Morphological Studies on the Systematics of South East Asian Water Monitors (*Varanus salvator* Complex): Nominotypic Populations and Taxonomic Overview

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Abstract

The South East Asian water monitor, sometimes referred to as *Varanus salvator* (subspecies) complex, is the most widespread species among all varanids. Despite its extensive distribution in combination with conspicuous differences in colour pattern and scalation characters of recognized subspecies and other distinct isolated populations, the water monitor has not been reviewed taxonomically for more than 60 years. Because of the unresolved systematics of this subspecies complex morphological and morphometric characters were studied resulting in new data on the taxonomy of *V. salvator*. More than 330 specimens from 41 localities from nearly all parts of the species' range make up our database.

The present study deals with all nominotypic populations of *V. salvator* (Laurenti, 1768) and provides a general taxonomic overview over all other extant subspecies. The Philippine subspecies *marmoratus*, *nuchalis* and *cumingi* are herein resurrected to their original species status. Since the holotype of *V. salvator*, i.e. the model for Albertus Seba's (1735) illustration of the iconotype, has to be regarded as lost, a neotype is designated to serve the stability of zoological nomenclature. Moreover, the morphological distinctiveness of *V. salvator* from Sri Lanka is demonstrated resulting in the resurrection of the mainland form *V. s. macromaculatus* Deraniyagala, 1944 from synonymy. Consequently, *V. s. salvator* is solely restricted to the type locality Sri Lanka. The validity of the melanistic taxon *komaini* Nutphand, 1987 of continental South East Asia could not be confirmed morphologically. As a result, we regard *komaini* as a junior synonym of *V. s. macromaculatus*. In contrast, the melanistic taxon *togianus* Peters, 1872 from the Sulawesian region could be resurrected to species rank because of its unique and diagnostic morphology. However, the taxonomic status of other Sulawesi water monitor populations remains still unresolved.

Key words: Squamata: Varanidae, *Varanus salvator* complex, morphology, systematics, taxonomy, South East Asia.

Introduction

The South East Asian water monitor is not only among the largest squamate lizards in the world, but is also the most widespread species of all monitor lizards (Varanidae). Its vast distribution range extends from Sri Lanka in the West through continental South East Asia and the Sunda Islands east to the Moluccas and Luzon in the northern Philippines (see Fig. 3.2-1 in Auliya 2003: 280). Records from Australia and New Guinea require verification (Mertens 1963, Gaulke & Horn 2004).

Taxonomic history

Since the water monitor was described by Laurenti (1768) as *Stellio salvator* ten years after Carl v. Linné's fundamental 10th edition of his "Systema Naturae", numerous taxa have been described within the long lasting taxonomic history of this species. Currently most of them are considered to be synonyms of the nominotypic taxon *s. salvator* (Mertens 1963, Böhme 2003). Today, the validity of eight subspecies is accepted according to Böhme (2003). These are, in chronological order:

Genus *Varanus* Merrem, 1820
Subgenus *Soterosaurus* Ziegler & Böhme, 1997
Varanus salvator (Laurenti, 1768)
Subspecies:
V. s. salvator (Laurenti, 1768)
V. s. bivittatus (Kuhl, 1820)
V. s. marmoratus (Wiegmann, 1834)
V. s. cumingi Martin, 1838
V. s. nuchalis (Günther, 1872)
V. s. togianus (Peters, 1872)
V. s. andamanensis Deraniyagala, 1944
V. s. komaini Nutphand, 1987

Taxonomy and nomenclature of the water monitor was complicated by the circumstance that Linnaeus (1758) described his *Lacerta monitor* in 1758 but referred his description to plate 94, Figures 1 and 2 of Tome I and to the plates 86, Figure 2 (Fig. 1) and 105, Figure 1 of Tome II of Seba's "Thesaurus" (1734-65), respectively. According to Mertens (1942a), these tables definitely show two different but phenotypically similar species of varanids: the South East Asian water monitor, *V. salvator*, and the African Nile monitor, *V. niloticus*. Consequently, the name *monitor* Linné, 1758 is older

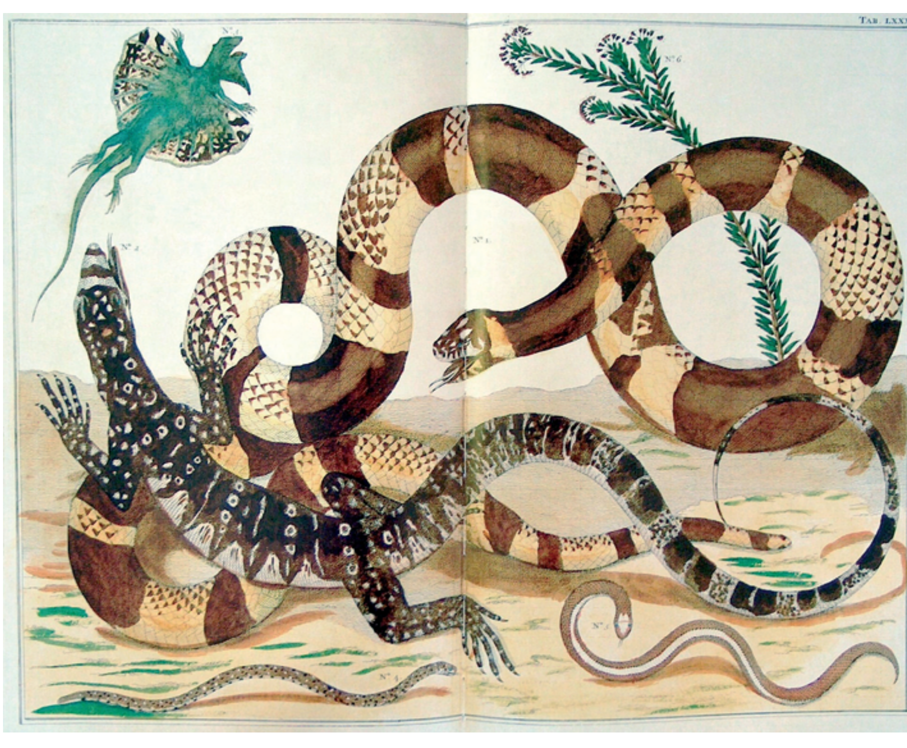

Fig. 1. Plate 86 of Albertus Seba's (1735) "Thesaurus", Tome II, showing the iconotype of *V. s. salvator* next to a green flying lizard (*Draco* sp.) and three snakes.

than *salvator* Laurenti, 1768 and would have had priority over the latter. But eventually Linné's *Lacerta monitor* was declared a *nomen rejectum* and thus an invalid taxon to retain nomenclatural clarity (ICZN 1959). This decision was discussed in detail by Mertens (1942a: 14, 1959a).

From the fact that Lacépède (1788) also listed *Lacertus Tupinambis* as a taxon comprising *V. salvator*, *V. niloticus* and South American teiids, Mertens (1942a-c) believed that the difference between varanids and teiids was not recognized by scientists of the late 18th century. Besides, Brygoo (1987) concluded that this binome has been erroneously created by Mertens (1942). In addition, Mertens (1942a) indicated that this error was also raised by Daudin (1802) who erected the genus *Tupinambis* for these two morphologically convergent lizard groups. Therein, *Tupinambis elegans* comprised the taxa *salvator*, *niloticus* and *bengalensis* whereas the water monitor was not recognized as a distinct species. Merrem (1820) was the first to make a taxonomic distinction between varanids and teiids. He erected the genus *Varanus*, however, Daudin's *Tupinambis elegans* remained unmodified.

Another old taxon in this context is *Tupinambis bivittatus* Kuhl, 1820 which occasionally represented *V. salvator* (cf. Schlegel 1837-44, Bleeker 1860a, b). First it was treated by Mertens (1942a-c) as a synonym of the nominotypic *V. salvator*, until he recognized differences in colour pattern between both and subsequently resurrected *bivittatus* as a subspecies of the water monitor (Mertens 1959b). Next to two other monitors, Cuvier (1829) listed a "Monitor à deux rubans" (= *V. salvator*) within his "Règne animal" and recognized the systematic relationships between varanids and the prehistoric mosasaurs. One year later, Wagler (1830) divided all monitors into three groups; Kuhl's *Tupinambis bivittatus* was listed in the new genus *Hydrosaurus* which was used for monitor lizards until the end of the 19th century (e.g., Fischer 1885). In 1838, Martin described *Varanus cumingi* from the Philippines. In the same year, Gray (1838) mentioned neither *V. salvator* nor the recently described taxon *cumingi* but listed *marmoratus* described by Wiegmann (1834) and Kuhl's *bivittatus*. Fitzinger (1843) however, exclusively assigned the taxon *salvator* to the genus *Hydrosaurus*. Noteworthy, also in the history of zoological taxonomy, is Schlegel's (1837-44) attempt of a first subspecific classification for geographic variations. This was, amongst others, the case in *Monitor bivittatus* var. *celebensis*, a synonym of the water monitor's nominate form from Sulawesi, formerly Celebes (Mertens 1942c, Böhme 2003).

Cantor (1847: 635) was the first to use the current combination *Varanus salvator* for the Asian water monitor which was eventually confirmed by Boulenger (1885: 314) in the "Catalogue of the Lizards in the British Museum (Natural History)" representing the last comprehensive work on monitor lizards of the 19th century. Due to the shape and the position of the nostrils and the tail, Boulenger (1885) distinguished four groups of varanids: herein, the third comprised *salvator* in addition to the taxa *cumingi, togianus* and *nuchalis*; the latter both were described in 1872 by Peters and by Günther, respectively.

However, these remarkable reptiles have been largely neglected by taxonomists since Robert Mertens' fundamental revision of the genus *Varanus* in 1942. The outcome of this work termed „Die Familie der Warane (Varanidae)" marked the origin of the so-called *Varanus salvator* subspecies complex, although the nominotypic taxon *V. s. salvator* was initially used by Mertens in 1937. Mertens (1942a-c) recognized the close morphological relationships between the two Philippine taxa *cumingi* and *nuchalis* with *V. salvator*. Thus, Mertens (1942a-c) decreased the original species status of these two taxa and additionally added *marmoratus* Wiegmann, 1834 – which was formerly treated in the synonymy of *V. salvator* (cf. Boulenger 1885, de Rooij 1915, Taylor 1922) – as well as the melanistic taxa *togianus* named after the Togian Islands off the coast of Central Sulawesi, and *scutigerulus* Barbour, 1932, from Borneo to this groupage of subspecies and allospecies. Since Mertens (1942a-c) had no specimen of *V. scutigerulus*, some years later however, he recognized that Barbour's (1932) description of *V. scutigerulus* was based on a melanistic specimen of the Rough-necked Monitor, *V. rudicollis* (Mertens 1950). The same is true for Mangili's (1962) description of the black *V. swarti* (Mertens 1964). Finally the *V. salvator* subspecies complex was completed (with the exception for *V. s. komaini*) by Mertens' (1963) „Liste der rezenten Amphibien und Reptilien: Helodermatidae, Varanidae, Lanthanotidae."

Unique autapomorphies in hemipenial morphology prompted Ziegler & Böhme (1997) to classify *V. salvator* into a new subgenus, *Soterosaurus* Ziegler & Böhme, 1997. Molecular data strongly support this decision and identify *Soterosaurus* as a monophyletic clade with *V. rudicollis* representing the adelphotaxon (Ast 2001).

The investigations of Ziegler & Böhme (1997) did not have consequences for the intraspecific systematics of *V. salvator*. Therefore, the current taxonomy of the water monitor is still largely based on the accounts of Mertens (1942a-c, 1959b, 1963). Although previous studies suggested that morphological and molecular characters obviously support a deeper differentiation within this (sub-)species complex and even within single presumed taxa (Mertens 1942a-c, Gaulke 1986, Gaulke 1991, Gaulke 1992a, b, Ast 2001), no taxonomic conclusions have been drawn to this point. The present study aims to resolve some of the taxonomic issues addressed within the *V. salvator* (sub-)species complex.

Material

We present data from 337 specimens representing 41 localities, covering almost the entire range of *Varanus salvator*. In addition, photographs of six specimens which could not be examined were included because of their taxonomic importance. These are: IM 2176 (Andaman Islands); IM 2174 (Andaman Islands), ZMB 470 (Luzon), BMNH 1946.9.1.17 (Philippines), BMNH 1946.8.31.5 (Mindanao), and SMF 23192 (Sumbawa).

The database represents those specimens from museum collections either examined by ourselves (293 specimens) or available through published material. Additional data of 38 specimens were adopted from Lauprasert (1999) and Brandenburg (1983).

Collection acronyms following Leviton et al. (1980) are mentioned in alphabetical order:

BMNH: The Natural History Museum, London, UK; IM: Indian Museum, Calcutta, India; MNHN: Muséum National d'Histoire Naturelle, Paris, France; RMNH: Nauurhistorisch Nationaalmuseum (Naturalis), Leiden, Netherlands; SMF: Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt a.M., Germany; ZFMK: Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany; ZMA: Zoölogisch Museum, Universiteit van Amsterdam, Netherlands; ZMB: Zoologisches Museum der Humboldt Universität, Berlin, Germany; ZMUC: Universitetets Zoologiske Museum, Kǿbenhavn, Denmark; ZSM: Zoologische Staatssammlung München, Germany; ZSI: Zoological Survey of India, Calcutta, India.

Preserved specimens examined are listed alphabetically by their locality under each relevant taxon within the 'results' chapter. Not included are Lauprasert's (1999) 19 specimens from Thailand. The number of specimens available from each locality is stated in parentheses. Additional information about sex, collector/donator, date and locality data are given if available. If more than one specimen is catalogued by the same collection number, these are mentioned alphabetically within the analyses. For specimens of RMNH and ZMA collections, the alphabetical order is adopted from Brandenburg (1983).

Methods

Selection of taxonomic units

In order not to compare just the single subspecies of the water monitor but also to examine intrasubspecific differentiations, which might be correlated by the distribution of their phenotypes, we divided the examined specimens into 15 operational taxonomic units (OTU). A short explanation for the composition is given, where necessary. Because of taxonomic and geographical considerations, the following populations were selected:

OTU 1 (15 spec.): Sri Lanka (all specimens of the type locality of *V. salvator*). OTU 2 (30 spec.): Continental South East Asia (all specimens of the South East Asian mainland are included in this OTU except the melanistic specimens from Thailand which are treated separately; see OTU 3). OTU 3 (3 spec.): Thailand *komaini* (only the melanistic *salvator* specimens from Thailand). OTU 4 (73 spec.): Sumatra (includes not just the Sumatran specimens but also those from the offshore islands Belitung, Bangka, Simalur, Weh, Nias and Batu). OTU 5 (57 spec.): Borneo. OTU 6 (55 spec.): Java. OTU 7 (10 spec.): Lesser Sunda Islands (specimens from this islands chain build one OTU, although differences in colour pattern are identifiable between single populations; see account about *V. s. bivittatus*). The Philippine taxa *marmoratus*, *nuchalis* and *cumingi* are each divided into two different OTUs, representing a light (spotted) and a dark form, due to obvious differences in colouration, which were already recognized by Gaulke (1992a, b). OTU 8 (13 spec.): Luzon/*marmoratus* light (contains the lightly coloured and spotted *marmoratus* populations from the islands of Luzon, Polillo, Calauit and Busuanga. Specimens from Mindoro were not available). OTU 9 (10 spec.): Palawan/*marmoratus* dark (all dark specimens from Palawan and Balabac are included in this OTU. Moreover, three specimens from the Sulu Islands [SMF 74295, ZMUC E141 and ZMUC E136] represent this OTU, although their taxonomic status as *V. s. marmoratus* remains unclarified; see chapter about *V. marmoratus*). OTU 10 (16 spec.): Panay/*nuchalis* light (contains the lightly spotted specimens of *V. s. nuchalis* from the islands of Panay, Negros and Cebu). OTU 11 (8 spec.): Masbate/*nuchalis* dark (includes the dorsally melanistic monitors from Masbate and Ticao). OTU 12 (8 spec.): Samar/*cumingi* dark (contains all *cumingi* specimens from the islands of Samar, Leyte and Bohol). OTU 13 (5 spec.): Mindanao/*cumingi* light (represents the population of Mindanao with more yellowish parts). OTU 14 (7 spec.): *Togianus* (among both *togianus* type specimens, the melanistic monitors from the main island of Sulawesi also describe this OTU). OTU 15 (18 spec.): Celebes (non-melanistic specimens from Sulawesi as well as the few from Sangihe [1 spec.], the Moluccas [2 spec. from Halmahera and Seram, respectively] and New Guinea [1 spec.] are included here).

Selection of morphological characters

Examination methods of standard morphological characters used in this study basically refer to the works of Brandenburg (1983) and Böhme et al. (1994). Tab. 1 describes 25 morphometric and meristic characters. Head measurements were taken with a transparent plastic ruler of 30 cm. Body and tail lengths of subadult and adult specimens were taken with a measuring tape. All measures were taken to the nearest 1 mm. Inaccurate measurements of SVL, TaL, ToL, A, B, C, G and H may result from body deformation of specimens due to their long time preservation or damage. Scale counts were taken using pins and with check marks. In juvenile specimens with very small scales, a binocular microscope or a magnifying-glass was used. In order to minimize the errors based on observer bias, all measurements and scale counts were made by AK. The scalation values of P may constitute the most unreliable data, as the dorsal head scales are of irregular shape and varying size. Therefore, this character was only applied under restricted circumstances. For the measurement of the scalation character Q, the

Tab. 1. List of morphological characters and abbreviations used in this study.

Number	Abbreviation	Definition of Characters
Morphometry		
1	SVL	Snout-vent length from tip of snout to cloaca
2	TaL	Tail length from cloaca to tail tip
3	ToL	Total length from tip of snout to tip of tail
4	A	Head length from tip of snout to anterior margin of ear
5	B	Head width (= maximum width between eyes and ears)
6	C	Head height above the eyes
7	G	Distance from anterior eye margin to middle of nostril
8	H	Distance from middle of the nostril to tip of the snout
9	Index 1(= TaL/SVL)	Relative tail length
10	Index 2 (= G/H)	Position of nostril between tip of snout and eye
11	Index 10 (= A/B)	Relative head length in relation to head width
12	Index 11 (= A/C)	Relative head length in relation to head height
Scalation		
13	P	Scales across head from rictus to rictus
14	Q	Scales around tail base
15	R	Scales around tail at approximately one third from base
16	S	Scales around midbody
17	T	Transverse ventral scale rows from gular fold to insertion of the hind legs
18	N	Gular scales from tip of snout to gular fold
19	TN (= T+N)	Ventral scales from tip of snout to insertion of hindlegs
20	X	Transverse dorsal scale rows from hind margin of tympanum to gular fold
21	Y	Transverse dorsal scale rows from gular fold to insertion of hind legs
22	XY (= X+Y)	Dorsal scales from hind margin of tympanum to insertion of hind legs
23	c	Supralabials exclusive the rostral scale
24	m	Scales around neck anterior to gular fold
25	U	Differentiated (= enlarged) supraocular scales

first continuously tail-spanning row of scales near the tail base was counted by excluding the first rows immediately after the cloaca, which form a non-continuous bow. The transverse scale rows on the ventral side to the insertion of the hindlimbs (character T) were counted until the last continuous row when the scales eventually decrease and are of irregular shape. In contrast to Brandenburg (1983) and Böhme et al. (1994), "N" instead of "n" abbreviates the number of gular scales from the tip of the snout to the gular fold, to avoid confusion with the standardised variable "n" for the number of specimens (see below). The values for the supralabial scales (character c) are provided for the right (r) and left (l) side, respectively. If only one value is provided, it represents the right side. This single value was doubled to estimate the total amount of supralabials for these specimens. The larger rostral shield was not included in all counts and estimates.

In addition to the morphological characters outlined above, all specimens of the *V. salvator* (sub-)species complex were studied for the following colour pattern characters:

I. Dorsal side:
(1) Colouration of back and dorsal side of limbs; (2) Number of transverse rows of light spots and blotches between the forelimbs and hindlimbs (This character can either be totally reduced or can consist of very well defined light ocelli with a dark centre); (3) Colour pattern of tail (Transverse rows of the back, if present, continue on the tail where they form a more or less well defined pattern of light and dark cross bands); (4) Colouration of head and neck (If present, number of dark transverse bands on snout; temporal stripe behind the eyes).
II. Ventral side:
(5) Colouration of venter (always lighter than dorsal side); (6) Number and definition of lateral pattern at transition to dorsal side (if present, usually as more or less well defined dark, V-shaped markings or dark cross band; sometimes as a net like pattern of dark surrounded light spots); (7) Colour pattern of limbs and tail; (8) Colour pattern of chin and throat (chin usually light with dark V-shaped markings at the lower jaw that may build cross bands; throat mostly light with dark markings of small dots, bigger blotches, V-shaped elements or cross bands).
III. Other characters:
(9) Colouration of the tongue.

Statistical analysis of morphological data

In our present study, data were analysed in using both univariate and multivariate analyses. The calculations of descriptive statistics (variation by minimum and maximum value, mean value, standard deviation) and multivariate methods for the analyses of scalation characters and proportion indices were made using Microsoft Excel© for Windows XP©, but basically with SPSS 11.5© for Windows. In all calculations and analyses the standardised value of $p < 0.05$ served as level of significance. Statistical and mathematical abbreviations used in this study are: n = number of specimens; x = mean value; s = standard deviation; F = standard error; df = degree of freedom.

