko (formerly known as Fernando Póo) off the west coast of central Africa, Böhme & Ziegler (1997c) showed that the total length of *V. ornatus* distinctly surpasses 250 cm in total length.

New features in genital morphology and advances in monitor lizard systematics

In monitor lizards, which are generalized active foragers and characterized by a weakly expressed sexual dimorphism, their highly diversified genitals seemed to provide much more reliable information on phylogenetic relationships than traditional classifications based on external morphology (Böhme, 1988b; Ziegler & Böhme, 1997).

In 1988, Wolfgang Böhme's professorial dissertation "Zur Genitalmorphologie der Sauria: Funktionelle und stammesgeschichtliche Aspekte" (= On the genital morphology of saurians: functional and phylogenetic aspects) was published. The monitor lizards (Varanidae) occupied the largest part (32 pages) of the systematic chapters of this 176 page monograph (Böhme, 1988b). Therein, the genital morphology of 26 different monitor lizard taxa was systematically investigated. These hemipenial studies resulted in the surprising finding that the mangrove-dwelling *V. indicus* is actually a close relative of the arboreal *V. prasinus*, which was

traditionally assigned to the round-tailed dwarf monitors of the subgenus *Odatria* from Australia (see Mertens, 1963). This phylogenetic hypothesis which was not supported by lung morphology (see Becker *et al.*, 1989) was later confirmed by molecular studies (Ast, 2001; Ziegler *et al.*, 2007). Thus, both ecologically distinct monitor groups are today united in the subgenus *Euprepiosaurus*. In addition, Böhme (1988b) recognized the morphological distinctness of the hemipenes of Southeast Asian water monitors (*V. salvator* complex), which led to the definition and delimitation of a new monitor subgenus called *Soterosaurus* (Ziegler & Böhme, 1997).

In 1995, Wolfgang Böhme (1995) (re-)discovered miniaturized, paired, evertible and erectile structures in female monitor lizards, for which he proposed the term hemiclitoris. This sexual structure represents the morphological equivalent to the intromittent hemipenis of male squamates. These hemipenis-like organs were also later found in females of other squamates (Ziegler & Böhme, 1997). Ziegler & Böhme (1997, 1999) also demonstrated that these female copulatory organs can be used for taxonomic conclusions and (sub)generic assignments.

The advantages of hemipenial morphology in contrast to traditionally-studied external morphological features (see e.g., Mertens 1942a-c, 1963) to uncover the real systematic relationships of monitor lizards (and other squamate reptile groups) were recently summarized and compared with modern molecular studies by Böhme & Ziegler (2009). Furthermore, Böhme & Ziegler (2009) identified a number of nodes of species groups (including several monotypic ones) where genital morphological clades agreed with molecular inference, such as the subgenera *Empagusia*, *Euprepiosaurus*, *Odatria*, *Polydaedalus*, *Soterosaurus*, and *Varanus*, to name only a few. Also within groups of closely related species, hemipenial morphology can contribute valuable data and taxonomic insights which are in a broad consensus with molecular data sets. Böhme & Ziegler (2009) suggested that the better agreement in regard to phylogenetic signals between genitalia structures and genetic data may be due to the fact that squamate genital organs are "hidden" inside the tail base and, thus, are not affected by environmentally-effected selective pressures. In contrast to ecologically dependent, peripheral structures, these internal features seem to be merely subject to sexual selection: namely that convergence owing to natural selection is less likely to arise in genital morphology. Based on the recent review of Böhme & Ziegler (2009), it can be stated that genital morphology still plays an

important role in squamate taxonomy and phylogeny, and will be crucial for further functional, evolutionary and systematic analyses of monitor lizards and other squamates.

Other aspects of monitor lizard biology

Next to taxonomic and systematic research, Wolfgang Böhme also supported and supervised ecological studies on monitor lizards. Investigations of the stomach contents of *V. spinulosus* (Böhme & Ziegler, 2007), *V. dumerilii* (Ziegler & Böhme, 1996), and the New Guinean members of the *V. indicus* species group (Philipp *et al.*, 2007) provided important information on the biology and habitat preferences of these monitor species. Wolfgang Böhme also supervised the ecological studies of Sigrid Lenz on the Nile monitor *V. niloticus* in West Africa, which resulted in a detailed monograph on this species (Lenz, 1995).