In an explorative analysis all 15 OTUs were compared separately for each character by using boxplots to detect specimens with very high or low values o (i.e. values in a distance between 1.5 and 3 times the box length from the upper or lower margin of the box representing the interquartil) or extreme values x (i.e. values in a distance of more than 3 times the box length from the upper or lower margin of the box). The interquartil represents all values which comprise 50% of all data.

In this study unifactorial ANOVA (analysis of variance) was applied in order to identify significant differences within the mean values of single characters between distinct OTUs. This analysis of variance was made using 17 quantitively dependent variables (the characters) and one single independent variable (the locality or OTU, respectively) to prove the null hypothesis whether differences in the mean values could be explained by chance. The essential condition for this procedure is that all values belong to a normally distributed basic set. Although the ANOVA is not influenced by deviations from the normal distribution, all data have to be distributed symmetrically. To verify this precondition the data of each character were tested by the non-parametric Kolmogorov-Smirnov method (Tab. 2).

In cases where the mean values differed significantly, we used the post-hoc test Tukey-HSD (Honestly Significant Differences) to ascertain by means of multiple comparisons what mean values revealed statistical deviations. These mathematical procedures produced statistically significant trends for several OTUs which were similar in their particular parameter values by calculating homogeneous groups. The Levene-test which is inured against injuries of the normal distribution was applied to control the homogeneity of variances.

Not all characters listed in Tab. 1 proved to be useful to reveal diagnostic differences between the examined OTUs and subspecies, respectively. This was the case in the proportion indices 1, 10 and 11 and the scalation character U. Therefore, only about 70 % of all 331 examined specimens which provided data for all 13 statistically significant

Tab. 2. Kolmogorov-Smirnov test: Mean value and standard deviation of parameters under investigation for all *V. salvator* specimens examined.

Character	n	x	s	Extreme differences			Kolmogorov-Smirnov-Z	p
				absolute	positive	negative		
index 1	223	1.56	0.11	0.061	0.061	-0.042	0.904	0.387
index 2	324	2.24	0.28	0.072	0.072	-0.051	1.293	0.071
index 10	306	1.90	0.14	0.078	0.078	-0.045	1.364	0.048
index 11	302	2.70	0.22	0.071	0.071	-0.048	1.232	0.096
P	298	55.94	3.92	0.064	0.064	-0.060	1.104	0.174
Q	253	101.94	7.38	0.054	0.054	-0.040	0.864	0.444
R	253	58.20	6.68	0.057	0.042	-0.057	0.914	0.373
S	251	148.82	11.05	0.058	0.043	-0.058	0.916	0.371
T	254	84.98	4.28	0.083	0.083	-0.053	1.326	0.059
N	251	80.18	5.10	0.087	0.087	-0.037	1.385	0.043
TN	249	165.05	7.81	0.053	0.053	-0.039	0.831	0.495
X	258	34.95	6.62	0.053	0.036	-0.053	0.858	0.453
Y	257	105.39	13.54	0.570	0.031	-0.057	0.906	0.385
XY	257	140.40	19.02	0.060	0.042	-0.060	0.957	0.319
c	296	64.31	3.43	0.073	0.073	-0.059	1.252	0.087
m	250	100.38	10.02	0.063	0.063	-0.054	1.001	0.269
U	185	12.20	1.55	0.173	0.173	0.114	2.351	0.000

characters (i.e. index 2, P, Q, R. S, T, N, TN, X, Y, XY, m and c) were classified by using an algorithm in a concluding Hierarchic Cluster Analysis (HCA). The intention of this multivariate method is to show clusters of morphological similar specimens and taxa, respectively, by comparing their combination of meristic characters. However, this complex cladogram does not reflect direct phylogenetic information since it is solely based on phenotypic similarity.

Results

Multivariate analyses

Our results show that all characters describe a normal distribution, with exceptions of the characters index 10 ($p = 0.048$), N ($p = 0.043$), and U ($p < 0.001$). Tab. 2 also portrays statistical calculations for the parameters of all specimens examined. The Levene test reveals that index 2 ($p < 0.001$), index 11 ($p < 0.001$), T ($p = 0.019$), N ($p = 0.011$), TN ($p = 0.034$), X ($p = 0.024$), Y ($p = 0.015$), XY ($p = 0.004$), U ($p = 0.076$), and m ($p = 0.002$) display non-homogeneous variances (Tab. 3). The large sample size, however, generates suitable results from the ANOVA. These results are outlined in Tab. 4, demonstrating that only the mean values of index 10 ($p = 0.112$, $F = 1.493$) do not differ significantly between the OTUs. All mean values of index 10 are plotted in Figure 2. OTU 14 (*togianus*) and OTU 15 (Celebes) with mean values of 2.05 and 1.94, respectively, are the only values above the overall mean value while all other OTUs range close to 1.90. However, only the deviation of OTU 14 shows a significant difference ($p = 0.015$) from OTU 7 (Lesser Sunda Islands, $x = 1.80$). In contrast, the plot of character S shows significant differences between the OTUs examined (Fig. 2).

Tab. 3. Homogeneity of variances.

Parameter	Levene statistics	df 1	df 2	p
index 1	1.738	14	208	0.050
index 2	3.739	14	309	0.000
index 10	1.093	14	291	0.363
index 11	3.166	14	287	0.000
P	1.502	14	283	0.109
Q	0.896	14	238	0.564
R	1.529	14	238	0.101
S	0.804	14	236	0.664
T	1.996	14	239	0.019
N	2.127	14	236	0.011
TN	1.842	14	234	0.034
X	1.934	14	243	0.024
Y	2.050	14	242	0.015
XY	2.359	14	242	0.004
c	0.905	14	281	0.554
m	2.559	14	235	0.002
U	1.628	14	170	0.076

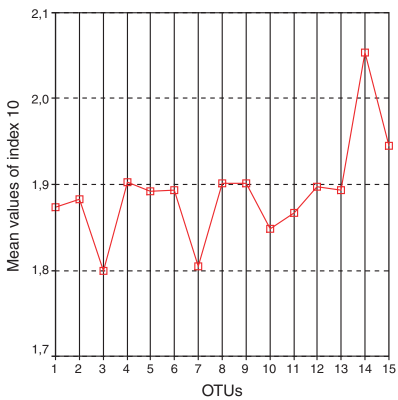

Fig. 2a. Distribution of mean values of proportion index 10 (= head length/head width) for the examined OTUs. No significant differences are recognizable.

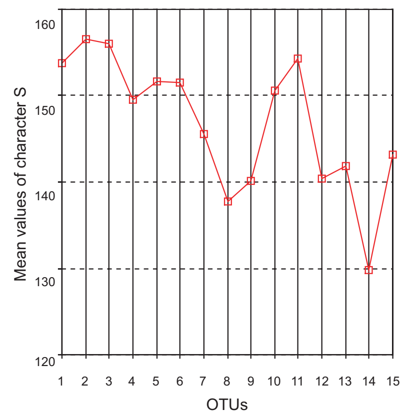

Fig. 2b. Distribution of mean values of scalation character S (= scales around midbody) showing statistical significances between the examined OTUs.

The statistical significance of characters between single OTUs calculated by the post-hoc test Tukey-HSD are discussed in detail below (see taxa accounts). For details, see Tab. 5 in Koch (2004).

Homogeneous groups

The Tukey-HSD method also provides a cluster analysis resulting in character-correlated homogeneous groups of OTUs with similar mean values. By this statistical procedure, the mean values are arranged hierarchically starting with the lowest value at the beginning of cluster I and ending with the highest value at the end of the last cluster. Between the first and the last cluster (maximum cluster VI), intermediate groups build a slice plane of the extreme outer clusters.

This multivariate analysis details that single characters lead to different results for the significance of the resulting clusters. Among the morphometric proportion indices examined, index 1, 10 and 11 clearly show only one or two clusters, hence indicating little or no significant difference between these data. Although index 2 builds five homogeneous groups, these five clusters overlap largely because all values describe a continuous succession.

In general, meristic scalation characters provide more useful parameters for the distinction of separate clusters (see Tab. 6 to 17 in Koch [2004] for more details about single parameters). Tab. 5 for instance represents the homogenous groups for parameter XY, the number of dorsal scales between tympanum and insertion of hindlimbs. Cluster I consists of OTU 11 (x = 108.13), OTU 10 (x = 11.13), OTU 8 (x = 115.15), OTU 13 (x = 119.20), OTU 12 (x = 119.38), and OTU 1 (x = 125.67), representing five in six Philippine OTUs in addition to Sri Lanka's water monitors. OTU 9 (*marmoratus* dark, x = 128.50), the sixth Philippine OTU, is placed in cluster II although the next higher value of OTU 14 (*togianus*, x = 139.00), *inter alia* placed at the beginning of cluster V (together with OTUs 2 to 7 and 15), indicates a significant larger interval. Within clus-

Tab. 4. Unifactorial ANOVA (analyses of variance): Statistical significances of characters between OTUs (Level of significance: $p < 0.05$).

Character		Square of sum	df	Mean of squares	F	p
index 1	Between OTUs	0.326	14	0.023	2.172	0.010
	Within OTUs	2.228	208	0.011		
	Total	2.554	222			
index 2	Between OTUs	8.754	14	0.625	11.988	0.000
	Within OTUs	16.117	309	0.052		
	Total	24.871	323			
index 10	Between OTUs	0.377	14	0.027	1.493	0.112
	Within OTUs	5.244	291	0.018		
	Total	5.620	305			
index 11	Between OTUs	1.318	14	0.094	1.949	0.022
	Within OTUs	13.862	287	0.048		
	Total	15.180	301			
P	Between OTUs	1467.325	14	104.809	9.604	0.000
	Within OTUs	3088.463	283	10.913		
	Total	4555.789	297			
Q	Between OTUs	2486.149	14	177.582	3.762	0.000
	Within OTUs	11235.962	238	47.210		
	Total	13722.111	252			
R	Between OTUs	4874.726	14	348.195	13.038	0.000
	Within OTUs	6355.993	238	26.706		
	Total	11230.719	252			
S	Between OTUs	8253.937	14	589.567	6.242	0.000
	Within OTUs	22291.633	236	94.456		
	Total	30545.570	250			
T	Between OTUs	1213.006	14	86.643	6.036	0.000
	Within OTUs	3430.852	239	14.355		
	Total	4643.858	253			
N	Between OTUs	1623.410	14	115.958	5.621	0.000
	Within OTUs	4868.877	236	20.631		
	Total	6492.287	250			
TN	Between OTUs	4277.844	14	305.560	6.581	0.000
	Within OTUs	10865.578	234	46.434		
	Total	15143.422	248			
X	Between OTUs	6687.826	14	477.702	25.465	0.000
	Within OTUs	4558.519	243	18.759		
	Total	11246.345	257			
Y	Between OTUs	26151.942	14	1867.996	21.765	0.000
	Within OTUs	20769.366	242	85.824		
	Total	46921.307	256			
XY	Between OTUs	58328.411	14	4166.315	29.380	0.000
	Within OTUs	34317.309	242	141.807		
	Total	92645.720	256			
c	Between OTUs	960.117	14	68.580	7.679	0.000
	Within OTUs	2509.663	281	8.931		
	Total	3469.780	295			
m	Between OTUs	6584.601	14	470.329	6.007	0.000
	Within OTUs	18400.535	235	78.300		
	Total	24985.136	249			
U	Between OTUs	90.198	14	6.443	3.099	0.000
	Within OTUs	353.402	170	2.079		
	Total	443.600	184			

Tab. 5. Homogeneous groups of OTUs for the mean values of parameter XY according to Tukey-HSD post-hoc test.

		Cluster				
OTUs	n	1	2	3	4	5
11	8	**108.125**				
10	16	**111.125**	111.125			
8	13	**115.154**	115.154			
13	5	**119.200**	119.200			
12	8	**119.375**	119.375			
1	15	**125.667**	125.667	125.667		
9	8		128.500	128.500	128.500	
14	7			139.000	139.000	**139.000**
3	3			141.000	141.000	**141.000**
7	10			142.500	142.500	**142.500**
2	14			143.286	143.286	**143.286**
15	17				144.765	**144.765**
5	18					**151.389**
6	54					**151.870**
4	61					**151.885**
p		**0.093**	0.101	0.090	0.170	**0.548**

Tab. 6. Number of used specimens for the Hierarchic Cluster Analysis (HCA).

Valid specimens		Missing specimens		Total amount	
n	%	n	%	n	%
230	69.9	99	30.1	329	100.0

ter V another step is obvious between OTU 15 (x = 144.76) and OTUs 4 to 6, the three Greater Sunda Islands (Sumatra, Borneo, and Java), with the highest mean values for character XY ($x \approx 152$).

A very similar pattern of Homogeneous groups as shown by character XY results from the mean values of parameter R (Tab. not presented here, see Koch [2004]), the scales around the tail at approximately one third of its length from the tail base to tail-tip. Here, it is cluster I (OTU 11, OTU 13, OTU 12, OTU 10 and OTU 8) and cluster VI (OTU 14, OTU 7, OTU 15, OTU 6, OTU 4, OTU 5, OTU 1, OTU 2 and OTU 3) with x = 46.38 to 53.67 and x = 57.57 to 64.67 respectively, creating two significantly distinct groups. OTU 9 (*marmoratus* dark), although providing a mean value of x = 54.88, is placed in clusters II to V. OTU 9, however, shows a higher similarity to cluster I than to cluster VI.

The statistical distinction between the six Philippine OTUs 8 to 13 and the remaining OTUs is more or less consistent through most considered parameters. On average the Philippine OTUs are characterized by lower scale counts, thus dominating cluster I of eight in 13 scalation features with more than 50 % of the OTUs included. This applies to parameter P (4 in 6 OTUs of cluster I), R (5/5), S (4/6), c (5/9) and m (5/9) as well as all three dorsal scale characters X (6/6), Y (6/7), and XY (5/6). This differentiation of scalation characters, particularly of the last three parameters is strongly correlated with the colour pattern of the Philippine OTUs, compared to the remaining populations of *V. salvator* (see taxonomic accounts).

Interestingly, OTU 1 (Sri Lanka), which represents the type locality of the water monitor is found in cluster I of seven (parameters P, Q, N, Y, XY, U, and c) of the 13 scalation characters examined. In contrast, other OTUs of *salvator* typical-populations (i.e. OTUs 2, 4, 5, 6, 7 and 15 including OTU 3, the melanistic specimens of continental South East Asia) are characterized by statistically higher mean values for characters P (7 in 10 OTUs of the last cluster), Q (6/10), R (8/9), S (7/11), N (4/6), X (8/9), Y (8/8), XY (8/8), c (8/11) and m (4/6). In addition, OTU 1 is found in the last cluster of eight (characters R, S, T, TN, X, U, c, and m) of the 13 scalation features. Apparently, the inconsistent overlap in parameters U and c (see also above) is caused by the similar mean values resulting in only three and four homogeneous groups respectively, with large slice planes between the first and last groups.

Consequently, the morphological similarity in pholidosis between Sri Lankan monitor lizards and the Philippine populations is generally higher than between the Philippine populations and the remaining OTUs.

Hierarchical Cluster Analyses (HCA)

Based on the 13 promising scalation and proportion characters, individual data of 230 specimens representing 69.9 % of 329 specimens are analysed using a first HCA. Of all 331 examined specimens of the *V. salvator* complex, SMF 74295 and ZMUC E141, both from the Sulu Archipelago, were excluded because of their uncertain taxonomic identification. However, a HCA dendrogram based on all specimens examined is illustrated in Koch (2004), as well as a simplified dendrogram, identifying all major tendencies and clades.

As previously indicated by the homogeneous groups for single parameters, the multi combined HCA analysis clearly confirms at least two morphologically divergent clusters within the *V. salvator* complex, reflecting the Philippine OTUs 8 to 13 and OTU 1 (Sri Lanka) as the phenetic sister group to the remaining *salvator*-typical OTUs including both *bivittatus* OTUs 6 and 7. Melanistic specimens of OTU 3 (Thailand *komaini*) are likewise located on this branch. A small cluster consisting of four specimens of *V. salvator togianus* of OTU 14 (RMNH 3178, ZMA 15437, ZMA 15460, and ZMA 15462) and three specimens of OTU 15 (RMNH 7222a, RMNH 15434b, and ZMA 15459) are basically positioned near the *salvator*-typical branch. This cluster of specimens is referred to as “Sulawesi”. The identification of ZMA 15459 as *V.* (*s.*) *salvator* refers to the ZMA catalogue. Regardless of their taxonomic status, all of these specimens listed originate from Sulawesi. Furthermore, RMNH 3173 from Luzon is located at the base of this clade.

Along the Philippine branch, *nuchalis* specimens of the respective OTUs 10 (light) and 11 (dark) form two intermingled but clearly defined phenotypic clusters. However, specimens of the OTUs 12 and 13 (*cumingi* dark and light) are hardly separated and those of the OTUs 8 and 9 (*marmoratus* light and dark) are allocated along the entire branch. Specimens of OTU 8 and OTU 9, however, show a trend towards a differentiation between both colour pattern-related OTUs of the taxon *marmoratus*. This trend is not evident among the remaining Philippine taxa *cumingi* and *nuchalis*. Moreover, specimens of OTU 8 (*marmoratus* light) show a higher similarity in their combined scalation characters to *nuchalis* specimens of OTU 10 (light) and OTU 11 (dark) than to other *marmoratus* specimens of OTU 9 (dark). In contrast, specimens of OTU 9 create a large cluster together with specimens of OTU 12 (*cumingi* dark) and OTU 13 (*cumingi* light), and those of OTU 1 (Sri Lanka).

Not mentioned are some specimens on the Philippine branch illustrated in Koch (2004), characterized as *salvator* typically-coloured, which do not belong to OTU 1. These are ZSM 132/1909 (Sumatra), ZFMK 26356 (Java), ZMB 29619 (New Guinea), RMNH 23440 (Simalur), ZMB 33837 (Lombok), RMNH 23441 (Simalur), ZSM 66/1996 (Borneo), ZMB 47902 (Ceram), ZSM 68/1996b (Sumatra), ZMA 15455 (Sumatra), and ZMB 53565 (Java). Also not considered in this simplified dendrogram is the aberrant position of both type specimens of the taxon *togianus* (ZMB 7388, 7389), as they are not located near the other melanistic specimens of OTU 14 at the root of the *salvator*-typical branch, but in the immediate vicinity of the *cumingi* specimens. This phenomenon and the disjunctive position of the specimens of OTU 1 within the Philippine branch of the first HCA dendrogram is discussed in the taxonomic account of *togianus*.

On the second main branch of the dendrogram, which reflects the *salvator* typically-coloured specimens, no large OTU-correlated clusters are found. Despite smaller groups of specimens of certain OTUs cluster together, specimens are generally distributed stochastically along the entire length of the right branch. This large cluster is intermixed with only a few Philippine specimens: SMF 43949 (Mindanao), ZMUC E136 (Sulu Archipelago), and ZMUC E78 (Balabac).

The HCA method was used to analyse a second data set using the same 13 parameters. This data set comprised 230 of the 329 specimens available (Tab. 6), including ZMUC E141 and SMF 74295 both from the Sulu Archipelago, but excluding ZMB 29619 from New Guinea, and ZMA 15459 from Sulawesi which were not examined by the authors. This analysis resulted in a dendrogram with slightly different topology, as shown in Figure 3. The most distinguishing difference to the first HCA applies to the clearer morphological separation between the Philippine taxa *cumingi*, *marmoratus* and *nuchalis* on the left branch and the *salvator* typically-coloured populations on the right branch. In this particular case, the *salvator* typically-coloured populations also include the specimens of OTU 1 (Sri Lanka), with the exception of ZFMK 19205. Although some groups of the nominate form and *V. s. bivittatus* specimens are easily identified, they do not generate geographically correlated clusters except those specimens of OTU 1, which represent the designated type locality. The three melanistic specimens of OTU 3 (Thailand *komaini*) are not included in Figure 3. On the right branch, some Philippine specimens are found. These are SMF 73949 (Mindanao), SMF 74740 (Balabac), SMF 73920 (Cebu), ZMUC E141, ZMUC E136 (both Sulu Archipelago), and ZMUC E78 (Balabac). Similarly, some *salvator* typically-coloured specimens from non-Philippine OTUs are located on the left branch. These are RMNH 23441 (Simalur), ZMB 33837 (Lombok), and RMNH 23440 (Simalur) forming a small cluster next to ZSM 132/1909 (Sumatra), ZFMK 26356 (Java), and ZFMK 19205 (Sri Lanka).

In this second simplified dendrogram, too, some specimens of OTU 14 (*togianus*) and OTU 15 (Sulawesi) cluster together. But in this instance, the clade consisting of only five Sulawesi specimens is positioned at the base of the Philippine branch (cf. Fig. 3). Three *togianus* specimens from OTU 14 (RMNH 3178, ZMA 15437, and ZMA 15462) are included, as well as two more or less *salvator* typically-coloured specimens from

Sulawesi (ZMA 15434b and RMNH 7222a). The three Sulawesi specimens ZMA 15459-61 are excluded from this analysis as they could not be traced by AK in the herpetological collection of the ZMA. According to the ZMA catalogue, ZMA 15460 and ZMA 15461 were identified as *V. togianus* by R. Sprackland. The alignment of the Philippine branch almost resembles the first HCA (not shown here, see Koch [2004]).

The same topology of two divergent clusters, the Philippine OTUs in opposition to the *salvator*-typical OTUs including Sri Lankan specimens of OTU 1, is confirmed by a third HCA analysis including 232 or 70.1 % of the 331 specimens examined. Although this dendrogram is not presented here, the "Sulawesi" cluster is again positioned basal to the Philippine main clade.

The results of these multivariate analyses clearly show the occurrence of two morphologically distinct clusters within the *V. salvator* complex. According to the OTUs defined above, these two clusters are independently generated by both (1) the compari-

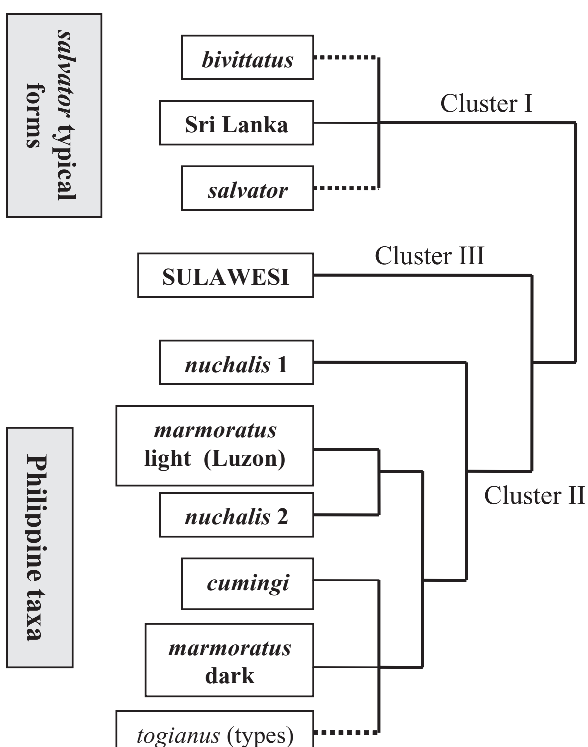

Fig. 3. Simplified HCA dendrogram based on scalation and proportion characters (see text) showing all major clusters and tendencies for the phenetic similarity of the taxa examined. The length of lines between clusters reflects approximately the phenotypic distance. Dotted lines indicate an irregular distribution of specimens, while full lines indicate relatively distinctive clusters.

son of mean values of the respective OTUs (i.e. homogeneous groups) and by (2) the comparison of single specimens' absolute values of the meristic characters examined (HCA). As already revealed by the HCA analysis and shown in Figure 3, several specimens of OTU 14 (*togianus*) and OTU 15 (Celebes) belong to either one of both main clusters, or occur as a separate third cluster at the basis of the Philippine branch:

Cluster I: OTU 1 + OTU 2 + OTU 3 + OTU 4 + OTU 5 + OTU 6 + OTU 7 + OTU 15 (partly)
Cluster II: OTU 8 + OTU 9 + OTU 10 + OTU 11 + OTU 12 + OTU 13 + OTU 14 (partly)
[**Cluster III**: OTU 14 + OTU 15 (both Sulawesian OTUs in part)]

In addition to these main clusters, single subgroups can be recognized along both branches:

Subcluster Ia: OTU 1
Subcluster IIa: OTU 12 + OTU 13
Subclusters IIb + IIc: OTU 10 + OTU 11

Morphological tendencies of single OTUs among the Philippine populations of the *Varanus salvator* complex have been mentioned above, such as the suggested distinction between light (or spotted) and dark coloured specimens of the *marmoratus* OTUs 8 and 9. Nevertheless, larger and well defined clusters of *marmoratus* specimens can not be recognized within the dendrogram. In contrast, most *cumingi* specimens represent one homogeneous cluster. Only two *cumingi* specimens are not positioned within Subcluster IIa, subsequently called "*cumingi*". These are SMF 73949 located within Cluster I, and SMF 73945 within Cluster II. Both these specimens originate from Mindanao. Subcluster IIa, however, is interspersed with specimens SMF 74741 (Balabac), SMF 73932 (Negros), and SMF 73917 (Cebu) all representing the remaining Philippine taxa *marmoratus* and *nuchalis*. In addition, specimens ZMFK 19205 (Sri Lanka), SMF 73907 (Calauit), SMF 73914 (Bohol), and SMF 74741 (Balabac) also compose this subcluster.

Specimens of the taxon *nuchalis* form two subunits, Subclusters IIb and IIc, which may be referred to as "*nuchalis* I" and "*nuchalis* II", respectively. Although both subclusters are intermingled with specimens of OTU 10 and OTU 11, specimens other than Philippine OTUs are not found here. Hence they represent the most homogeneous of all identified clusters. Of the four *nuchalis* specimens not positioned within these two subclusters, only one specimen, SMF 73920 from Cebu, is not located within the Philippine Cluster II.

Within the *salvator*-typical Cluster I, a Subcluster Ia, subsequently called "Sri Lanka", can be identified including all specimens of OTU 1 (type locality) used in this analysis with exception of ZFMK 19205 (Sri Lanka) which is located in Cluster II. Subcluster Ia comprises 16 specimens in total, but includes six specimens from other OTUs: ZMB 53565 (Java), ZMA 15455 (Sumatra), ZSM 68/1996b (Sumatra), ZMB 47902 (Ceram), ZSM 66/1996 (Borneo), and SMF 73920 (Cebu).

In the taxon accounts below the taxonomic consequences of these specific arrangements, and the alignment of specific specimens within the phenotype dendrograms is discussed.

Univariate analyses

Results of univariate analyses and statistical calculations are presented below under each taxon account and are summarised in Tab. 7 and Tab. 8. Tab. 2 outlines standard statistics for all characters examined. The significance of these values, however, is limited as they represent the combined mean values of all water monitor populations under investigation. The analysis of colour patterns in all OTUs reveals identical results as those obtained through the multivariate analyses.

Taxonomic interpretation

Univariate and multivariate analyses distinguish three different main clusters of OTUs (I to III) and three or four subclusters (Ia and IIa to IIc), respectively. These six clusters differ from each other by combinations of morphometric and meristic characters and colour pattern. Despite the fact that almost every cluster includes aberrant specimens (see above), their taxonomic integrity is not affected.

In this paper, the phylogenetic species concept (Wheeler & Platnick 2000) is adopted for allopatric populations and the biological species concept (Mayr & Ashlock 1991, Mayr 2000) for sympatric populations. On the basis of the results presented here, the main clusters are regarded as distinct species or a species group, respectively. In addition, subclusters are regarded as taxonomic units representing either a subspecies within a taxon or separate species within the species group. The following taxonomic interpretation is proposed: Cluster I corresponds to *V. salvator* sensu latu and comprises three morphologically similar subspecies: *s. salvator*, *salvator* ssp., and *s. bivittatus*. Subcluster Ia corresponds to *V. s. salvator* sensu strictu. Although scale counts of the Andaman populations were not available for analyses, the taxon *andamanensis* is also considered as a member of this group due to its colour pattern. Cluster II represents the Philippine taxa *marmoratus*, *nuchalis* and *cumingi* which were previously recognized as subspecies of *V. salvator* (sensu Mertens 1942a-c), but are, herein, raised to their original specific rank. Subcluster IIa corresponds to *V. cumingi*, subclusters IIb and IIc to *V. nuchalis*. Finally, Cluster III corresponds to the Sulawesian populations of water monitors. While the specific status of the taxon *togianus* is resurrected, the more or less *salvator* typically-coloured specimens of Sulawesi are left *incertae sedis* (see respective taxon account). The melanistic specimens of OTU 14 from Sulawesi, however, remain problematic as they differ in their ventral colour pattern from the *togianus* type specimens collected from Sulawesi's offshore Togian Islands. Specimens examined from the Philippines (OTUs 8 to 13), the Moluccas (included in OTU 15) and the Lesser Sunda Islands (OTU 7) also show a high variability in colour pattern. Due to the small sample size, particularly reflecting OTU 7 and 15, further investigations are required to solve their taxonomic status.

Systematics of the *Varanus salvator* complex

Starting with the nominotypic *salvator* Laurenti, 1768, the well established members of the *V. salvator* complex are defined according to the following criteria: first description (in parentheses exact pages), type material, type locality (optional), non-type material, diagnosis, variation, comparison with other taxa, range, and taxonomic comments.

The new morphological data set developed during the course of our study, strongly suggests that populations of the nominotypic subspecies require taxonomic partition,

Tab. 7. Comparison of main morphological characters in the *Varanus salvator* complex.

	s. salvator (n = 13-15)	*s. macromaculatus* (n = 92-163)	*s. bivittatus* (n = 63-65)	*salvator ssp.* (n = 17-18)
Index 2	2.17-2.91	1.82-3.46	1.67-2.88	1.90-2.64
	(x = 2.47)	(x = 2.30)	(x = 2.21)	(x = 2.17)
	(s = 0.19)	(s = 0.26)	(s = 0.25)	(s = 0.20)
P	48-56	49-65	47-63	50-68
	(x = 51.93)	(x = 57.43)	(x = 55,75)	(x = 57.33)
	(s = 2.10)	(s = 3.34)	(s = 3.12)	(s = 4.10)
Q	92-108	88-126	79-128	83-107
	(x = 98.73)	(x = 103.68)	(x = 102.70)	(x = 97.29)
	(s = 4.65)	(s = 7.40)	(s = 7.93)	(s = 6.42)
R	55-67	41-82	51-71	51-68
	(x = 62.13)	(x = 60.84)	(x = 59.60)	(x = 59.61)
	(s = 3.50)	(s = 6.42)	(s = 4.66)	(s = 4.89)
S	142-165	135-178	101-175	116-162
	(x = 153.73)	(x = 151.24)	(x = 150.58)	(x = 143.12)
	(s = 6.12)	(s = 9.05)	(s = 10.62)	(s = 10.92)
T	86-93	75-95	75-97	77-89
	(x = 89.85)	(x = 84.60)	(x = 84.78)	(x = 82.65)
	(s = 2.23)	(s = 4.06)	(s = 4.19)	(s = 3.30)
N	75-85	69-95	70-91	70-89
	(x = 78.85)	(x = 81.12)	(x = 80.00)	(x = 78.55)
	(s = 2.30)	(s = 5.53)	(s = 5.08)	(s = 4.90)
TN	164-172	152-187	145-183	149-172
	(x = 168.69)	(x = 165.71)	(x = 164.56)	(x = 160.76)
	(s = 2.59)	(s = 8.51)	(s = 7.14)	(s = 6.73)
X	26-36	29-50	28-52	30-47
	(x = 32.40)	(x = 37.75)	(x = 38.59)	(x = 37.28)
	(s = 3.16)	(s = 4.66)	(s = 5.02)	(s = 4.78)
Y	86-99	80-135	91-138	97-124
	(x = 93.27)	(x = 112.34)	(x = 111.78)	(x = 107.18)
	(s = 3.99)	(s = 10.22)	(s = 9.96)	(s = 7.77)
XY	118-135	116-182	123-189	127-171
	(x = 125.67)	(x = 150.20)	(x = 150.41)	(x = 144.76)
	(s = 5.34)	(s = 13.07)	(s = 13.40)	(s = 11.20)
m	94-109	81-127	82-122	73-115
	(x = 102.43)	(x = 102.34)	(x = 101.40)	(x = 96.82)
	(s = 4.57)	(s = 11.30)	(s = 9.22)	(s = 10.71)

togianus (n = 7)	*marmoratus* (n = 18-21)	*nuchalis* (n = 23-24)	*cumingi* (n = 12-13)
1.82-2.70	1.69-2.60	1.78-2.20	2.00-3.29
(*x* = 2.24)	(*x* = 1.99)	(*x* = 1.94)	(*x* = 2.30)
(s = 0.29)	(s = 0.19)	(s = 0.12)	(s = 0.43)
44-58	46-65	50-61	47-57
(*x* = 51.71)	(*x* = 54.80)	(*x* = 54.39)	(*x* = 49.92)
(s = 4.39)	(s = 4.75)	(s = 2.74)	(s = 2.99)
87-112	90-119	91-110	90-109
(*x* = 97.57)	(*x* = 101.10)	(*x* = 100.00)	(*x* = 102.38)
(s = 9.00)	(s = 8.19)	(s = 5.18)	(s = 5.24)
54-63	48-65	44-61	44-55
(*x* = 57.57)	(*x* = 54.15)	(*x* = 48.71)	(*x* = 49.25)
(s = 3.05)	(s = 4.68)	(s = 4.04)	(s = 3.44)
120-142	115-178	137-169	130-152
(*x* = 129.86)	(*x* = 138.78)	(*x* = 153.04)	(*x* = 140.92)
(s = 8.25)	(s = 13.32)	(s = 9.74)	(s = 7.32)
77-82	78-95	84-94	77-87
(*x* = 79.00)	(*x* = 86.48)	(*x* = 87.75)	(*x* = 82.54)
(s = 1.83)	(s = 4.90)	(s = 2.94)	(s = 2.54)
68-77	76-94	74-84	72-90
(*x* = 73.14)	(*x* = 82.70)	(*x* = 79.78)	(*x* = 78.46)
(s = 2.91)	(s = 4.60)	(s = 3.00)	(s = 4.68)
145-157	155-183	159-176	149-175
(*x* = 152.57)	(*x* = 169.00)	(*x* = 167.52)	(*x* = 161.00)
(s = 4.43)	(s = 7.73)	(s = 4.88)	(s = 6.15)
31-42	24-33	19-32	21-33
(*x* = 34.43)	(*x* = 28.81)	(*x* = 23.33)	(*x* = 27.69)
(s = 4.20)	(s = 2.80)	(s = 2.93)	(s = 2.81)
86-130	79-118	72-103	86-103
(x = 104.57)	(x = 91.43)	(x = 86.79)	(x = 91.62)
(s = 14.56)	(s = 10.41)	(s = 7.92)	(s = 4.87)
117-172	106-145	94-135	114-136
(*x* = 139.00)	(*x* = 120.24)	(*x* = 110.13)	(*x* = 119.31)
(s = 18.34)	(s = 10.63)	(s = 10.10)	(s = 6.63)
78-107	72-120	87-106	86-104
(*x* = 86.86)	(*x* = 99.32)	(*x* = 98.33)	(*x* = 96.70)
(s = 10.25)	(s = 10.54)	(s = 5.27)	(s = 5.42)

Tab. 8. Comparison of colour pattern in the *salvator*-typically coloured subspecies of the *V. salvator* complex including *V. togianus* (± means 'more or less'). Note: The colour patterns of the Philippine taxa are not presented here.

a. Dorsal side: Diagnostic colour pattern characters.

Taxon	Head	Neck	Back	Tail
V. s. salvator (Sri Lanka, probably N-India)	dark brown to black, with 2-3 light cross-bands on snout	black, in juveniles with irregular small light dots	black, 5-6 transverse rows of ocelli, with thin lines of light dots in between	black, with thin and broad light cross-bands, more distinctive in juveniles
V. s. macromaculatus (SE Asia, Sumatra, Borneo)	dark, with 1-3 light cross-bands on snout	brown, with or without indistinctive light dots	dark, with 4-7, ± distinctive transverse rows of spots or ocelli, mostly with light dots or marbling in between	dark, proximad with transverse rows of light spots or ocelli, distad fused to ± distinctive light crossbands
V. s. andamanensis (Andaman Isl.)	dark, juveniles with 2 light crossbands on snout	dark, probably with single light scales or light bordered scales	dark, with small dots, in juveniles sometimes forming up to 6 transverse rows	dark, with small dots or scales arranged irregularly or in crossbands
V. s. bivittatus (Java, Lesser Sunda Islands)	dark, with up to 3 ± distinctive light cross-bands on snout	brown, mostly with lighter markings, laterally longitudinal dark stripes or spots	dark, with 4-6 transverse rows of light spots or ocelli, spots of first rows sometimes fuse to cross-bands	dark proximad with transverse rows of light spots or ocelli, distad fused to ± distinctive light crossbands
V. salvator ssp. (Sulawesi, Moluccas)	dark, with 2-3 light cross-bands on snout	dark, with many single light scales or dots	dark, with light dots, or 2-5 transverse rows of light spots or ocelli	dark, proximad light mottled, distad with ± distinctive light crossbands
V. togianus (Togian Islands, Sulawesi)	black, with 1-2 light cross-bands on snout	dark brown to black	black, posterior margins of many scales whitish	black, without light crossbands

based on a clear definition of the type locality and morphological features characterizing the typical population.

Varanus salvator salvator **(Laurenti, 1768)**

Stellio salvator Laurenti, 1768. Specimen Medicum exhibens Synopsin Reptilium emendatam cum Experimentis circa venena et antidote Reptilium Austriacorum, Vienna, 214 pp. [p. 56].

Synonymy:
1758 Lacerta monitor part. Linnaeus, Syst. nat., 10(1): 201. – Type locality: In Indiis (*Nomen rejectum* according to ICZN 1959, Opinion 540).

1947 *Varanus salvator kabaragoya* Deraniyagala, Proc. 3rd ann. Sess. Ceylon A s-soc, Sci., 2 (Abstr.): 12. – Type locality: "Ceylon" = Sri Lanka.

Type material:
Within the description of *Stellio salvator* Laurenti (1768) did not refer to any specimen that constituted his new taxon. Instead, he referred to the illustration of Figure 2, Tab. 86 in Tome II of Seba's (1734-65) "Thesaurus" which shows a monitor lizard next to a green flying lizard (*Draco* sp.) and three snakes of different size (Fig. 1).

Although Mertens (1959b: 234) recognized that a type specimen of the taxon *salvator* Laurenti, 1768 was unknown, he did not designate a neotype. According to Article 73 of the ICZN (1999) code, the specimen depicted at Tab. 86 of Seba's (1735) Tome II, has to be regarded as the (icono)type of *V. salvator*. It can easily be identified as a monitor lizard by (i) the long neck, (ii) its bifurcate tongue, and (iii) the light-coloured pineal organ dorsally on the head. In addition, it shows the typical combination of colouration characters as declared by Laurenti (1768) in his description for the taxon *salvator*.

In comparison with the material examined during the course of our study, Laurenti's original specimen(s) illustrated was apparently juvenile or subadult.

Type locality:
In Laurenti's short description the type locality is "Habitat in America." Mertens (1959b) designated "Ceylon" (Sri Lanka) as the type locality due to the identical colour pattern of both, the specimens from Sri Lanka he examined and the specimen illustrated in Seba's (1735) "Thesaurus". Mertens (1959b) based his conclusion on the examination of a single specimen (SMF 48094, see his material paragraph), although later he mentioned four specimens from Sri Lanka (Mertens 1959b: 236).

Based on our findings, Mertens' (1959b) designation of the type locality Sri Lanka can be confirmed without exception, although his decision was not conform to Article 76 of the ICZN (1999) code because he did not designate a neotype. Nevertheless, there is an unambiguous agreement between the colour patterns shown by the monitor lizard depicted by Seba (1735) and the 15 voucher specimens from Sri Lanka deposited at the ZFMK collection (ZFMK 19205, 18092, 22091-99). Accordingly, the specimen which was illustrated by Seba's (1735) Figure 2 of Tab. 86 in Tome II represents the holotype of *Stellio salvator*.

Designation of a neotype:
Despite enormous efforts several authors had to detect the present storage location of specimens of Albertus Seba's cabinet of natural history (e.g., Oldfield 1892, Engel 1961, Boeseman 1970, Thireau et al. 1998), this particular specimen remains untraceable (Mertens 1959b).

Consequently, Laurenti's (1768) specimen of *Stellio salvator* must be regarded as definitively lost. The designation of a neotype is warranted from the following arguments (see Art. 75, ICZN 1999): (1) After partition of the formerly nominotypic taxon *V. s. salvator*, an unequivocal definition of the identity of this taxon seems necessary to avoid considerable taxonomic confusion; (2) The Latin original description by Laurenti (1768) provides insufficient information to diagnose the name *salvator*; and (3) The type locality of the nominal taxon *Stellio salvator* Laurenti, 1768, needs to be definitively fixed.

In congruence with Mertens' (1959b) designation of the type locality and the reasons mentioned above (see 'Type locality'), we think it appropriate to select a Sri Lankan specimen as the neotype, which is designated below.

Neotype: ZFMK 22092 (Fig. 4), juvenile, "Ceylon" (= Sri Lanka) collected by B. Schulz, March 1978, donated by B. Schulz, April 1978.

Description of neotype:
Habitus slender. Total length 499 mm (SVL = 195 mm, TaL = 304 mm), Head length 37 mm. Head width 19 mm. Head height 14 mm. Nostrils much closer to the tip of the snout than to eye (index 2: 2.80). Tympanum oval-shaped. Tail largely compressed laterally.

Scalation of body heterogeneous. Scales of head irregularly pentagonal or hexagonal. Scales arround eye granulous. 6/6 enlarged supraoculars. 65 (31/34) supralabials, plus one rostral. Scale covering the pineal organ likewise enlarged, irregularly pentagonal with a round whitish blotch in the center. Scales of nape smooth, oval, slightly larger than dorsals. Limbs covered with smooth, oval scales. Caudal scales rectangular, above slightly keeled, below with prominent keels, double as large as dorsally. The two median rows of dorsal tail scales form a double crest starting from the base. Gular scales smooth, oval, increasing in size to gular fold. Ventrals of belly rectangular, arranged in regular transverse rows. Scales around cloaca, on ventral side of hindlimbs, and first fifth of tail bear an apical pit posteriorly. Remaining scale counts of neotype and proportion indices as follows: P: 56, Q: 103, R: 63, S: 154, T: 90, N: >78 (some scales on chin missing), TN: >168, X: 32, Y: 99, XY: 131, m: 103, index 1: 1.56, 10: 1.95, 11: 2.64.