Wolfgang Böhme also recorded the remarkable age of a male *V. salvator* kept between 1973 and 1999 in a school terrarium in Bonn (Böhme, 2003a). Due to its size when purchased, Böhme (2003a) concluded that the specimen could have attained an individual age of 28 years, which represents the second oldest age ever reported in a member of the Varanidae. This is only surpassed by the Komodo dragon. The skeleton of this *V. salvator* specimen now forms part of the osteological herpetology collection at ZFMK.

The monitor lizard collection of ZFMK

When he commenced his job as curator of herpetology at ZFMK in August 1971, the collection contained only three monitor lizard species. By 1984, this number had increased to 24 species (Böhme & Bischoff, 1984), which represented more than 70% of the then known 30 monitor species. A quarter of a century later, the ZFMK collection now houses 58 different monitor species, which is nearly 80% of the known global monitor lizard diversity. Thanks to Wolfgang Böhme's dedicated efforts and investigations into monitor lizard diversity and systematics for more than 25 years, the herpetological section at ZFMK keeps one of the most important and most complete monitor lizard collections in the world.

In the early 1980s, no monitor type specimens were represented in the ZFMK monitor collection (Böhme & Bischoff, 1984). This situation changed some years later with the descriptions of *V. panoptes horni* and *V. yemenensis* in 1988 and 1989, respectively (Böhme, 1988a; Böhme *et al.*, 1989). The current ZFMK

collection is also particularly rich in primary type specimens (i.e., name-bearing specimens) for various new *Varanus* species and subspecies descriptions. Of 73 currently recognized monitor lizard species, the ZFMK collection currently holds primary type specimens (i.e., holo-, neo-, lecto-, [and syn-]types) of 13 species and subspecies (viz., *panoptes horni*, *yemenensis*, *doreanus*, *finschi*, *melinus*, *indicus*, *caerulivirens*, *cerambonensis*, *macraei*, *boehmei*, *rainerguentheri*, *s. salvator*, and *cumingi samarensis*). This number is supplemented by paratypes of 4 additional species (*juxtindicus*, *lirungensis*, *palawanensis*, and *rasmusseni*) (Böhme 2010). For comparison, the Senckenberg collection in Frankfurt (SMF), where Robert Mertens (1894-1975), the father of modern varanid taxonomy worked between 1919 and 1960, contains primary type specimens of eight valid monitor taxa (viz., *albigularis microstictus*, *acanthurus brachyurus*, *scalaris*, *griseus koniecznyi*, *flavirufus*, *s. storri*, *reisingeri*, and *palawanensis*), six of which were already there in the 1960s (Mertens, 1967). This equals the number of primary types of valid monitor taxa in the Muséum National d'Histoire Naturelle (MNHN) in Paris (Brygoo 1987, 1990, de Lisle 2009).

Live monitor lizards in the ZFMK vivarium

Even before the description of *V. yemenensis* in the late 1980s (Böhme *et al.*, 1989), live monitor lizards have regularly been displayed at the Museum Alexander Koenig to show visitors one of the main research foci of the herpetology section (Böhme & Ziegler, 1997c). After the opening of the vivarium in the lower level of the museum building in November 1984, a pair of *V. exanthematicus* lived together with *Kinixys belliana* in a large desert terrarium. In the following years, the newly discovered *V. yemenensis*, *V. melinus*, and *V. yuwonoi* were exhibited. At present, the recently-described *V. boehmei* is displayed on exhibit in the ZFMK vivarium (Fig. 12).

Large monitor species such as the powerful Komodo dragon (*V. komodoensis*) and the New Guinean crocodile monitor (*V. salvadorii*), which due to their enormous total length cannot be kept at ZFMK, are publicly exhibited as painted casts. In 1987, the museum received two adult specimens of *V. salvadorii* from the reptile zoo in Regensburg. The larger of both specimens had a total length of about 255 cm (Fig. 14), which remained the longest specimen of *V. salvadorii* recorded until the late 1990s (Böhme & Ziegler, 1997c). Anecdotal reports of crocodile monitors reaching total lengths of more than 4 m have never been substantiated.