Colour pattern (in preservative): black dorsal side, dorsum with five transverse rows of whitish ocelli with dark centre, first row consists of seven ocelli, interspaces with thin transverse rows of small dots. The tail is black and white striped on the dorsal side, where a thin white line separates two dark blocks, while the thicker white parts of the first third of the tail are interspersed with numerous dark scales. On the last third of the tail length the twofold dark parts fuse to one. Head dark, intermixed with several pale scales. Three light crossbands on snout. Tongue bluish-grey. Granular scales around eyes whitish. Whitish temporal streak extending from eye to tympanum. Nape dark, dotted with numerous whitish scales. Hindlimbs with whitish spots consisting of four to five scales, forelimbs two to five scales. Digits with light crossbands of two to three scale rows, first scale after each claw always with large white dot. Ventrally whitish, chin with four distinctive black crossbands. Throat and breast either black banded. Belly with eight black V-shaped markings. Tail with alternating whitish and black crossbands.

Fig. 4. Dorso-lateral view of the juvenile neotype of *V. s. salvator* (ZFMK 22092) from Sri Lanka.

Other material (14): Sri Lanka: ZFMK 19205 (southern vicinity of Colombo, coll. P. Kornacker, VIII. 1974, don. P. Kornacker, II. 1977); ZFMK 18092 (Colombo, coll. de Silva, 1975, don. P. Kornacker, V. 1976), ZFMK 22091 (juv.; Ceylon, coll. B. Schulz, III. 1978, don. B. Schulz, IV. 1978), ZFMK 22093-99 (juv.; Ceylon, coll. B. Schulz, III. 1978, don. B. Schulz, IV. 1978), ZFMK 41890 (Northern Ceylon, Ambepussa, coll. P. Kornacker, IV. 1974, don. P. Kornacker, XI. 1984), RMNH 3191a, b (2 juv.; Colombo, coll. Diard, 1859), ZSM 210/1912 (ad.; Colombo, coll. M. Hünten, April 1911).

Diagnosis:
The population of Sri Lanka, representing the designated and confirmed type locality of the water monitor, is distinguishable from the subsequently listed taxa of the *V. salvator* complex by having the following combination of characters: (1) a homogeneous black dorsal background colour with five to six transverse rows of whitish spots or ocelli between the forelimbs and hindlimbs. Another important feature of colour pattern on the dorsum are thin lines of whitish dots between the transverse rows of ocelli which are unique among juveniles of the population of Sri Lanka; (2) two to three light cross bands on the snout (particularly distinct in juveniles); (3) a V-shaped colour pattern of seven to eight long pointed dark bars on the whitish ventral side, mostly bearing a small white centre. These dark markings are also pronounced on chin, throat and underside of limbs to the extent that they often meet on the ventral mid-line; (4) the nostrils are positioned nearer to the tip of the snout (index 2: 2.17-2.91, x = 2.47, s = 0.19) compared with most other *V. salvator* populations; as well as by (5) on average low scale counts around the head from rictus to rictus (characters P), (6) around the base of the tail (character Q), (7) from the tip of the snout to the gular fold (character N), and (8) along the dorsal side (character XY). For single values see Tab. 7.

Variation:
The longest Sri Lankan in alcohol preserved specimen which was examined (ZFMK 41890) measures 1127 mm (SVL = 537 mm, TaL = 590 mm), with the tail-tip missing, and the longest varanid ever recorded also originates from Sri Lanka. This specimen had a total length of 3210 mm (Randow 1932).

Proportion indices for *V. s. salvator*: index 1: 1.48-1.80 (x = 1.61, s = 0.08), index 2: 2.17-2.91 (x = 2.47, s = 0.19), index 10: 1.70-2.27 (x = 1.87, s = 0.14), index 11: 2.31-3.09 (x = 2.69, s = 0.17). Scalation characters: 10 to 13 enlarged supraoculars on both sides; 60 to 70 supralabials excluding the rostral (cf. Tab. 7 for further data).

The colour pattern of juveniles resembles that of the neotype. Background colour of the dorsal side is black with five to six transverse rows of whitish round spots or ocelli between forelimbs and hindlimbs. Small light dots consisting of one to five scales forming distinctive parallel rows in between the transverse rows. Interestingly, a specimen from Orissa, northeastern India depicted by Whitaker & Whitaker (1980) shows the characteristic thin lines of dots on the back, as is characteristic for the Sri Lankan specimens. Tail vividly marked with alternating whitish and black stripes; anteriorly black parts of the tail are divided by a thin whitish line. Limbs whitish dotted (forelimbs 1-5, hindlimbs 1-6 scales), sometimes arranged in distinctive transverse rows. Head dark brown to black with two or three whitish crossbands on the snout. Nape black with few ill-defined bright spots. Ventrum whitish with six to eight distinct long pointed black bars which tend to meet towards the tail. These black bars sometimes occur with light longitudinal centres. Limbs with long distinctive black pointed bars that sometimes meet on the ventral midline. Tail anteriorly with black crossbands defining whitish rectangles, posteriorly distinct alternating whitish and black stripes. Throat whitish with more or less distinctive black crossbands, sometimes interrupted. Chin with four to five long black pointed bars, occasionally forming crossbands.

In adults the contrast of whitish and black markings, especially on the tail is less distinctive. The ventral dark bars or crossbands fade and dorsal spots and ocelli become indistinct. Additionally, the light thin lines of juveniles on the dorsal side disappear on adults.

Comparison with other taxa:
Compared with the rich contrasted colouration of the Sri Lanka population, water monitors examined from Continental South East Asia (Thailand, Vietnam, and the Malayan Peninsula) do not show this clear colour pattern, instead reveal an irregularly light dotted brown background colour with more or less well defined whitish ocelli. *V. s. andamanensis* shows strongly reduced transverse rows on the back. The broad stripe along the side of the neck characteristic for *V. s. bivittatus* is absent in monitors from the type locality, and the Philippine taxa exhibit peculiar colour features as, for instance, reduced transverse rows on the dorsum or intensive yellow markings (see taxa accounts).

With regard to scalation characters and morphometric features, *V. s. salvator* from Sri Lanka exhibits on average lower scale counts for characters P, Q, N, Y, and XY compared with scale counts characteristic of the continental South East Asian monitor lizards (for values see Tab. 7). In contrast, the latter population shows average higher values for character P (53-64, x = 56.79, s = 2.99), character Q (97-121, x = 109.62, s = 5.95), character N (82-95, x = 87.64, s = 3.97), character Y (94-127, x = 107.50, s = 8.93) and character XY (127-168, x = 143.29, s = 10.91).

By way of comparison with the remaining *salvator*-typically coloured populations excluding *bivittatus* (i.e. Sumatra, Borneo, and "Sulawesi" and the Moluccas), statistical differences can be observed for index 2 from Sumatra (1.82-2.53, x = 2.18, s = 0.17) and "Sulawesi" (for values of *V. salvator* ssp. from Sulawesi and the Moluccas see Tab. 7); character P from Sumatra (49-65, x = 57.00, s = 3.50), Borneo (51-64, x = 58.14, s = 3.23) and "Sulawesi"; character S for "Sulawesi" (not strictly significant, p = 0.05); character T from Sumatra (75-94, x = 83.70, s = 3.79), Borneo (79-92, x = 85.11, s = 3.48) and "Sulawesi"; character Y from Sumatra (80-135, x = 113.36, s = 11.10), Borneo: 95-123, x = 114.00, s = 7.03) and "Sulawesi"; and character XY from Sumatra (116-182, x = 151.89, s = 14.11), Borneo (125-172, x = 151.39, s = 9.74) and "Sulawesi".

In comparison to the *V. s. bivittatus* populations numerous significant differences exist for index 1 (1.48-1.80, x = 1.61, s = 0.08 versus 1.29-1.70, x = 1.51, s = 0.08), index 2, as well as scalation character P, T, X, Y, and XY.

In addition, *V. s. salvator* is statistically distinguishable from *V. togianus* by scalation features S, T, TN, and m.

Furthermore, water monitors of the Sri Lankan type locality differ significantly from the three Philippine taxa *marmoratus*, *nuchalis* and *cumingi* with regard to characters index 2 for both forms of *V. marmoratus* and *V. nuchalis*, respectively; character P for the dark form of *V. marmoratus* (53-65, x = 57.50, s = 3.96); character R for both phenotypes of all three Philippine taxa; character S for *V. marmoratus* and *V. cumingi*; character T for both forms of *V. cumingi* as well as characters X and XY for all *V. nuchalis* populations. For missing values of the relevant taxa see Tab. 7.

Range:
Based on the data presented here, the nominotypic subspecies *V. s. salvator* is restricted to the type locality Sri Lanka (Fig. 5).

Taxonomic comments:
According to O'Brien & Mayr (1991) a subspecies is characterized by (1) a unique geographic range or habitat, (2) a group of phylogenetically concordant phenotypic characters, and (3) a unique natural history relative to other subdivisions of the species. On the basis of these biological criteria the morphologically differentiated populations of Continental South East Asia (OTU 2), including the melanistic specimens of the taxon *komaini* (OTU 3) and those of Sumatra (OTU 4) and Borneo (OTU 5), are considered as distinct subspecies of the *V. salvator* complex. On the basis of this conclusion, the validity of the synonyms available for these populations is discussed in chronological order:

Lacerta monitor Linnaeus, 1758 (Type locality: "in Indiis")
In 1959 Linné's *Lacerta monitor* was declared a *nomen rejectum* by the International Commission on Zoological Nomenclature (ICZN 1959).

Stellio salvator Laurenti, 1768 (Type locality in error: "America")
As discussed by Mertens (1959b) and confirmed during the course of this study, the specific epithet *salvator* used as the nominotypic taxon *s. salvator* is restricted to the designated type locality Sri Lanka.

Tupinambis elegans Daudin, 1802 (type locality in error: "Surinam")
This binome also represents a group of several species based on the varanid taxa *salvator*, *bengalensis* and *niloticus* (Mertens 1942a-c).

Tupinambis exilis Gray in Griffith (1831) (Type locality: "India")
This taxon is often incorrectly cited as *Monitor exilis* (e.g., Mertens 1942, Bennett 1998, Böhme 2003). On page 25 of his "Synopsis of the species of the class Reptilia", Gray (1831) provided a short description of the "Two Banded Monitor, *Mon. bivittatus*, nob. *Tupinambis bivittatus*. Kuhl" therein stating after the locality "India" that juveniles ("Jun.") are "more spotted". He closed this short paragraph with "*Tup. exilis*. Reinw. Mss. Mus. Brit." Therefore, it is reasonable to conclude that the (juvenile) type specimen was collected by Mr. Reinwardt for the British Museum in London (Mertens 1942: 245). In contrast to this assumption, there is no specimen listed among the 25 preserved *V. salvator* collected by Reinwardt in Boulenger's (1885) "Catalogue of the lizards in the British Museum." In addition, the herpetological collection according to Boulenger (1885), did not include a single specimen from India. Apparently Boulenger (1885) was also not aware of the name *exilis* Gray, 1831, because he added the name *elegans* Gray, 1828, to the synonymy of the water monitor, while Daudin's former binome *Tupinambis elegans* published in 1802 was not mentioned.

The situation became more complicated when Gray (1838: 394), in his "Catalogue of the Slender-tongued Saurians", placed the taxa *Stellio salvator* Laurenti, 1768, *Tupinambis bivittatus* Kuhl, 1820, *Varanus vitattus* Lesson, 1834 (incorrectly written as *Uaranus vitattus*), and *Monitor elegans* Gray, 1828, after Wagler's (1830) *Hydrosaurus bivittatus*. Demonstrably, Gray (1838) simply listed all previous synonyms of the water

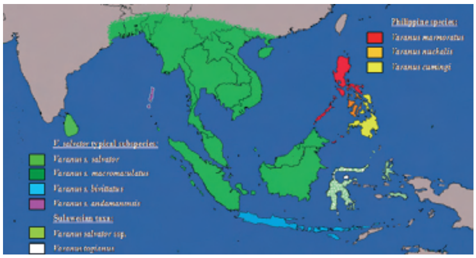

Fig. 5. Distribution of the members of the *V. salvator* complex according to the morphological results presented here.

monitor without giving any taxonomic priority. More confusingly, on this occasion, his *Tupinambis exilis* was listed in the end and was referred to Reeve. Besides, it obviously should have been restricted to juvenile specimens ("Young – *Tupinambis exilis* Reeve"). Finally, Java was added to the distribution of the above listed taxa.

In sum, *exilis* Gray, 1831 must be regarded as a *nomen nudum* due to the lack of a type specimen and diagnostic characteristics. This name, therefore, is unavailable for the taxonomy of the *V. salvator* complex.

Varanus vitattus Lesson in Bélanger (1834) (Type locality: Indian Subcontinent and islands at the mouth of the Ganges River)

Obviously, Lesson (1834) recognized the similarity between his *Varanus vitattus* and Kuhl's *Tupinambis bivittatus* when he placed the latter (cited as *Lacerta bivittata*) immediately after his new specific epithet, followed by a question mark. Consequently, Duméril & Bibron (1836) placed Lesson's taxon in the synonymy of *Varanus bivittatus*, likewise Laurenti's *Stellio salvator*. Gray (1845) was the first to allocate *vitattus* Lesson, 1834, to the synonymy of *salvator*, which was at that time included in the genus *Hydrosaurus*.

According to Mertens (1942: 245, 1963: 16), the type locality is restricted to the islands near the mouth of the Ganges River. Lesson (1834), however, reported that this species also inhabited the deep forests of the Indian Subcontinent ("Ce *Varanus* habite les profondes forêts du Continent indien et les îles qui sont placées aux embouchures du Gange."). Although Lesson (1834) provided measurements of a specimen, he did not mention any type specimen deposited in the Paris collection (MNHN). This omission was confirmed by Brygoo (1987: 36). An anonymous handwritten note declaring the specimen MNHP 2189 (1519), 212 (120) mm, V 17 as the type specimen for *vitattus*, is with certainty a mistake, as the locality for this particular specimen was given as Ambon. The remaining data also do not correspond (Brygoo 1987).

Since no type specimen exists, the taxonomic interpretation of Lesson's (1834) description remains problematic because he listed features of colour patterns characteristic for both populations: that of the type locality Sri Lanka (black background colour; ventral side of legs with black stripes) and those of the South East Asian mainland (whitish dotted interspaces between transverse rows on the dorsum; 'yellowish' coloured ventrum).

These inconsistencies and their explanations, together with the description of the above-mentioned juvenile specimen collected in the proximity of the type locality in northern India, forces the conclusion that the taxon *vitattus* Lesson, 1834 should be regarded as a *nomen dubium* due to the lack of a type specimen and its ambiguous description. Consequently, the name *vitattus* Lesson, 1834 is not available.

Varanus binotatus Blyth, 1842 (Type locality: "India")
Blyth (1842) mistakenly credited the description of *Varanus binotatus* to Duméril & Bibron (1836) and mentioned that the type specimen originated from India.

Mertens (1942c, 1963) allocated the taxon *binotatus* Blyth, 1842, within the synonymy of *Varanus s. salvator* as a name used in error, due to the fact that Blyth (1842) incorrectly transferred the name *binotatus* from *Varanus bivittatus* Duméril & Bibron 1836.

Lacertus tupinambis (non Lacépède, 1788) Mertens, 1942 (Type locality: Cape of Good Hope, Senegal)

According to Brygoo (1987), *Lacertus tupinambis* was a *combinatio nova* created by Mertens (1942a: 8) who mistakenly credited this binome to Lacépède (1788-1789). Mertens (1942a-c), however, explained that this taxon originally consisted of three taxa: *V. salvator*, *V. niloticus* and the South American teiids. While the taxon was first listed without locality data in the synonymy of *V. salvator* (Mertens 1942c: 245), some pages later, there used as a synonym of the Nile monitor, Mertens (1942c: 320) restricted the type locality to "Kap der Guten Hoffnung; außerdem Senegal" (Cape of Good Hope; also Senegal). Consequently, the taxon *tupinambis* is not available for the taxonomy of the South East Asian water monitor.

V*aranus salvator macromaculatus* Deraniyagala, 1944 (Type locality: "Siam" = Thailand)

Type specimens: syntypes MNHN 871 (Siam) and MNHN 1518a, 84.77 (Malacca).

Deraniyagala (1944) listed the following localities for the range of this taxon as: "Burma, Indo-China, and Nicobar Islands." Later, he described the Nicobar population as a separate subspecies, *V. s. nicobariensis* (Deraniyagala 1947). The taxon *nicobariensis*, however, was also placed within the synonymy of the nominotypic subspecies by Mertens (1959b). Interestingly, Brygoo (1987) did not list the name *macromacula-*

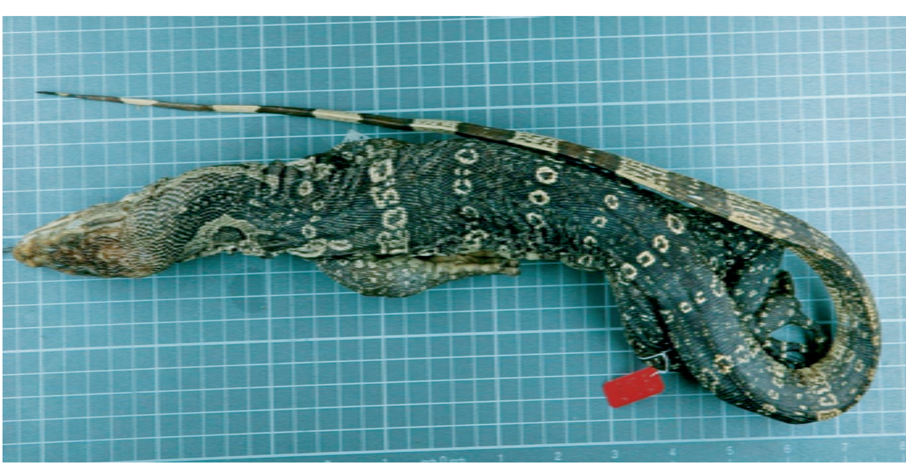

Fig. 6. Dorsal view of the designated lectotype of *V. s. macromaculatus* (MNHN 871) from "Siam" (=Thailand).

tus Deraniyagala, 1944, neither both type specimens among the type material deposited in the collections of the MNHN.

Although the original description by Deraniyagala (1944) provided scant diagnostic characters of this taxon and its type material, the nomen *macromaculatus* Deraniyagala, 1944 must be regarded as valid. The type specimens still exist in the Paris collection (Fig. 6).

***Varanus salvator macromaculatus* Deraniyagala, 1944**
Varanus salvator macromaculatus Deraniyagala, 1944. Spolia Zeylanica, 24: 59-62

Synonymy:
1802 Tupinambis elegans part. Daudin, Hist. nat. Rept., 3: 36. – Type locality: Surinam.

1831 Tupinambis exilis Gray in: Griffith, Anim. Kingd., 9: 25. – Type locality: India (*Nomen dubium*, this study).

1834 Varanus vittatus Lesson in: Bélanger, Voyage Ind. Orient. Zool.: 307. – Type locality: Indian subcontinent and islands at the mouth of the Ganges River (*Nomen dubium*, this study).

1842 Varanus binotatus Blyth, J. asiat. Soc. Bengal, 11: 867 (Lapsus according to Mertens, 1942).

1942 *Lacertus tupinambis* part. Mertens (non Lacépède, 1788) Abh. Senckb. Naturf. Ges., 466: 245. – Type locality: unknown (Lapsus according to Brygoo, 1987).

1947 Varanus salvator nicobariensis Deraniyagala, Proc. 3rd ann. Sess. Ceylon Assoc, Sci., 2, Abstr.: 12. – Type locality: Tillanchong, Nikobar Islands. (Synonym according to Mertens, 1959b: 236).

1987 *Varanus salvator komaini* Nutphand, J. Thai. Zool. Center, 2(15): 51. – Type locality: "Sea shore areas and small islands in south western Thailand" (Synonym, this study).

Type material:
Syntypes: MNHN 871 from "Siam" (= Thailand) collected by d'Istria, 1864 and MNHN 1518a, index no 84.77 from Perak, "Presqu'île de Malacca" (= Perak Province, Malacca peninsula) Malaysia.

The second specimens' correct number is MNHN 1884.77 (I. Ineich, pers. comm.).

Although specimen MNHN 1884.77 was listed and described first by Deraniyagala (1944) among the examined material of the Paris collection, in the third paragraph the author designated MNHN 871 as "type" of his new taxon. However, at the end Deraniyagala (1944) noted that the specimen MNHN 1518a (1884.77) from Malacca is the "type". According to Article 74 of the ICZN (1999) code and in order to clarify this irritation, we designate MNHN 871 (Fig. 6) as the lectotype of *V. salvator macromaculatus* Deraniyagala, 1944, the type locality being "Siam" (= Thailand).

Other material (147): Bangka/Banka (1): RMNH 5627 (coll. Buitendijk, 3. II. 1929); Batu Island (1): ZMA 15447 (Batoe eil., coll. W. Schröder); Billiton/Belitung (2): ZMA 15429a, b (2 spec.; Billiton, don. Cleintuar); Borneo (57): ZFMK 65794 (ad.; Kalbar, Putussibau, coll. M. Riquier, IV/V. 1996), ZFMK 65795-7 (3 juv.; Anjungan, coll. einheim. Sammler, VI. 1996), ZFMK 70165-70189 (25 spec.; Kalbar, Sambas-Region, coll. VI./VIII. 1996, don. M. Boesl-Riquier, II. 1999, just heads), ZFMK 70191-70204 (14 spec.; Kalbar, Sambas-Region, coll. einh. Sammler, VI./VIII. 1996, don. M. Boesl-Riquier, II. 1999, just heads), RMNH 3174a, b (2 juv.), RMNH 3187 (juv.; Sintewang), RMNH 7368 (juv.; Smitau Kapuas, coll. Büttikofer, 11. XII. 1893), RMNH 7308 (juv.; Pontianak, coll. Schädler), RMNH 8191a-c (2 juv., 1 ad.; Rantau, coll. F. C. E. van der Putten, May 1916), RMNH 3183 (juv.; SO-Borneo, coll. J. Semmelink, 1866), RMNH 7367 (Borneo, coll. J. Büttikofer, 1893-94), ZMB 13101 (Borneo, coll. Pagel), ZSM 66/1996 (subad.; Buitenzorg, coll. Dr. Bruegel, Jan. 1907), ZSM 11/1918 (subad.; Sarawak, Baram River District, coll. C. Hose), ZSM 610/0 (juv.; Borneo, coll. Ruppert); Malaysia (8): ZFMK 16508 (Kepala Batas, coll. G. Nikolaus, 18. IV. 1975), ZFMK 16509 (Ipoh, coll. G. Nikolaus, 11. IV. 1975), ZFMK 16510 (Kuanton, coll. G. Nikolaus, 15.-16. V. 1975), ZFMK 16511 (Kuanton, coll. G. Nikolaus, 15.-16. V. 1975), ZMA 15430 (juv.; Malacca, Penang, coll. Kruninger, VI. 1892), ZMB 3014 (Malacca, coll. Jagor), ZMB 6897 (Malacca, coll. Baumgarten), RMNH 8317 (ad.; Port Dickson, coll. et don. J. J. Parmentier, II. 1946); Nias (4): ZMA 15446 (Nias, coll. Kleinweg de Zwaan, 1910), ZMA 15445 (Nias, coll. Kleinweg de Zwaan, 1910), ZMA 15438 (Nias, coll. Kleinweg de Zwaan, 1910), ZMB 37670 (Nias, coll. Rapp); Pulau Weh (4): ZMA 15432a, b (2 spec.; Sabang, don. G. Herman, 1912), RMNH 6365a, b (2 spec.; Sabang, coll. P. Buitendijk); Simalur (9): ZMA 15444 (coll. Jacobson), RMNH 23440-47 (8 spec.; Sigulé, coll. et don. E. Jacobson, 14. IX. 1913); Sumatra (52): ZMB 34277 (Sumatra?, coll. W. B. Sachse), ZSM 732-36/1997 (5 ad.; Cikampak, coll. Abel & Erdelen, 27. I. 1997, just heads), ZSM 663/1997 (Torganda, coll. Abel & Erdelen, 20. XI. 1996, just head), ZSM 132/1909 (subad.; Sumatra, don. Museum Breslau, 1909), ZSM 342/1909 (ad.; Medan-Deli, coll. Prof. Durck, 1904), ZSM 340/1909 (Medan-Deli, coll. Prof. Durck, 1904), ZSM 2608/0 (subad.; east coast, coll. Dr. Martin, 1900), 68/1996a, b (2 juv.; Batang Kwis, coll. Wiedemann, 2. V. 1908), ZSM 137/1907 (subad.; Batang Kwis, coll. Dr. C. Bruegel, 1906), ZSM 67/1996 (juv.; Sumatra, coll. W. Volz, III. 1905), ZMA 15427a, b (2 juv.; Deli, coll. F. C. van Heurn, 1920), ZMA 15443 (Kajoe Tanan, coll. M. Weber, 1888), ZMA 15435 (juv.; Taloek, coll. Coll. Kleinweg de Zwaan), ZMA 10354 (juv.; Palembang, coll. Tropeninstituut), ZMA 15455 (juv.; Sabang, don. G. Hermann), ZMA 15454 (juv.; east coast, don. Salm), ZMA 15441a-d (4 juv.; Deli), ZMA 15451 (juv.; Deli, coll. De Bussy), ZMA 15452 (juv.; Djambi, coll. P. E. Moolenburgh), ZMA 15428a, b (2 subad.; Deli, coll. De Bussy), ZMA 15431 (juv.; Deli, coll. De Bussy, 1920), ZMA 15426 (ad.; Deli, don. De Bussy), ZMA 13419a-d (4 juv.; Deli, coll. Tropeninstituut), ZMA 15439 (ad., Deli, coll. De Bussy), ZMA 11603 (ad.; Deli, coll. De Bussy, 1920), RMNH 7595a, b (2 juv.; Atjeh), RMNH 7401a-c (1 ad., 2 juv.; Deli, November 1882), RMNH 8178 (juv.; Deli, coll. Neeb), RMNH 18790 (juv.; Deli, coll. B. Hagen, 1882), RMNH 7149a-c (2 juv., 1 ad.; Padang), RMNH 3171 (juv.; east coast, coll. Müller, 1833-37), ZMB 53585 (Deli, coll. Martin), ZMB 28613 (Langkat, coll. Heinze), ZMB 27732 (Palembang, coll. Ruhe); Thailand (5): ZFMK 49289 (Bangkok, coll. Derwanz, XI. 1988, don. H.-G. Horn, XII. 1988), ZMA 14121 (subad.; Umgebung Bangkok), ZFMK 47845-46 (2 "*komaini*" spec; Krabi, coll. pet trade, 1987, don. H.-G. Horn, II. 1988), ZFMK 48074 ("*komaini*", Krabi, coll. einh. Sammler, don. H.-G. Horn, II. 1988). Additional data of three further melanistic specimens (M1, M2, U1) adopted from Lauprasert (1999) were available for this study; Vietnam (4): ZFMK 55943 (Saigon, coll. Zoo Saigon, don. Zoo Leipzig, VII. 1993), ZFMK 81433-434 (2 subad.; Ha Tinh, Ky Anh-Ke Go, coll. T. Ziegler), ZMB 7390 (Saigon, coll. Conradt).

Diagnosis:
V. s. macromaculatus is distinguished from other taxa of the *V. salvator* complex by the following combination of characters: (1) A brown dorsal background colour, with four to seven, more or less distinctive transverse rows of spots or ocelli, in between mostly

light dotted or marbled; (2) a dark tail, anteriorly with transverse rows of light spots or ocelli, posteriorly fused to more or less distinctive light crossbands; (3) a whitish chin, with three to four more or less long bars, sometimes fused to crossbands; (4) a whitish belly, with six to ten more or less distinctive short dark pointed bars laterally; (5) average high scale counts around the head (character P), (6) around the tail's base (character Q), (7) around midbody (character S) and (8) on the dorsum (characters X, Y, and XY).

Comparison with other taxa:
V. s. macromaculatus is statistically distinguished from *V. s. salvator* (Sri Lanka), on average, by higher scale counts around the head (characters P) and along the dorsum (characters X, Y, XY), but averaging less ventral scales (character T, see Tab.7). Moreover, *V. s. macromaculatus* shows a brown rather than a black dorsal background colour and the distinct thin lines of light dots between the transverse rows of spots are missing or are less regular.

Diagnostic characters in the colour pattern to distinguish *V. s. macromaculatus* from *V. s. andamanensis* concern the lack of distinctive dorsal transverse rows of light spots in both juveniles and adults of latter subspecies.

While *V. s. macromaculatus* from Sumatra and Borneo shows almost no significant differences in scalation characters compared to *V. s. bivittatus* (with exception for Borneo for parameter P: 51-64, x = 58.14, s = 3.23 versus *V. s. bivittatus* from Java: 50-63, x = 55.94, s = 3.12), the continental South East Asian populations (CSEA) are statistically distinct from *V. s. bivittatus* populations (i.e. Java and the Lesser Sunda Islands) with regard to the nostrils (nares) positioned closer to the tip of the snout (index 2), as well as characters N, TN, and m indicating that *V. s. macromaculatus* from CSEA has on average more and smaller scales along the ventral side and around the neck. Altogether, *V. s. macromaculatus* from all populations differs significantly from *V. s. bivittatus* in having longer mean head lengths relative to the head height (index 11: 2.17-3.42, x = 2.72, s = 0.19 versus 2.13-2.92, x = 2.61, s = 0.17) and more scales around the head (character P). With regard to the colour pattern, dark longitudinal stripes on the lateral side of the neck only occasionally occur in *V. s. macromaculatus* and are less pronounced than in *V. s. bivittatus*. Moreover, the dorsal spots in *V. s. macromaculatus* usually show no tendency to fuse to light crossbands.

Compared to *V. salvator* ssp. from Sulawesi and the Moluccas, *V. s. macromaculatus* from CSEA is statistically distinct by characters index 2 (2.07-3.46, x = 2.55, s = 0.31), Q (97-121, x = 109.62, s = 5.95), S (139-178, x = 156.57, s = 11.32), N (82-95, x = 87.64, s = 3.97), TN (161-187, x = 174.93, s = 7.57), and m (106-127, x = 113.92, s = 7.06), while Bornean and Sumatran water monitors can not be distinguished by differences in scalation or morphometry (but see descriptions for colour pattern on Tab. 8). However, all populations of *V. s. macromaculatus* together significantly differ from the Sulawesi monitor lizards by higher mean scale counts around the base of the tail (character Q) and around midbody (character S).

In contrast, *V. s. macromaculatus* is statistically distinct from *V. togianus* in having shorter mean head lengths relative to head width (index 10 for *macromaculatus*: 1.53-2.22, x = 1.90, s = 01.12 versus *togianus*: 1.78-2.29, x = 2.05, s = 0.19) and higher scalation values for characters P, S, T, N, TN, and m. For the corresponding scale counts, see Tab. 7. Furthermore, *V. s. macromaculatus* is generally characterized by light spots on the dorsum lacking in the melanistic Sulawesi species. Even melanistic specimens from CSEA are easy to distinguish from *V. togianus* in having a dark ventrum without the distinct V-shaped pattern.

Among the numerous characters to statistically differentiate *V. s. macromaculatus* from the Philippine species *V. marmoratus*, *V. nuchalis* and *V. cumingi*, the most meaningful are the higher mean scale counts around the head from rictus to rictus (character P), the scales around the tail at one third of its length (character R), and the smaller dorsal scales in general (characters X, Y, and XY). In addition, the nostrils in *V. s. macromaculatus* are situated closer to the snout-tip than in both *V. marmoratus* and *V. nuchalis* (index 2), and the latter taxa possess on average fewer supralabials (character c for *macromaculatus*: 58-74, x = 65.30, s = 3.01 versus *marmoratus*: 57-66, x = 61.15, s = 2.30 and *nuchalis*: 58-66, x = 60.39, s = 2.37). Additionally, *V. s. macromaculatus* differs significantly from *V. marmoratus* and *V. cumingi* with a higher mean number of scales around midbody (character S), and only from the latter in a higher mean number of supraoculars (character U for *macromaculatus*: 9-19, x = 12.64, s = 1.57 versus *cumingi*: 8-12, x = 10.92, s = 1.08).

Description of the type specimens:

As Deraniyagala (1944) provided only a short account of the type specimens, an additional description based on data and photographs made available to us by I. Ineich and S. Soubzmaigne (both MNHN) is given here:

Lectotype MNHN 871 (Fig. 6): Subadult, total length 800 mm. Nostril much closer to tip of snout than to eye; tail largely compressed laterally. 6/6 enlarged supraoculars, scale covering the pineal organ likewise enlarged, irregularly pentagonal with a round whitish blotch in the centre. Scales of nape smooth, oval.

Colour pattern (in preservative): Black dorsum, back with five transverse rows of whitish ocelli with dark centre, first row consists of seven ocelli, interspaces with thin transverse rows of small dots. The tail is black and white striped, a thin white line divides two dark blotches, while the thicker white parts of the first third of the tail are interspersed with numerous dark scales. The last third of the tail length shows the twofold dark parts fuse to one. Head dark, intermingled with several pale scales. Three light crossbands on snout. Tongue bluish-grey. Granular scales around eyes whitish. Whitish temporal streak extending from eye to tympanum. Nape dark, dotted with numerous whitish scales. Hindlimbs with whitish spots consisting of four to five scales, forelimbs with two to five scales. Digits with light crossbands of two to three scale rows, first scale after claws always with large white dot. Ventrally whitish, chin with four distinctive black crossbands. Throat and anterior belly are black banded. Belly with eight black V-shaped markings. Tail with alternating whitish and black crossbands.

Paralectotype MNHN 1884.77: Juvenile, total length 353 mm. Habitus slender; nostril much closer to tip of snout than to eye; tail largely compressed laterally. 7/7 enlarged supraoculars, scales of head irregularly pentagonal or hexagonal. Scale covering the pineal organ likewise enlarged, irregularly hexagonal with a round whitish blotch in the centre. Scales of nape smooth, oval.

Colour pattern (in preservative): Dorsal side dark, back with five transverse rows of whitish ocelli with dark centre, first row consists of seven ocelli, interspaces with thin transverse rows of small dots. The tail is black and white striped dorsally, where a thin white line divides two dark blotches, while the thicker white parts of the first third of the tail are interspersed with numerous dark scales. On the last third of the tail length the twofold dark parts fuse to one. Head dark, intermixed with several pale scales. Three light crossbands on snout. Tongue bluish-grey. Granular scales around eyes whitish. Whitish temporal streak extending from eye to tympanum. Nape dark, dotted with numerous whitish scales. Hindlimbs with whitish spots consisting of four to five scales, forelimbs two to five scales. Digits with light crossbands of one to two scale rows only, first scale after each claw always with large white dot. Ventrally whitish, chin with four distinctive black crossbands. Throat and anterior belly are black banded. Belly with eight black V-shaped markings. Tail with alternating whitish and black crossbands.

Variation:
The total length of the longest specimen of *V. s. macromaculatus* examined (ZMB 27732) is 1902 mm. However, records from the Asian mainland describe total length of more than 2700 mm (Lim 1958).

Proportion indices: index 1: 1.31-1.88 (x = 1.56, s = 0.12); index 2: 1.82-3.46 (x = 2.30, s = 0.26); index 10: 1.53-2.22 (x = 1.90, s = 0.12), index 11: 2.17-3.42 (x = 2.72, s = 0.19).

Scalation characters: 9 to 19 enlarged supraoculars on both sides. 58 to 74 supralabials excluding the rostral. For further data see Tab. 7.

Within the wide range of *V. s. macromaculatus* statistically significant differences between the three OTUs (continental South East Asia = CSEA, Sumatra and Borneo) are identifiable for character index 2 for CSEA (2.07-3.46, x = 2.55, s = 0.31) versus Sumatra (1.82-2.53, x = 2.18, s = 0.17) and Borneo (2.00-2.80, x = 2.31, s = 0.20); for character Q for CSEA (97-121, x = 109.62, s = 5.95) versus Sumatra (88-126, x = 101.67, s = 7.43); for character N for CSEA (82-95, x = 87.64, s = 3.97) versus Sumatra (69-92, x = 79.48, s = 4.31) and Borneo (72-93, x = 80.94, s = 6.75); for character TN for CSEA (161-187, x = 174.93, s = 7.57) versus Sumatra (152-186, x = 163.09, s = 6.82) and Borneo (154-185, x = 166.10, s = 9.48), and for character m for CSEA (106-127, x = 113.92, s = 7.06) versus Sumatra (81-125, x = 98.08, s = 9.87) versus Borneo (94-125, x = 106.78, s = 10.98).

With regard to the colour pattern, Vietnamese specimens of *V. s. macromaculatus* show the tendency to have fewer dorsal transverse rows (4-6) than specimens from the Malaysian Peninsula (5-7); the same applies to the number of dark pointed bars at the belly (Vietnam: 7-9 versus Malaysian Peninsula: 8-10). Longitudinal stripes on the sides of the neck, as characteristic for *V. s. bivittatus* are occasionally present in specimens of *V. s. macromaculatus*.

Range:
V. s. macromaculatus inhabits the South East Asian mainland, Sumatra, Borneo and smaller associated offshore islands (Fig. 5). Given the sparsity of information available (only from photographs), the taxonomic status of continental South Asian populations originating from northern India, Bangladesh, and northern Myanmar can not be discussed here unequivocally.

Taxonomic comments:
In 1981 Nutphand reported, that 29 black specimens of the water monitor were captured in Satun Province (Amphur Thung Wa and Amphur La-Ngu), southern Thailand, between 1975 and 1981 (Nutphand 1981). Six years later Nutphand (1987) described these melanistic monitor lizards as the new taxon, *V. s. komaini*, based on vague diagnostic characters.

[Translation from Thai by M. Stanner (25 July 2003): "The black dragon (mang gon dam)

Size: Much smaller than *V. salvator*. SVL of adults 50 cm, tail length 60 cm. Colour: Black colour all over the body, there is no colour pattern of straps or dots. The belly is dark. The tongue is gray-purple. Habitat: Only near seashore areas and on small islands in south western Thailand. It is a new monitor species. The general appearance is like that of *V. salvator* and in terms of scales, there are only minor differences between the two species. The general behaviour resembles that of the black monitor of Papua New Guinea, but the dorsal scales at the nape region of the Papuan monitor are thorn-like and sharper as in *V. rudicollis* and the tail is more pointed. Apart from that, it is very much like *V. salvator* of the Philippines, but in *V. salvator* of the Philippines there are colour patterns all over the body. If we examine and compare the two species thoroughly the 'mang gon dam' is quite different from closely related monitors that have been previously described."]

Obviously, within his description of *V. s. komaini*, Nutphand (1987) failed to declare a type specimen. Nevertheless, he presented a photograph of a melanistic varanid. With reference to Lauprasert & Thirakhupt (2001), Böhme (2003) designated the type locality to "Amphoe La-ngu, Satun Province, Thailand, and Thai-Malaysian border area."

While it seems that the taxon *komaini* Nutphand, 1987 was not even known to herpetologists ten years after its publication (see Eidenmüller 1997, Ziegler & Böhme 1997, Bennett 1998), the validity of *V. s. komaini* has lately been subject to taxonomic controversies. Recently, Eidenmüller (2003) and Böhme (2003), for instance, listed *V. s. komaini* within the water monitor's subspecies complex, while Gaulke & Horn (2004) questioned the validity of this taxon.

Currently, this most recently described subspecies of *V. salvator* is rarely found in herpetological collections and publications (cf. photographs by K.-D. Schulz in Chanard et al. [1999: 147], by E. Pesci in Bennett [1998: 243] or Sprackland [1992: 126, 128]). The real identity of an alleged *V. s. komaini* illustrated by Deraniyagala (1961) as *V. s. andamanensis* remains dubious, and is therefore discussed below in more detail (see *V. s. andamanensis*).

Data about the distribution of melanistic water monitors shows considerable variation. According to Nutphand (1987) and Lauprasert & Thirakhupt (2001), *V. s. komaini* has a very restricted distribution, occurring only at the designated type locality between Thailand and Malaysia. In contrast, Bennett (1995), for instance, reported black specimens from Malaysia, Thailand, the Philippines, Sulawesi and India. Our own investigations confirmed the existence of melanistic monitor lizards from several islands and archipelagos (e.g., Panaitan Island off the west coast of Java, Sulawesi, Sumba, and the Philippines) within the entire range of the water monitor complex, thus suggesting that melanism is a common phenomenon in this group. In contrast to the characteristic dark belly of the taxon *komaini*, all specimens examined did not exhibit a totally black ventral side. Therefore, uniformly black water monitors as evident seem to be restricted to the Thai-Malaysian border area. As early as 1829, however, Cuvier described *Monitor nigricans*, a synonym of *V. s. bivittatus*, as a unicoloured dark taxon ("une espèce noirâtre uniforme") from Java. Thus, further investigations are required to identify the real extent and distribution of melanism in water monitor lizards and other congeners in general.

Lauprasert (1999) studied morphometric parameters of three specimens of *V. s. komaini*. All three, one was preserved and two were alive, came from the Pata Zoo in Bangkok, and a local Thai reptile dealer. Therefore, no locality data could be provided. According to Lauprasert (1999), *V. s. komaini* can be significantly distinguished from the common water monitor (i.e. *V. s. macromaculatus* and all other monitor lizard species from Thailand, i.e., *V. bengalensis*, *V. dumerilii*, *V. nebulosus* and *V. rudicollis*) by seven parameters. He used the characters of the proportion indices ToL/SVL (not examined here) and TaL/SVL, equivalent to index 1 of this work. For the correlation of ToL/SVL, Lauprasert (1999) calculated a mean value of 2.67 ± 0.35 for *s. komaini* (n = 3) versus 2.41 ± 0.20 for Thai *s. macromaculatus* (then *s. salvator*). Index 1 is stated as 1.67 ± 0.35 (*s. komaini*) and 1.41 ± 0.20 (*s. macromaculatus*), respectively. These results ostensibly indicate that *V. s. komaini* has a significantly longer mean tail length than the nominate form. On the basis of these data, Lauprasert (1999) preliminary summarised that the taxon *komaini* can be easily distinguished from the spotted morphotype by its colouration and the size of body and tail.