When a male Komodo dragon died in the Rotterdam Zoo in the mid 1980s, it was also used to prepare painted casts. The large *V. komodoensis* specimen had a total length of 265 cm and clearly demonstrated the differences in body proportions between both giant monitor species (Fig. 15). While the skeleton of the specimen remains in the ZFMK collection, three copies of the cast were transported to the Netherlands. Both ZFMK casts of *V. salvadorii* and *V. komodoensis* are today on display at the entrance of the vivarium. The detailed process of making the painted casts was documented and depicted by Böhme & Ziegler (1997c).

Conclusions

Starting in the late 1980s, Wolfgang Böhme initiated and co-organized three successive “Multidisciplinary World Conferences on Monitor Lizards” held at the ZFMK. Many international monitor lizard experts attended these meetings in 1989, 1997 (Fig. 16), and 2005; the contributions of which were published in three

volumes, each co-edited by Wolfgang Böhme (Fig. 17) (see Böhme & Horn, 1991; Horn & Böhme, 1999; Horn *et al.*, 2007).

In the tradition of his scientific idol Robert Mertens (1894–1975) and his important contributions to monitor lizard research (see *e.g.*, Mertens, 1942a-c, 1958, 1959, 1963), Wolfgang Böhme (1997, 2003b) issued two updated and revised taxonomic checklists of extant monitor lizards (Fig. 18). The 2003 “checklist of the living monitor lizards of the world” was prepared on behalf of the CITES (= Convention on international trade in endangered species of wild fauna and flora) Nomenclature Committee due to the growing number of species and far reaching changes in their taxonomy since Mertens’ time. This checklist was adopted as the standard reference for the genus *Varanus* by the 12th Conference of the Parties to CITES in November 2002. A necessary update of the latest checklist by Böhme (2003b) has recently been published by Koch *et al.* (2010b).

To date, Wolfgang Böhme’s research activities on monitor lizards of Africa and Southeast Asia have resulted



Fig. 14. Portrait of a painted cast of *V. salvadorii* with a total length of 255 cm. Photograph by **André Koch**.



Fig. 15. A painted cast of *V. komodoensis* on exhibit at the ZFMK. Photograph by **André Koch**.



Fig. 16. Attendees of the “First Multidisciplinary World Conference on Monitor Lizards” held at the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK) in Bonn, Germany, in September 1989. In front from left to right: Hans-Georg Horn, Brian Green, Dennis King, Gil L. Dryden, David B. Carter, and Max King. At the left margin behind H.-G. Horn is Hans-Otto Becker and behind D. B. Carter and M. King are Hugh I. Jones and Robert G. Sprackland in the background. Photograph by **Wolfgang Böhme**.

in nearly 80 publications (see Appendix 3), including the descriptions of 15 new monitor taxa (*viz.*, two subspecies, 12 species, and one subgenus; see appendix 1), and there is no end in sight to his scientific research and prodigious output of publications. The monitor lizard species described by Wolfgang Böhme and his collaborators in the last twenty-one years represent about 10% of the extant monitor lizard diversity, with further undescribed monitor taxa awaiting formal description (Koch *et al.*, unpubl. data).

Since most of the new monitor species described by Wolfgang Böhme and colleagues are native to the Indo-Australian Archipelago (only *V. yemenensis* originates from the Arabian Peninsula), it is the more amazing that he never set foot on Indonesian soil, or in any other country in Southeast Asia. The discoveries of several of these species in recent years were possible due to the fact that monitor lizards are favorite pets of reptile enthusiasts in Europe.

Today, Wolfgang Böhme belongs to the most successful students of the systematics and taxonomy of extant monitor lizards.