However, based on the results of our own studies presented here (Lauprasert's data are included), there is no significant difference in the mean values of index 1 between black (OTU 3: x = 1.65, n = 6) and spotted specimens of continental South East Asia (OTU 2: x = 1.55 ± 0.14, n = 27). Excluding the conspicuously high value of Lauprasert's specimen M2 (2.07), whose tail was probably not complete, the mean value for the remaining five melanistic monitor lizards is 1.56 ± 0.11, thus virtually identical to the value of the normally coloured populations of the South East Asian mainland. This concordance applies for all morphometric and scalation characters examined in our analysis although the poor *komaini* sample size (n = 3) is not adequate for statistical significance of comparisons. Nevertheless, the three *komaini* specimens, due to their enormous morphological similarity to the spotted form of *V. s. macromaculatus*, are located well within the *salvator*-typical clade of the phenotype dendrogram (Fig. 3).

Accordingly, Lauprasert (1999) finally diagnosed a strong overlap in values of *s. macromaculatus* (then *s. salvator*) and *s. komaini* from Thailand using a discriminant canonical analysis of 22 parameters. Investigations of the genital morphology of ZFMK 47845 (black form) and ZFMK 49289 (spotted form) by Ziegler & Böhme (1997) showed the same congruence in characters for both these morphotypes of water monitor lizards. Additional unpublished data on the molecular genetics of the *V. salvator* complex provide results establishing 100% congruence between melanistic and normally coloured specimens from CSEA (Kuch et al. in prep.).

Accordingly, the morphological results presented here combined with previous data strongly suggest that the taxon *komaini* Nutphand, 1987 can not maintain subspecific status but should be regarded as a synonym of the Asian mainland taxon *macromaculatus* Deraniyagala, 1944.

Varanus salvator andamanensis **Deraniyagala, 1944**

Varanus salvator andamanensis Deraniyagala, 1944. Spolia Zeylanica, 24: 59-62.

Synonymy: No synonyms for this subspecies are known (Böhme 2003).

Type material:

Holotype: IM 2176, juvenile, Port Blair, South Andaman Island, Andaman Islands, Gulf of Bengal; Paratype: IM 2174 with the same locality data (Fig. 7).

Although indicated by Deraniyagala's (1944) descriptive text, both juvenile type specimens are not illustrated on plates X and XII but on plate XI. According to the legend, the photographs of plates X and XII show two juveniles of the "typical form" from Sri Lanka and of *V. s. macromaculatus*, respectively.

Fig. 7. Dorsal view of the juvenile type specimens of *V. s. andamanensis*; left holotype IM 2176, right paratype IM 2174 (from Deraniyagala 1944, pl. XI).

Description of the type specimens:
Deraniyagala (1944: 60): "Two specimens from the Indian Museum, Calcutta, numbered 2174 and 2176 respectively. The latter is the type of *Varanus salvator andamanensis* sub sp. nov. Head length 54 mm., axilla to groin 96 mm. No. 2174 is slightly smaller and has the tail mutilated. In these two specimens the yellow dorsal body spots are only represented by two feeble transverse rows. Lack of a series of both younger and older specimens for examination makes it impossible to state whether these rows are rudimentary or vestigial, but the coloration is characteristic. (Pls. X and XI) and the body scales are also finer than in other varieties where specimens of this size display strongly defined ocelli."

Because Deraniyagala (1944) failed to provide a detailed description of the *andamanensis* type specimens, we herein attempt to remedy this deficiency.

The illustration of the type specimens in Figure 7 shows two juvenile water monitors with a dark background colour and evenly distributed light spots on the dorsum and particularly on the upper side of the limbs. Due to the underexposed photographs the exact extent of bright markings on the head and neck are not visible. The colour of the tongue is also not identifiable, although it may be dark. The dark tail is banded with thin crossing lines of light dots. Ventrally, both specimens are whitish and have well defined V-shaped dark markings with long light centres, which to some extent, appear to meet in the middle of the venter. As far as visible, the limbs are also marked with short dark spiky elements where upper and underside meet. The thoracic region below the gular fold shows two dark crossing stripes, the throat shows irregular dark blotches, while the ventral side of the head, although poorly visible, has lateral dark, pointed bars which may meet under the jaw.

Other material: Andaman Islands: Three specimens depicted by Whitaker & Whitaker (1980).

Diagnosis:
As far as known, *V. s. andamanensis* is characterized only by the reduction of the dorsal colour pattern of light spots. According to Deraniyagala (1944), the body scales are finer than in other taxa.

Variation and comparison with other taxa:

Although Deraniyagala (1944) asserted that no other material than the two type specimens from the Andaman Islands was available to him, he emphasised that the reduced dorsal transverse rows are characteristic for the colour pattern of the Andaman water monitor.

Whitaker & Whitaker (1980) were the first to illustrate live specimens of *V. s. andamanensis*: one juvenile and two adults from Interview Island in the Andamans next to one juvenile from Orissa, northeastern India. Apparently, the difference between both juveniles is the finer ornamentation of small dorsal dots in the Andamanese specimen. In contrast to the type specimens of *V. s. andamanensis* with only two hardly visible rows, the dots in the specimen illustrated by Whitaker & Whitaker (1980) seem to be arranged in five transverse rows. The limbs are finely spotted. The tail of this specimen does not have the characteristic colour pattern of large bright and dark cross bands as seen in the Indian specimen but shows a clear and distinctive pattern of small light dots arranged in numerous transverse rows. Here, each row of larger dots is followed by three rows of smaller ones. On the lateral side of the head five dark markings crossing the mouth are visible. They may proceed on the ventral side as it is seen in the type specimens (Fig. 7).

The colouration of hatchlings of *V. s. andamanensis* described by Kala (1998) underlines the morphological distinctiveness of the Andamanese populations as the background colour is grey and the spots of the body together with the markings on the head are orange, and not yellow as known from specimens from the Asian mainland. Obviously, these distinctions can not be confirmed by Whitaker & Whitaker (1980) as their publication only provided black and white photographic evidence. Their photographs of adult Andaman water monitors show dark dorsums and tails, only speckled with few small light dots, hence revealing that the bright colour pattern in juveniles must fade during ontogenesis. Although this phenomenon may represent a certain grade of melanism related to aging, the ventrum remains light coloured. At its throat one adult specimen, as well as both type specimens, display large dark blotches. But nevertheless, the background colour of the throat is light, which is not the case for the adult melanistic monitor lizard illustrated by Deraniyagala (1961). Based on these facts, the identification of Deraniyagala's specimen as *V. s. andamanensis* should be rejected.

As discussed above, the live juvenile from the Andaman Islands illustrated by Whitaker & Whitaker (1980) is characterized by a more pronounced colour pattern on the dorsal side than the type specimens. One possible explanation could be the poor condition of preservation, despite the fact that Deraniyagala (1944) provided no collecting data. Another possibility could be a geographic variation of the Andaman water monitor within this small archipelago. However, all three monitor lizards largely reflect a similar colour pattern, as far as the photographic quality allows estimating these properties.

Range:

V. s. andamanensis is an endemic subspecies of the water monitor only known from the Andaman Islands in the Gulf of Bengal (Fig. 5).

Taxonomic comments:

Although the validity of the taxon *andamanensis* Deraniyagala, 1944 was initially doubted by Mertens (1959b), the subspecies *V. s. andamanensis* was recognized by Mertens within the systematics of the water monitor in 1963.

In 1961, Deraniyagala published photographs and provided additional data on an adult Andamanese water monitor which was donated to the Zoological Survey of India (ZSI 13743) by C. Casey on 3 July 1894. Unfortunately, no locality data was provided. Horn & Gaulke (2004: 259) incorrectly stated that "some more specimens" were available to Deraniyagala. In fact, Deraniyagala (1961) only had access to the specimen ZSI 13743.

Because of its dark colouration, Deraniyagala (1961) identified this specimen as *V. s. andamanensis* with reference to Dr M. L. Roonwal (Director of the Zoological Survey of India in Calcutta at that time), who noted that "the specimen being very old (collected earlier than 3 July 1894) the yellow rings on the body have become faded to a great extent leaving only a trail of markings on the body". Moreover, Deraniyagala (1961) based his new assumptions on the comparison of the two former juvenile type specimens and the adult specimen ZSI 13743, when he stated: "the scarcity of yellow pigmentation in the adult … is to be expected and probably the yellow rings are as inconspicuous in the living animal as they are in this preserved adult."

According to Deraniyagala (1961), the total length (ToL) of the specimen ZSI 13743 is 1010 mm with a tail length (TaL) of 580 mm, resulting in a ToL/SVL ratio of 1.74. Another specimen mentioned of the nominate form from Sri Lanka (ToL = 1257 mm, TaL = 813 mm) exhibits a slightly smaller value of 1.64. In accordance with the definitions of Brandenburg (1983) and Böhme et al. (1994), the ratios of index 1 for the melanistic monitor ZSI 13743 and the *V. s. salvator* specimen from Sri Lanka are 1.35 and 1.55, respectively.

Although Deraniyagala (1961) did not provide any further data, he came to the conclusion that the Andaman water monitor "is considerably smaller than the forma typica. Its yellow dorsal pigmentation is the least pronounced of all the races of *Varanus salvator*, its snout is more acuminate than that of the forma typica, and it possesses 8 to 10 supraocular scales instead of 5 or 6." Krammig (1977), who visited the Andaman Islands measured a specimen with a total length of almost two meters and H. Andrews (pers. comm. in Kala 1998) recorded specimens from South Sentinel Island often exceeding 2.5 m in total length.

Despite the bad copy quality of this article, the totally dark ventral side is clearly recognizable, which is an important taxonomic character as pointed out above. Dorsally, bright dots or markings are not visible, thus the specimen is entirely black. Compared to the type specimens this is a surprising finding because (although showing only a weakly pronounced bright colouration on the dorsal side) both juveniles have a bright ventrum with the characteristic lateral V-shaped markings. The totally black ventral side of this specimen (which to some extent may be explainable by the specimen's long preservation in alcohol) as a major diagnostic feature, makes it doubtful that this adult monitor described by Deraniyagala (1961) belongs to the subspecies *V. s. andamanensis*. It is more reasonable to assume that this specimen reflects the entirely melanistic taxon *komaini* described by Nutphand in 1987 (see *V. s. macromaculatus*).

Although no pholidotic data are available for the water monitor population of the Andaman Islands, the distinctive characteristics of the colour pattern of *V. s. andamanensis* discussed above suggest that there are reasonable taxonomic grounds to validate this subspecific distinction on the basis of further morphological, biometric or genetic investigations. In addition, the appraisal of the distinctive systematic situation of the

Andamanese water monitor is in congruence with the high endemicity of vertrebrates recorded from the Andaman Islands (Das 1999).

Varanus salvator bivittatus **(Kuhl, 1820)**
Tupinambis bivittatus Kuhl, 1820. Beiträge zur Zoologie und vergleichenden Anatomie, 1. Abtheilung: Beiträge zur Zoologie, Verlag der Hermannschen Buchhandlung, Frankfurt a. M., pp. 152 [p. 125].

Synonymy:
1829 Monitor nigricans Cuvier, Règne animal, **2**(2): 27. – Type locality: Java.

1844 Monitor bivittatus var. *javanica* Schlegel, Abb. Amphib.: X. – Type locality: Java.

1845 Varanus crocodilinus Owen, Odontography 1: **265**. – Type locality (restricted by Mertens, 1942 to): Java.

1942 Varanus salvator salvator part. - Mertens, Abh. Senckenb. naturf. Ges., **465**: 149; 466: 245.

Type material:
Although Kuhl (1820) did not provide details on potential type specimens, he referred the description of *Tupinambis bivittatus* to a plate of Seba's (1735) "Thesaurus", Tome II, Tab. 30, Figure 2 (Fig. 8), as previously was done by Laurenti (1768). The specimen therefore represents the iconotype of *Tupinambis bivittatus* Kuhl, 1820. Nevertheless, Kuhl (1820) introduced the genus *Tupinambis*: „Ich besitze drei Arten, und habe von jeder viele Exemplare untersucht, kann also mit Gewißheit ihre Verschiedenheit angeben." (Translation: I possess three species and I have examined many specimens of each, so I can with certainty declare their distinctiveness.). Subsequently, however, Kuhl (1820) listed 15 different species within this genus, hence the species Kuhl's

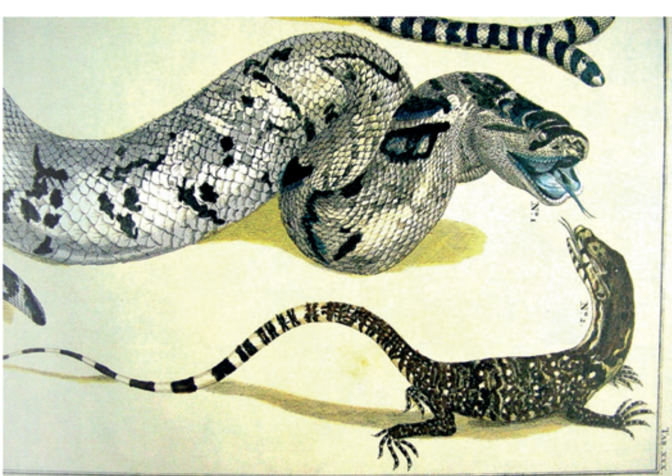

Fig. 8. Plate 30 of Albertus Seba's (1735) "Thesaurus", Tome II, showing the juvenile iconotype of *V. s. bivittatus* (No. 2) next to a partly albinotic python.

(1820) former statement referred to remains ambiguous.

Although Heinrich Kuhl travelled to Java as a member of the Natuurkundige Commissie voor Nederlands-Indië, he could not have collected the type material of *V. s. bivittatus* himself, since the scientific team did not reach Java earlier than December 1820 (Kuhl & van Hasselt 1820, Boeseman 1997). Not long after his arrival in the Dutch East Indies, Kuhl succumbed to an early death on 14 September 1821 and thus never returned to Europe (van Swinderen 1822). Before his journey to South East Asia – as stated in the preface of his „Beiträge zur Zoologie" – Kuhl made journeys to Berlin and also to the collections of London and Paris to prepare his forthcoming overseas expedition.

According to our investigations, however, it is very unlikely that alcohol preserved specimens which could have served as vouchers of the Javanese water monitor (still) exist in the museum collections under investigation for this study.

On this basis, it seems very difficult, if not impossible, to identify Kuhl's type specimen(s) of *Tupinambis bivittatus*; provided such specimen(s) ever existed. Similarly, Mertens (1959b) also did not mention any voucher specimens.

Schlegel (1837-44) based his comments about *Monitor bivittatus* on the description by Duméril & Bibron (1836), adding Seba's (1735) Figure 2 of Tab. 86 (which was already occupied by Laurenti's *Stellio salvator*, see Fig. 1) to the illustration of Figure 2, plate 30 (Fig. 8), which is the picture Kuhl (1820) had originally used as the basis of his taxon. By comparing both plates, a certain similarity becomes obvious in colour pattern. But there are also some distinct differences: (1) while the monitor's dorsum ground colour on Tab. 86 (*s. salvator*) is uniformly black with well defined white transverse rows of ocelli and a thin light line in between two such rows, the specimen of Tab. 30 (*s. bivittatus*) is characterized by smaller, somewhat indistinct spots on a heterogeneous coloured brown background; (2) the limbs of the latter specimen are spotted with smaller and less distinct light dots; and (3) the dorsal neck has no bright spots or markings as is the case in the lizard of Tab. 86 (*s. salvator*), while *V. s. bivittatus* in Tab. 30, has a light stripe between the eye and the tympanum proceeding laterally on the neck to the shoulders and defining the upper margin of the characteristic dark stripes at both sides of this subspecies (lat. *bivittatus* = with two stripes).

Type locality:
Kuhl (1820) failed to specify a locality in the description of *Tupinambis bivittatus*. Mertens (1959b) designated Java as the type locality of this taxon because of the matching colour pattern of Javanese specimens with the specimen illustrated by Seba (1735). Morphological investigations of the colour pattern during the course of this study, strongly confirm Mertens' (1959b) designation of the type locality Java.

Other material (66): Bali (2): ZSM 70/1996a, b (2 spec.; Bulaleng, coll. E. Stresemann, 1911); Flores (4): ZMB 33899 (Endek, coll. Sunda-Expedition, Rensch), ZMA 15450 (east Flores), ZMA 15449 (Endek, coll. M. Weber, 1888), RMNH 8713 (Sika, coll. H. ten Kate, 1891); Java (55): ZFMK 66645-66648 (4 subad.; Java, coll. pet trade, 1997, don. T. Holtmann, V. 1998), ZFMK 74320 (W-Java, Tambun, coll. Mr. Amin, 21. IX. 1999, don. M. Auliya, IV. 2001), ZFMK 26351 (Buitenzorg, coll. König v. Hannover; 1844, don. Mus. Göttingen, VI. 1979), ZFMK 26352-56 (5 spec.; Buitenzorg, coll. Graf Solms, 1844, don. Mus. Göttingen, VI. 1979), ZMB 473 (juv.; Java, coll. Göring), ZMB 53565 (juv.; Java, coll. Göring), ZMB 31292 (juv.; Java, Res. Bezoekie, coll. Semmelink), ZMB 31301 (juv.; Buitenzorg), ZMA 15433a, b (2 subad.; Buitenzorg, coll. M. Weber, 1888), ZMA 15425 a, b (2 juv.; Buitenzorg, coll. M. Weber), ZMA 15442a-h (8 juv.; Java), ZMA 14646 (juv.; Java, coll. Legrand, Oktober 1910), ZMA 13418 a, b (2 juv.; Java, coll. Tropeninstituut), ZMA 11642 (subad.; Java), ZMA 15453 (juv.; Java, don. W. A. Frank, 3. II. 1892), ZMA 11153 (juv.; Java, coll. Mus. Middelburg), ZMA 15458 (juv.; Java, coll. Bartels, 1892), ZMA 15448 (juv.; Smeroe, coll. P. Buitendijk), RMNH 7186a, b (1 juv., 1 ad.; W-Java), RMNH 7307a, b (2 juv.; Malang, coll. Hillebrandt, 1876), RMNH 7206 (sub.; Madoera), RMNH 5457 (juv.; Java, coll. Soeterman, 12. IV. 1932), RMNH 5386 (juv.; Java, coll. Buitendijk, 23. XII. 1925), RMNH 3172 a, b (2 juv.; Java, coll. Boie & Macklot, 1826-1827), RMNH 3175 (juv.; Java), ZSM 63/1996 (ad.; Java, coll. Dr. Merck, 14. VI.) ZSM 64/1996 (ad.; Pasir Getjing, coll. Dr. Merck, 14. VI.), ZSM 62/1996a, b (1 subad., 1 ad.; Pasir Getjing, coll. Dr. Merck, 14. VI.), 137/1909a, b (1 subad., 1 juv.; Java, don. Museum Breslau, 1909), ZSM 613/0 (subad.; Java, don. Mess.), ZSM 140/1907a, b (2 spec.; Semarang, coll. Bruegel, X. 1906), ZSM 612/0 (juv.; Java, coll. H. v. Leuchtenburg); Lombok (2): ZMB 33837 (Swela, coll. Sunda-Expedition Rensch), SMF 11565 (Sadjang, coll. Elbert); Sumba (2): ZMA 15436 (Sindikiri-Baai, don. v. de Sande, 1909), ZMA 12774 (Koroeni, coll. L. G. Krijger, 8.IX.1932); Sumbawa: SMF 23192 (Sumbawa Besar, Sumbawa, coll. R. Mertens, 1927).

Diagnosis:
The two-banded monitor lizard, *V. s. bivittatus*, from Java and the Lesser Sunda Islands, is characterized by the combination of (1) one dark band on the lateral sides of the neck; (2) usually displays a modification of the first transverse row of dorsal spots in front of the forelimbs towards a continuous light cross band (Fig. 9); (3) the shortest mean tail length of all members of the *V. salvator* complex (index 1: 1.29-1.70, $x = 1.51$, s = 0.08); (4) the largest mean distance between the nostril and the snout-tip among all *salvator* typically-coloured taxa (with exception for the population of Sulawesi and the Moluccas; index 2: 1.67-2.88, $x = 2.21$, s = 0.25); (5) high mean scale counts around the tail both at its base (character Q); and (6) high scale counts at one third of the tail length (character R); as well as (7) high mean scale counts along the dorsal side from tympanum to insertion of hindlimbs (characters X, Y, and XY). For single values see Tab. 7.

Variation:
The longest specimen of *V. s. bivittatus* examined (ZSM 62/1996 b) is from Java. It measures 1275 mm (SVL = 505 mm, TaL = 770 mm) despite the fact that the tail-tip is missing. In the wild, this subspecies may attain a total length of more than 2000 mm.

Proportion indices: index 1: 1.29-1.70 ($x = 1.51$, s = 0.08), index 2: 1.67-2.88 ($x = 2.21$, s = 0.25), index 10: 1.64-2.86 ($x = 1.88$, s = 0.15), index 11: 2.13-2.92 ($x = 2.61$, s = 0.17). Scalation characters: 9 to 14 enlarged supraoculars on both sides; 52 to 71 supralabials excluding the rostral (see Tab. 7 for further scalation data).

Colour pattern: Commonly, the characteristic light-bordered dark stripes on the lateral side of the neck proceed to the shoulders. Particularly in Javanese specimens the bright spots of the first transverse row on the back tend to be reduced in their number to only two spots which may be enlarged, may join or form a continuous crossing band on the anterior dorsum.

The examination of *bivittatus* specimens from the Lesser Sunda Islands reveals two contrary aspects: (1) an overall agreement in colour pattern with the Javanese topotypical population (Mertens [1959b] argumentation for the occurrence of *V. s. bivittatus* on this island chain); as well as (2) a conspicuous variation in colour pattern resulting in two differing Lesser Sunda phenotypes. Morphologically, two specimens, one from Lombok and one from Sumbawa [ZMB 33837, Lombok and SMF 23192, Sumbawa as illustrated by Mertens (1942a: 85)] show distinct large white spots which are dark encircled on a light brown background colour on the dorsal side. The transverse rows of spots even reach the nape region in these specimens, and both exhibit an interrupted whitish medio-dorsal line on the back. This characteristic is otherwise only known from the Philippine taxa *nuchalis* and *cumingi* (Fig. 20). By contrast, two specimens from Flores (ZMB 33899, Fig. 10, and RMNH 8713 from Flores) also exhibit an unusual bright greyish background colour and a reduction of the dorsal bright spots. Auffenberg (1980) made similar observations on *V. salvator* during the course of his studies of the Komodo dragons on Flores. He described the colour pattern, as follows: "brownish-black with five faint (even in the young) crossbands produced by yellowish-white-edged scales, forming very ill-defined ocelli (rarely seen in live animals but evident when dried skins are held to the light), thus unlike the vividly marked Sumbawa specimen depicted in Mertens (1942)." He also documented a change in colouration of the Flores population presumably related to ontogenetic when he noted: "(…) tail almost uniformly grayish-black above, without obvious light colored bands; (…) Sides of head yellow with 4 vertical brownish-black bars extending onto lower jaws, becoming faint from general darkening with age; dorsally head brownish-black with 3 darker lateral head bars extending over snout and down other side, but observable only in juvenile, head almost uniformly black in adults". Weber (1890) who first recorded the water monitor from Flores did not mention any particular characteristics of this population.

Furthermore, two specimens from Sumba (ZMA 15436, ZMA 12774) among the material examined exhibited differing characteristics: specimen ZMA 12774, a hatchling showing the typical *bivittatus*-markings and bright dorsal dots; and specimen ZMA 15436, an adult with an almost unicoloured dark dorsum but whitish-yellow ventral parts.

Comparison with other taxa:

Compared with *V. s. salvator* from Sri Lanka, *V. s. bivittatus* is distinguished by its lighter dorsal background colour and the dark lateral neck stripes, and by its significantly shorter mean tail length (index 1: for *s. bivittatus* see above versus 1.48-1.80, x = 1.61, s = 0.08). The nostrils of *V. s. bivittatus* are more distant from the tip of the snout (index 2), and more mean scales around the head (character P), and on the dorsal side (characters X, Y, and XY), but less mean scales along the belly (character T) than *V. s. salvator*. For values see Tab. 7.

The colour pattern of *V. s. bivittatus* is easily distinguished from *V. s. andamanensis*, despite the lack of scalation data, by the dark stripes or longitudinal spots on the lateral side of the neck and the distinctive transverse rows of light spots or ocelli in *V. s. bivittatus*.

Significant differences between *V. s. bivittatus* and the herein resurrected subspecies *V. s. macromaculatus* are scarce. Even in colour pattern, the lateral neck stripes occasionally occur in *macromaculatus* specimens from Sumatra and Borneo. However, *V. s. bivittatus* from Java and the Lesser Sunda Islands exhibit shorter mean head lengths relative to the head height (index 11 for *s. bivittatus*: 2.13-2.92, x = 2.61, s = 0.17 versus *s. macromaculatus*: 2.17-3.42, x = 2.72, s = 0.19), and less scales from rictus to rictus (character P). There are additional significant differences between *V. s. bivittatus* (for values see Tab. 7) and the continental South East Asian population of *V. s. macromaculatus* (CSEA) with regard to proportion index 2 (CSEA: 2.07-3.46, x = 2.55, s = 0.31) and

Fig. 9. Dorsal view of a subadult *V. s. bivittatus* (ZFMK 66645) from the designated type locality Java, with characteristic fused spots of the first transverse row in front of the forelimbs.

Fig. 10. Dorsal view of a subadult *V. s. bivittatus* (ZMB 33899) from Endek, Flores, Lesser Sunda Islands with greyish ground colour and reduced light spots.

scalation characters N (CSEA: 82-95, x = 87.64, s = 3.97), TN (CSEA: 161-187, x = 174.93, s = 7.57), and m (CSEA: 106-127, x = 113.92, s = 7.06).

Interestingly, no significant scale or meristic differences exist between *V. s. bivittatus* and the light-spotted monitor lizards of OTU 15 "Sulawesi" (*V. salvator* ssp.). However and despite the classification of both these populations as *salvator* typically-coloured, diagnostic differences exist in the colour pattern of the neck and the dorsum (Tab. 8). In contrast, significant differences to the melanistic *V. togianus* from Sulawesi are numerous with regard to morphometrics (index 10 for *s. bivittatus*: 1.64-2.68, x = 1.88, s = 0.15

versus *togianus*: 1.78-2.29, $x = 2.05$, s = 0.19), and scalation characteristics (characters S, T, N, TN, and m) showing that *V. s. bivittatus* has lower mean scale counts for all the respective characters (Tab. 7).

At the same time, *V. s. bivittatus* is statistically well defined and separated from the three Philippine taxa *marmoratus*, *nuchalis* and *cumingi* by exhibiting smaller and therefore more dorsal scales (characters X, Y, and XY) but also around the tail at one third of the length (characters R), and around midbody (character S, except for *nuchalis*). Moreover, *V. s. bivittatus* is distinguished from *marmoratus* and *nuchalis* by shorter mean tails (index 1 for *s. bivittatus* see 'diagnosis' versus *marmoratus*: 1.48-1.73, $x = 1.61$, s = 0.07 and *nuchalis*: 1.42-1.71, $x = 1.61$, s = 0.08), the nostrils are located closer to the tip of the snout (index 2), and more mean supralabials (character c for *s. bivittatus*: 52-71, $x = 65.29$, s = 3.14 versus *marmoratus*: 57-66, $x = 61.15$, s = 2.30 and *nuchalis*: 58-66, $x = 60.39$, s = 2.37). Additionally, *V. s. bivittatus* is distinct from *cumingi* by having significantly more scales around the head (character P).

Range:
V. s. bivittatus inhabits Java, Bali, Lombok, Sumbawa, Flores, Alor, Wetar and smaller offshore islands. On Komodo Island, water monitors have only occasionally been encountered (C. Ciofi, pers. comm.). The existence of *V. s. bivittatus* on Sumba could be confirmed during the course of this study, while the taxonomic identity of the monitor populations on the islands of Selayar, Tanahjampea and Kalao located between Flores and South West Sulawesi remains unresolved (Fig. 5).

Taxonomic comments:
In his revision of the family Varanidae, Mertens (1942a-c) initially treated the taxon *bivittatus* Kuhl, 1820 as a synonym of the nominotypic subspecies. In his later work, however, he recognized its distinctiveness and taxonomic validity (Mertens 1959b). In contrast, Brandenburg (1983) concluded that the lateral dark stripes on the neck characteristic for this taxon, are not always so clearly expressed in Javanese specimens, and additionally also sometimes occurred in specimens from Borneo and Sumatra. Thus, Brandenburg (1983) treated the specimens from Java and the Lesser Sunda Islands as conspecific with the nominotypic subspecies.

Comparing the geographic range distance of *V. s. bivittatus* to that of South East Asian mainland population of *V. s. macromaculatus*, more diagnostic scalation differences between these allopatric populations are recognizable than within the Greater Sunda Island populations.

Although there are virtually no statistical differences recognizable in proportion indices and scalation characteristics between the three populations of the Greater Sunda Islands inhabited by the two distinct subspecies *V. s. macromaculatus* on Sumatra and Borneo and *V. s. bivittatus* on Java respectively, variations in colour pattern clearly show a distinct tendency towards the populations of Java and further east to the Lesser Sunda Islands (see 'Variations'), again highlighting the subspecific status of the taxon *bivittatus*. Mertens (1942a-c) also recognized these differences in colour pattern, e.g., that the dorsal spots of specimens from Sumatra and Borneo are normally smaller than in Javanese water monitors and those populations from the Lesser Sunda Islands, and for this reason encompassing the range of *V. s. bivittatus*. Our morphological comparisons can only partly confirm this particular observation by Mertens (1942a-c), but additionally we recognized that the dorsal light spots are usually more distinct and better defined in *V. s. bivittatus* (but see 'Variations').

Since only the colour pattern of juveniles and subadults from Flores and Sumbawa is known from the available museum specimens, the question arises how do adult specimens look like? Provided that the vivid colour pattern of Sumbawa specimens does not undergo an ontogenetic change, pictures of vividly coloured water monitors from the internet (e.g., see http://www.kingsnake.com/dnj/monitors/salvator.html) could answer this question.

Only ten specimens (respectively eleven if the depicted Sumbawa monitor lizard of Mertens (1942a) is included) from the Lesser Sunda Islands distributed over four islands (respectively five including Sumbawa) could be examined for this revision. It was not possible to carry out a separate statistical analysis of the various *bivittatus* populations due to the low sample size. At this time, therefore, it is not possible to draw definitive taxonomic conclusions on the aberrantly coloured populations.

***Varanus salvator* ssp.** (OTU 15 "Sulawesi")

Material (18): Ceram (2): ZMB 47902 (Ceram, coll. Stresemann), ZSM 69/1996 (Ceram, coll. E. Stresemann, 1911); Halmahera (2): RMNH 3177 (subad.; Gilolo [= Halmahera], coll. et don. E. A. Forsten, 1841), RMNH 3170 (ad.; Gilolo [= Halmahera], coll. et don. E. A. Forsten, 1841); New Guinea (1): ZMB 29619 (Neuguinea, coll. Menke & Heinroth); Sangihe/Sangir Island (1): RMNH 7328 (Groot Sangihe of Sumalata); Sulawesi/Celebes (12): ZMA 15459 (Celebes, 1909-1910, coll. C. E. Abendanon), ZMA 15440 (Gorontalo, coll. Kimmel), ZMA 15434a, b (2 spec.; North Celebes, coll. Musschenbroek), RMNH 3179 (Manado, coll. E. A. Forsten, 1841), RMNH 7222a, b (2 spec.; Gorontalo), RMNH 3176a, b (2 spec.; Celebes, don. van Delden, 1872?), ZMB 7391 (Gorontalo, 1871-72, coll. A. B. Meyer), ZMB 53562 (Gorontalo, 1871-72, coll. A. B. Meyer), ZSM 609/0 (Celebes, 1861-64, coll. E. W. A. Ludeking).

Diagnosis:
Due to great variations in colour patterns of Sulawesi's varanids (see paragraph 'variation'), no such diagnostic characters are mentioned here (but see Tab. 8).

However, with regard to morphometrics and scalation features, *V. salvator* from Sulawesi and the Moluccas (OTU 15) is characterized by (1) having the greatest mean distance between the nostril and the snout-tip compared with all other *salvator* typically-coloured subspecies of the water monitor (index 2: 1.90-2.64, x = 2.17, s = 0.20); (2) high mean scale counts around the head from rictus to rictus (character P); (3) but the lowest mean scale counts around the base of the tail of all members of the *V. salvator* complex (character Q); (4) low mean scale counts around the midbody (character S) and (5) on the ventral side (character TN); but (6) high mean scale counts along the dorsal side (character XY; see Tab. 7 for single values).

Variation:
The longest preserved specimen examined from the OTU "Sulawesi" (RMNH 3179) measures 1103 mm (SVL = 449 mm, TaL = 654 mm), but the tail-tip is missing. Recent investigations of the Sulawesi varanids confirmed a total length of at least 1600 mm (Koch pers. obs.).

Proportion indices for *V. salvator* spp. from Sulawesi and the Moluccas: index 1: 1.36-1.76 (x = 1.52, s = 0.12), index 2: 1.90-2.64 (x = 2.17, s = 0.20), index 10: 1.61-2.18 (x = 1.94, s = 0.15), index 11: 2.23-2.93 (x = 2.69, s = 0.19).

Scalation characters: 10 to 15 enlarged supraoculars on both sides; 59 to 73 supralabials excluding the rostral (see Tab. 7 for further data).

According to our investigations, the non-melanistic monitor lizards of Sulawesi and the Moluccas exhibit an unusual variety of colour patterns. These are (1) a *salvator* typically-coloured phenotype with large light spots from Sulawesi (e.g. ZMA 15434b, Fig. 11); (2) a small-dotted form from Sulawesi (see Auliya 2003: 431, Fig. 4-2, left); (3) a distinctively ocellated form from Ceram (ZMB 47902, Fig. 12) and probably Sulawesi (Auliya 2003: 431, Fig. 4-1 right); and (4) a morphotype showing a pattern of reduced orange dorsal transverse rows but numerous yellowish spots and markings on the anterior dorsum and nape region from Sulawesi (RMNH 3179, Fig. 13) and Halmahera (RMNH 3170, 3177). In addition, photographic evidence reveals the existence of a morphotype similar to the latter phenotype from Sangihe Island north off Sulawesi.

Comparison with other taxa:
Due to the observed heterogeneity in colour pattern of monitor lizards from OTU 15 (Sulawesi and the Moluccas) together with the small sample size from the latter island group, the subsequent comparisons with other taxa of the *V. salvator* complex basically focuses on morphometric parameters and scalation characters (for single values see Tab. 7):

Noticeably, monitor lizards from Sulawesi (including the Moluccan specimens) are almost exclusively statistically distinguishable from the nominotypical subspecies from Sri Lanka, as well as from the three Philippine taxa *marmoratus*, *nuchalis* and *cumingi*. In comparison with *V. s. salvator*, Sulawesi's monitor lizards exhibit nostrils with a consistently greater mean distance from the tip of the snout (index 2), significantly more scales around the head (character P) and on the dorsal side (characters X, Y, and XY), but less scale rows along the belly (character T).

In general, the diagnostic differences between *V. salvator* ssp. and the three Philippine taxa are most obvious in the three dorsal scale features (characters X, Y, and XY), as the latter species are characterized by significantly larger scales. In addition, Sulawesi's monitor lizards have on average more scales around the tail at one third of its length (character R). There are some additional specific differences between *V. salvator* ssp. and the respective Philippine taxa with regard to the ventral scale rows (character TN) for *marmoratus*, with regard to scalation characters S, T, and U for *nuchalis*, as well as for *cumingi* with regard to the mean amount of head scales (character P).

In contrast, varanids from Sulawesi do not differ significantly from *V. s. bivittatus* in any parameter examined. Despite striking differences in colour pattern, spotted monitor lizards from Sulawesi and the Moluccas can only be distinguished from the melanistic *V. togianus* by more mean scales from rictus to rictus around the head (character P), and around midbody (character S, $p = 0.056$). The latter morphological trait is, however, statistically not strictly significant. Ultimately, *V. salvator* ssp. from Sulawesi differs significantly from *V. s. macromaculatus* by having less mean scales around midbody (character S) and around the base of the tail (character Q).

Range:
Mertens (1930, 1942a-c, 1959b) reported *V. s. salvator* from Sulawesi, Obi, Halmahera, and Bacan (Batjan) at the eastern boundary of its range, although no material from either of the latter both islands were available to him. More recent authors have added Sulawesi to the distribution area of the taxon *togianus* (Eidenmüller 2003, Gaulke & Horn 2004) or to both taxa (Boulenger 1897, Iskandar & Nio 1996) while the possi-

Fig. 11. Dorsal view of a juvenile *V. salvator* ssp. (ZMA 15434b) from Sulawesi: *salvator* typically-coloured (spotted) phenotype.

Fig. 12. Dorsal view of *V. salvator* ssp. (ZMB 47902) from Ceram: ocellated phenotype.

Fig. 13. Dorsal view of *V. salvator* ssp. (RMNH 3179) from Manado, north Sulawesi: phenotype with reduced dorsal transverse rows of light spots.

Fig. 14a, b. Dorsal and ventral view of the paratype of *V. togianus* (ZMB 7389) from Togian Island, Central Sulawesi.

ble distribution of water monitors in the Moluccas has been largely ignored in all these studies.

Therefore, new investigations are needed to verify these locality data, since past records of water monitors from several Moluccan islands, i.e. Halmahera, Bacan, Buru, Ambon and Ceram (Bleeker 1857, 1860a, b, De Rooij 1913, 1915), remain equivocal. The material examined during our study, however, seems to confirm the occurrence of water monitors for Halmahera (RMNH 3170, RMNH 3177) and Ceram (ZMB 47902, ZSM 69/1996).

Specimen ZMB 29619 from New Guinea, and records of *V. salvator* from Northern Australia (see Loveridge 1934: 331) are based on false locality data (Mertens 1963: 16). Thus, the exact eastern boundary of the distribution of *V. salvator* remains unknown (Fig. 5).

Taxonomic comments:
Sprackland (1992: 129) depicted a live monitor lizard with orange-yellowish dorsal spots very similar to RMNH 3179 from Sulawesi mentioned above. This specimen,

however, was erroneously identified by Sprackland as the Philippine *V. cumingi*, although no locality data was provided. In contrast, Lemm (2001) illustrated another live specimen – allegedly from Sulawesi – belonging to the *salvator* typically-coloured phenotype, but displaying dorsal light spots partly fused to crossbands; and the colour pattern lacking orange pigmentation (the same photograph is presented in Eidenmüller, 2003: 114). He also referred to an orange-spotted colour morph of the Sulawesi monitor lizard available through the US pet trade (Lemm 2001).

Ongoing genetic studies of the *V. salvator* complex revealed the basal – and thereby distinct – position of varanids from Sulawesi and Sangihe Island within this closely related group (Kuch et al. in prep.).

Consequently, the genetic and morphological differentiations emphasize the need to consider a distinct taxonomic rank for Sulawesi's water monitor populations. The name *celebensis* Schlegel, 1844 – originally published as *Monitor bivittatus* var. *celebensis* – would be available for these insular populations. This taxon is currently used as a synonym for *V. s. salvator* (Böhme 2003). There are, however, reasonable grounds that prevent an accurate taxonomic definition of the taxon *celebensis*. These are in particular, (1) the observed polymorphism in colour patterns of monitor lizards from Sulawesi (including associated islands); (2) the unknown exact distribution of single Sulawesian morphotypes; together with (3) a very short description provided by Schlegel (1837-44); (4) a missing type specimen; and finally, (5) the unknown exact type locality. Therefore, at this point in time, it seems to be premature to formally resurrect the taxon *celebensis* Schlegel, 1844. Ongoing research into the phylogeography and systematics of water monitors in the Sulawesian region will enlighten the taxonomy of these polymorphic monitor populations (Koch & Böhme 2005, Koch et al. 2007, unpubl. data).

***Varanus togianus* (Peters, 1872)**
Monitor (*Hydrosaurus*) *togianus* Peters, 1872. Monatsbericht der Königlich Preußischen Akademie der Wissenschaft zu Berlin, 1872: 581-585 [p. 582].

Synonymy: No synonyms for this species are known (Böhme 2003).

Type material:
Lectotype, designated by Mertens (1942c): ZMB 7388, adult male, Timotto, Togian Island, Gulf of Tomini, Sulawesi; Paralectotype: ZMB 7389 (Fig. 14), adult female, same locality data as holotype, both collected in 1872 by A. B. Meyer.

Good et al. (1993) pointed out that Peters (1872) did not mention any hierarchy between either type specimens. These authors treated them as lectotype (ZMB 7388) and paralectotype (ZMB 7389).

Here, we prefer to depict the paralectotype rather than the lectotype itself because it is in a much better condition (Fig. 14). A colour illustration of the lectotype can be found in Koch (2004).

Other material (5): Sulawesi/Celebes: ZMA 15460 (Makassar, coll. G. J. Terwiel, 1925), ZMA 15461 (Celebes, 1893, coll. Hudig & Blokhuizen), ZMA 15437 (Makassar ?, don. H. W. Boeckholt), ZMA 15462 (Tello near Makassar, coll. M. Weber, 1888), RMNH 3178 (Makassar, coll. Piller).

Diagnosis:
The melanistic taxon *togianus* is a member of the *V. salvator* complex, characterized by

the combination of (1) a dark (in preservative dark brown, in life black) dorsal background colour with dark scales more or less encircled by light brown to orange granula forming light distal margins; (2) lacking any spots or ocelli dorsally; (3) a unicoloured dark tail without light crossbands; (4) a dark coloured ventral side with distinctive yellowish rectangles on the chin and throat; (5) more than ten indistinct light crossbands on the belly; and (6) large (ventral) scales mirrored by the presence of OTU 14 in cluster I (i.e. lowest mean values) of nine in thirteen parameters (P, Q, S, T, N, TN, U, c and m). For pholidotic characters S, T, N, TN, and m these monitor lizards reveal the lowest mean scale counts on the ventral side among all taxa under investigation (see Tab. 7). The remaining diagnostic feature is the double mean head length relative to its width (index 10: 1.78-2.29, $x = 2.05$, s = 0.19). All other taxa have a shorter mean head length (index 10: $x < 2.00$).