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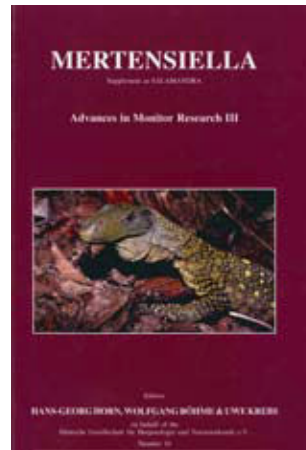


Fig. 17. The proceedings volume “Advances in Monitor Research III” (Mertensiella 16, published 2007) was co-edited by Wolfgang Böhme.



Fig. 18. Wolfgang Böhme’s (2003) checklist of the living monitor lizards of the world was adopted by CITES as standard reference of the genus *Varanus*.

colleague, and friend, as well as being an inspiring example in monitor lizard research for many years. He shared his passion and excitement for these fascinating giant reptiles with us and has crucially influenced our personal backgrounds in herpetology. We hope that Wolfgang Böhme will remain a part of the international monitor lizard community, continuing to be productive in publishing and supporting monitor lizard research for many years to come. We wish him all the best for future years in monitor research!

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Appendix 1: Chronological list of 15 new monitor lizard taxa described by Wolfgang Böhme and colleagues between 1988 and 2010.

- Varanus panoptes horni* Böhme, 1988
Varanus yemenensis Böhme, Joger & Schätti, 1989
Varanus finschi Böhme, Horn & Ziegler, 1994
Soterosaurus Ziegler & Böhme, 1997
Varanus melinus Böhme & Ziegler, 1997
Varanus caerulivirens Ziegler, Böhme & Philipp, 1999
Varanus cerambonensis Philipp, Böhme & Ziegler, 1999
Varanus macraei Böhme & Jacobs, 2001
Varanus juxtindicus Böhme, Philipp & Ziegler, 2002
Varanus zugorum Böhme & Ziegler, 2005
Varanus rainerguentheri Ziegler, Böhme & Schmitz, 2007
Varanus lirungensis Koch, Arida, Schmitz, Böhme & Ziegler, 2009
Varanus cumingi samarensis Koch, Gaulke & Böhme, 2010
Varanus palawanensis Koch, Gaulke & Böhme, 2010
Varanus rasmusseni Koch, Gaulke & Böhme, 2010

Appendix 2: List of monitor lizard taxa that were (re-)elevated to (original) species status, revalidated from synonymy, or synonymized with older names by Wolfgang Böhme and colleagues:

- Böhme (1991):
Varanus jobiensis Ahl, 1932 > revalidated from synonymy of *V. indicus*
Varanus karlschmidti Mertens, 1951 > recognized as junior synonym of *V. jobiensis*
- Böhme *et al.* (1994):
Varanus kalabeck Lesson, 1830 > declared a nomen dubium
Monitor douarha Lesson, 1830 > declared a nomen dubium
Varanus doreanus (Meyer, 1874) > revalidated from synonymy of *V. indicus*
- Böhme & Ziegler (1997a):
Varanus nebulosus (Gray, 1831) > elevated to species status
- Böhme & Ziegler (1997d):
Varanus ornatus (Daudin, 1803) > elevated to species status
- Koch *et al.* (2007):
Varanus salvator macromaculatus Deraniyagala, 1944 > revalidated from synonymy of *V. s. salvator*
Varanus salvator komaini Nutphand, 1987 > synonymized with *V. s. macromaculatus*
Varanus togianus (Peters, 1872) > re-elevated to original species status
Varanus marmoratus (Wiegmann, 1834) > re-elevated to original species status
Varanus nuchalis (Günther, 1872) > re-elevated to original species status
Varanus cumingi Martin, 1838 > re-elevated to original species status

Appendix 3: Chronological list of publications of Wolfgang Böhme about monitor lizards. Numbers in brackets indicate the position in his entire publication record since 1964.

- [90.] Böhme, W., J.P. Fritz & F. Schütte. 1987. Neuentdeckung einer Großeichse (Sauria: Varanidae) aus der Arabischen Republik Jemen. Herpetofauna 9(46): 13-20.

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3. [101.] Böhme, W. 1988. Zur Genitalmorphologie der Sauria: funktionelle und stammesgeschichtliche Aspekte. Bonn. zool. Monogr. 27: 1-176.
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