Variation:
The longest specimen examined is ZMB 7388, the lectotype. According to the description in Peters (1872), this specimen was 1125 mm long, but only measures 1062 mm after 130 years of preservation.

Proportion indices for *V. togianus*: index 1: 1.54-1.75 ($x = 1.62$, s = 0.09), index 2: 1.83 -2.70 ($x = 2.24$, s = 0.29), index 10: see above, index 11: 2.36-2.89 ($x = 2.68$, s = 0.23). Scalation characters: 10 to 11 enlarged supraoculars on both sides; 60 to 68 supralabials exclusive the rostral. Although only seven specimens were available for this study, the values of some scalation characters and one proportion index exhibit a high variability for index 10 (see above), Y (86-130), XY (117-172), and m (78-107) (see Tab. 7 for further data).

Colour pattern: In addition to the type specimens from the Togian Islands, only three other examples of the taxon *togianus* could be examined. These are ZMA 15437, ZMA 15462 and RMNH 3178 from Sulawesi (Fig. 15). All three specimens meet the description by Peters (1872), and resemble both type specimens in being unicoloured brown (possibly faded during preservation) and the absence of spots or ocelli on the dorsum. The Sulawesi specimens show a more or less distinctive pattern of small yellow dots created by single light scales on the dorsum, particularly on the limbs. Nevertheless, their colour patterns do not fully match with the characteristic features of the *togianus* type specimens, as they have a light temporal streak on the side of the head extending between the eye and the tympanum (a characteristic of most *salvator*-typically coloured populations), and unicoloured light ventral sides without the indistinct dark crossbands. In addition, their light chins show dark crossbands rather than the distinctive rectangles of *V. togianus*, and their throats are unicoloured dark without any distinct pattern.

Comparison with other taxa:
V. togianus is easily to be distinguished from most other members of the *V. salvator* complex by its entirely black dorsal colouration (probably also in juveniles) without any traces of a light-spotted pattern. Unlike the phenetic similarity to the dark morphotypes of *V. marmoratus* and *V. nuchalis* respectively, these taxa differ from each other in numerous scalation features (see below).

Similarly, significant differences in scalation characters mainly distinguish *V. togianus* from the populations of continental South East Asia, the Greater Sunda Islands and from those of the Philippine taxa *marmoratus* and *nuchalis* (see Tab. 7 for values of proportion and scalation characters).

Fig. 15a, b. Dorsal and ventral view of *V.* cf. *togianus* (RMNH 3178) from Macassar (Ujung Pandang), south-west Sulawesi.

In comparison with *V. s. salvator* statistical differences apply to lower mean values in scalation characters S, T, TN and m for *V. togianus*.

The diagnostic differences to *V. s. macromaculatus* are numerous so that *V. togianus* differs significantly from these populations by longer heads relative to head width (index 10: 1.78-2.29, x = 2.05, s = 0.19 versus 1.53-2.22, x = 1.90, s = 0.12) as well as by lower mean values for scalation characters P, S, T, N, TN, and m.

Almost the same combination of proportion and scale characters distinguishes the melanistic Sulawesian species from *V. s. bivittatus* (index 10: 1.64-2.68, x = 1.88, s = 0.15); only the mean values for character P are not significantly different.

In contrast, nearly no statistical differences are recognizable between *V. togianus* and the light-spotted monitor lizards of Sulawesi and the Moluccas (*V. salvator* ssp.) with exception for characters P and S. The latter mean value, however, is not strictly significant (p = 0.056).

Differences in mean scalation values between *V. togianus* and *V. marmoratus* exist for characters T, N, TN, Y, and XY reflecting the characteristic larger ventral scales and smaller dorsal scales in the Sulawesian species. Besides these scalation features, *V. togianus* differs significantly from *V. nuchalis* in proportion index 10 (1.64-2.29, x = 1.86, s = 0.12) and characters R, S, and X. In contrast, *V. cumingi* exhibits lower mean scale counts than *V. togianus* only around the tail at one third of its length (character R) and on the dorsal side (characters X and XY).

Range:

V. togianus inhabits the Togian Islands and Sulawesi (Fig. 5). Weber (1890: 169) asserted that *V. togianus* "is a typical species of the Celebesian fauna; for I found it in South Celebes and on the Island of Saleyer [= Selayar], that belongs faunistically and geographically to Celebes". Mertens (1930: 61) initially confirmed this record (see also Barbour 1912: 183, de Rooij 1915: 148) for Selayar (still as *V. togianus*), but later changed his opinion (Mertens 1942c: 252). In 1942, Mertens claimed that the records of *V. togianus* actually referred to *V. s. salvator*, which also inhabited Sulawesi. Hence Mertens (1942a-c, 1959b) never considered a sympatric occurrence of two different forms of the *V. salvator* complex, even though he had the opportunity to examine a female *V. togianus* specimen (MNVB 552) from "Celebes" some years later in Basel (Switzerland), which was donated by the Museum in Amsterdam (ZMA) in 1905 (Mertens 1959b). Boulenger (1897) also reported *V. togianus* from Central and South Sulawesi, based on material collected by P. & F. Sarasin and M. Weber. One *togianus* specimen had been donated to the BMNH by Max Weber (Boulenger 1894). More recently, Iskandar & Nio (1996) recorded *V. togianus* from the northern peninsula of Sulawesi.

Our investigations confirm the occurrence of dark coloured monitor lizards, *V.* cf. *togianus*, on the main island of Sulawesi of which three further melanistic specimens were examined during this study, including RMNH 3178 discussed above.

Taxonomic comments:
Since its description by Peters (1872), *V. togianus* has been rare in herpetological collections, in addition to the virtual absence of knowledge about its biology. The reason may be the restricted range of the taxon resultant with only few scientific expeditions. Hence, remarks about *V. togianus* in the herpetological literature refer mainly to diagnostic comments on the original description (e.g., Boulenger 1885, 1897, Horn & Gaulke 2004). As far as we are aware, photographs of these varanids have only been published recently by Auliya (2003: 431). Elsewhere, equivocal contributions have been made. Nelly de Rooij (1915), for instance, provided an account about the colour pattern and measurements of juvenile and adult *V. togianus*. Her measurements of the first, juvenile specimen together with the colour pattern of the second, adult specimen, however, seem to match with the specimen ZMA 15462: a unicoloured dark subadult specimen without any light stripe or spots along the neck and body (see Fig. 15 of RMNH 3178 as comparable specimen). Therefore, it remains unclear which juvenile specimen de Rooij (1915) described from the ZMA and RMNH collections as no *togianus*-like juvenile was tracked down during our investigations of these collections. Instead some specimens of the *salvator* typically-coloured Sulawesian form were discovered.

Auliya (2003: 431) provided a photograph of a live juvenile monitor lizard showing a dark grey background colour with a fine pattern of numerous yellowish dots consisting only of single scales, which is in agreement with the original description by Peters (1872). So far, the colour pattern of this specimen is in best agreement with the diagnostic characters of the taxon *togianus*. During the examination of both type specimens, however, no yellow dots could be recognized at the posterior end of the dorsal scales as mentioned by Peters (1872). A reasonable assumption is that this feature may have darkened during the specimen's long period of preservation in alcohol. In support of this assumption, Weber (1890) emphasised that "this species is easily to be distinguished from *Varanus salvator* by its larger scales of the upper surface and by the totally different colour."

Two specimens included in OTU 14, ZMA 15460 and ZMA 15461, were also involved in Brandenburg's (1983) unpublished study about "Monitors in the Indo-Australian Archipelago". These two specimens, however, could not be found in the ZMA collection in November 2003 (AK). Both specimens were reidentified by R. Sprackland as *V. togianus*, hence as a separate species, although according to the specimen labels, they had previously been identified as *V. salvator*. Since Brandenburg (1983) did not mention any aberrant, i.e. melanistic colouration of these specimens (see citations below), Sprackland's determination as *V. togianus* remains doubtful. Nevertheless, Brandenburg's (1983) values of the respective specimens are included in the analyses presented here and are assigned, with regard to Sprackland's classification, to the taxon *togianus*. The reason why Brandenburg (1983) did not recognize the assumed identity of these specimens is obvious by his remark, that "this subspecies (…) is only known from two specimens (adult) (Peters, 1872) which differ from *s. salvator* only in coloration (black with little yellow)." Since Brandenburg (1983) only examined the ZMA and RMNH material for his study, the ZMB type specimens were not included. Finally, Brandenburg (1983) even questioned the validity of the taxon *togianus* when he stated: "As adult specimens of *salvator* all tend to become more or less uniformly black, it is clear, that further material from the Togian Islands is important to investigate the validity of this subspecies."

The differences in colour pattern outlined above between both populations of melanistic Sulawesi monitor lizards, on the small Togian Islands (*V. togianus*) as well as on Sulawesi itself (*V.* cf. *togianus*), might represent some kind of intraspecific variation caused by genetic drift. In addition, the lack of homogeneity in some of the scalation characters mentioned above, could either indicate a mixed OTU 14 or could reflect geographic variation within *V. togianus*. Both hypotheses are supported by the Hierarchical Cluster Analysis that provides statistically significant evidence for the disjunctive position of both type specimens on the Philippine branch, and quite distinctive from the melanistic monitor lizards from Sulawesi (together with *salvator* typically-coloured specimens from that island) which build a separate clade.

A situation similar to the monitor lizard populations from Sulawesi exists on the South East Asian mainland, where a melanistic colour morph with no diagnostic morphological differences occurs next to *salvator* typically-coloured specimens (see above). The crucial difference here, however, lies in the distinctive occurrence of the colour pattern. Whereas the melanistic specimens from Thailand show no traces of a colour pattern, *V. togianus* possesses the characteristic rectangular-shaped and crossbanded colour pattern on the ventral side as described above. The monochrome black of the Thai *V. s. macromaculatus* may be the result of a melanism-generating mutation. This explanation, however, can not be applied to *V. togianus* as the distinctive ventral colour pattern argues against a trend towards melanism per se, and highlightens the fact that these dark Sulawesian monitors represent a distinct species, rather than a darkened *salvator* typically-coloured morph.

In conclusion, the data outlined above (i.e. the differential morphological characteristics of the melanistic monitor lizards and the possible sympatric occurrence on Sulawesi with a *salvator* typically-coloured form of the water monitor) strongly emphasise a need to resurrect the former species status of *Monitor* (*Hydrosaurus*) *togianus* Peters, 1872. Recent investigations on the phylogeny of varanids by Ast (2001), have confirmed that there are distinctive molecular genetic differences between *V. togianus* and other taxa of the *V. salvator* complex, which warrant species rank for these melanistic Sulawesian monitor lizards (A. Kluge pers. comm. in Ast 2001).

Interestingly, there are virtually no statistical differences in proportion and scalation characters between the studied specimens of *V. togianus* and the geographically adjacent taxa from Mindanao (*V. cumingi*), the Lesser Sunda Islands (*V. s. bivittatus*) and Sulawesi (*salvator* ssp.). As revealed in this study, the taxonomic identity of the black Sulawesi monitor lizards and the exact range of *V. togianus* are far from resolved, and are the subject of ongoing investigations of the *V. salvator* complex in Indonesia (Koch & Böhme 2005, Koch et al. 2007, unpubl. data).

***Varanus marmoratus* (Wiegmann, 1834)**
Hydrosaurus marmoratus Wiegmann, 1834a. In Meyen: Reise um die Erde ausgeführt auf dem Königlich Preussischen Seehandlungs-Schiffe Prinzess Louise, commandirt von Capitain W. Wendt, in den Jahren 1830, 1831 und 1832 von Dr. F. J. F. Meyen. Dritter Teil. Zoologischer Bericht. – Sander`sche Buchhandlung (C. W. Eichhoff), Berlin, pp. 522 [p. 446, pl. 53].

Also: Wiegmann (1834b): Beiträge zur Zoologie, gesammelt auf einer Reise um die Erde, von Dr. F. J. F. Meyen, M.d.A.d.N. Siebente Abhandlung. Amphibien. – Nova Acta Academiae Caesareae Leopoldino-Carolinae Naturae Curiosorum, 17(1): 184-268 [pp. 196-201, pl. 14].

Synonymy:
1829 Monitor marmoratus Cuvier, Règne animal **2**(2): 26. – Type locality: Manila, Luzon (*Nomen nudum* according to Good et al. 1993).

1844 Monitor bivittatus philippensis Schlegel, Abb. Amphib.: X. – Type locality: Manila, Luzon.

1876 Varanus manilensis v. Martens, Preuß. Exped. Ostas. Zool., **1**: 196. (Lapsus according to Mertens, 1942).

1944 Varanus salvator philippinensis Deraniyagala, Spol. Zeylan., **24**: 61. – Type locality: Luzon.

Type material:
Lectotype: ZMB 470, subadult, Luzon, Philippines, collected 1830-32 by F. J. F. Meyen.

As the valid description of the taxon *marmoratus* was written by Wiegmann (1834a), the voucher specimens for his description have to be regarded as the type material of this taxon (Good et al. 1993). In contrast, Guibé (1954) declared the specimen MNHN 8274 as holotype of *marmoratus*, although he accepted that the taxon's author was Wiegmann and not Cuvier. Brygoo (1987) added that Cuvier (1829) originally based his description on two specimens; MNHN 8274 and V 17/22. But these specimens are, according to Brygoo (1987), not the type specimens of Wiegmann's *Hydrosaurus marmoratus*. Although Wiegmann (1834b) mentioned two specimens in his description, Mertens (1942c) declared specimen ZMB 470 as the exclusive holotype of the Philippine taxon *marmoratus*. Good et al. (1993) confirmed the identification of ZMB 470 as the smaller syntype of Wiegmann's original description. It should, therefore, be regarded as the lectotype of the taxon *marmoratus* Wiegmann, 1834 since the second larger original syntype, which should have paralectotype status, is missing (Good et al. 1993).

Type locality:
Wiegmann (1834b) referred in his description of *V. s. marmoratus* to a text passage by Cuvier (1829) where this author mentioned a monitor lizard from "manille" (= Manila, Luzon, Philippines), called *Monitor marmoratus*, without giving details to this

taxon. At the end of his description, Wiegmann (1834b) stated that these reptiles are very common in the central area of Luzon citing the village of San Mateo (San Matheo) and the island of Talim in the Laguna Bay, both near Manila, as examples. Mertens (1942c: 254) restricted the type locality without any explanation solely to San Mateo (San Matheo). This decision was adopted by later authors (e.g., Wilms & Böhme 2001, Böhme 2003).

Other material (24): Balabac (3): ZMUC E78 (Dalawan Bay, coll. Noona Dan Eksp., 8. X. 1961), SMF 74740-41 (2 ad.; coll. T. Aguilar, don. M. Gaulke, VII. 1990); Busuanga (1): SMF 73909 (ad.; Provinz Palawan, coll. M. Gaulke, 5. VI, 1988, don. 29. VI. 1988); Calauit (2): SMF 73907-8 (2 ad.; Provinz Palawan, coll. M. Gaulke); Luzon (10): ZMB 470 (subad.; Manila, coll. F. J. F. Meyen, type); ZFMK 21093 (Luzon, coll. einh. Sammler, 1977, don. B. Schulz, X. 1977), RMNH 17052 (Luzon), ZMB 4894 (subad.; Luzon), ZMB 53586 (Luzon, coll. Meyer), ZMB 4895 (Luzon, coll. Jagor), RMNH 3173 (subad.; Luzon, Jalajalo, coll. et don. Verreaux, 1834), SMF 73910-11 (2 ad.; Bacon, Sorsogon, coll. M. Gaulke, III. 1989, don. 6. IV. 1989); Palawan (4): SMF 73912-15 (4 ad.; Tabon, coll. M. Gaulke, I. 1989, don. 6. IV. 1989); Polillo Island (1): ZFMK 73333 (Burdeos, coll. B. Klusmeyer, 18. IX. 1998, don. F. Glaw, VIII. 2000); Sulu Archipelago (3): ZMUC E141 (Tawi Tawi Island, Tarawakan, North of Batu Batu, coll. Noona Dan Eksp., 13. XI. 1961), ZMUC E136 (Tawi Tawi Island, Tarawakan, North of Batu Batu; coll. Noona Dan Eksp., 27. X. 1961), SMF 74295 (subad.; Sibutu Island, Kaban Kaban, coll. M. Gaulke, 16. VI. 1990, don. 30. VII. 1990).

Diagnosis:
V. marmoratus is characterized by the following combination of characters: (1) the nostril position (index 2) at approximately one third the distance from eye to tip of snout; (2) low mean scale counts around the tail at one third of its length (character R: 48-65, x = 54.15, s = 4.68) and (3) around midbody (character S: 115-178, x = 138.78, s = 13.32); (4) high mean scale counts on the ventral side (character TN: 155-183, x = 169.00, s = 7.73); but in contrast, (5) larger scales and thereby low mean numbers on the dorsal side (character XY: 106-145, x = 120.24, s = 10.63); (6) reduced light spots in the second transverse row on the dorsal side behind the forelimbs; (7) a whitish ventral side with up to five dark crossbands on the chin; and (8) six to eleven dark pointed bars or crossbands on the belly.

Variation:
The longest specimen of *V. marmoratus* examined (SMF 73913) originates from Palawan and measures 1249 mm (SVL = 475 mm, TaL = 774 mm). This Philippine monitor species, however, may reach a total length of up to 2000 mm (Gaulke 1991).

Proportion indices: index 1: 1.48 -1.73 (x = 1.61, s = 0.07); index 2: 1.69-2.60 (x = 1.99, s = 0.19); index 10: 1.60-2.15 (x = 1.90, s = 0.15); index 11: 1.94-3.16 (x = 2.66, s = 0.32). Scalation characters: 10 to 16 enlarged supraoculars on both sides; 57 to 66 supralabials excluding the rostral (see further data in Tab. 7).

Particularly the colour pattern of *V. marmoratus* shows a high degree of variability between the sample populations. Although specimens from Luzon and Polillo Island usually exhibit distinct transverse rows of light spots on the back – thereby superficially resembling rather *salvator* typically-coloured taxa – the second row to the shoulders, however, is largely reduced in these populations (Fig. 16). In other populations mainly from Palawan and Balabac but also from the Sulu Archipelago (*V.* cf. *marmoratus*, see

Fig. 17), adult varanids tend to have a melanistic appearance, or an extremely subdued dorsal colour pattern of light spots. Interestingly, this colour pattern is dissimilar in juveniles in some of these populations, which reveal an increased number of transverse rows of light spots (e.g. ZMUC E136 from the Sulu Archipelago). Variable whitish blotches on the head are also typical for at least a part of the dark-coloured *V. marmoratus* populations, thereby exhibiting phenotypic similarities to some *V. nuchalis* specimens (see respective paragraph in the *V. nuchalis* chapter).

Comparison with other taxa:
Colour pattern: Interestingly, *V. marmoratus* from Luzon with its light dorsal spots has the widest geographic separation from the next *salvator*-typically coloured population of Borneo, but has more external similarities with these monitor lizards than with any

Fig. 16. Dorsal view of juvenile *V. marmoratus* (ZFMK 73333) from Polillo Island, east of Luzon, Philippines: light (spotted) phenotype.

Fig. 17. Dorsal view of juvenile *V.* cf. *marmoratus* (ZMUC E141) from Tawi-Tawi, Sulu Archipelago, Philippines: dark phenotype (adults without light spots).

other *marmoratus* population. The reduction of the second dorsal transverse row is characteristic only for the Philippine *V. marmoratus*, which additionally distinguishes this taxon from *V. nuchalis* and *V. cumingi*. Notably, the white markings of the head in some populations of *V. marmoratus* (Palawan, Balabac, and Calauit) are very similar to *V. nuchalis* specimens from Negros, Cebu and Panay. This distinctive character in colour pattern for these taxa is unique within the *V. salvator* complex.

Scalation and proportion characters: Compared with *V. s. salvator*, *V. marmoratus* varies significantly in proportion index 2 (see above), reflecting the greater distance between the nostrils and the tip of the snout than in the nominotypical subspecies of the water monitor. Additionally, *V. marmoratus* differs from *V. s. salvator* in having fewer scales around the tail at one third of its length (characters R), and around midbody (character S), yet apparently a phenotypic similarity between certain populations of both taxa (see above).

Compared with *V. s. macromaculatus*, the diagnostic differences are numerous. This is exemplified in the position of the nostrils (character index 2, see above) and the fewer mean number of scales around the head (character P), around the tail at one third of its length (character R), around midbody (character S), along the dorsal side (characters X, Y, and XY), and supralabials (character c for *marmoratus*: 57-66, x = 61.15, s = 2.30 versus *macromaculatus*: 58-74, x = 65.30, s = 3.01).

Similarly, the significant statistical differences between the Philippine *V. marmoratus* and *V. s. bivittatus* are recognizable by the position of the nostrils (index 2) and a lower mean scale count for characters R, S, X, Y, XY, and c (*V. s. bivittatus*: 52-71, x = 65.29, s = 3.14; see Tab. 7 for the remaining values of both taxa).

For the water monitors of Sulawesi and the Moluccas (*V. salvator* ssp.), *V. marmoratus* again exhibits a lower mean scale count on the dorsal side (characters X, Y, and XY) and around the tail at one third of its length (character R); but a statistically higher scale count on the ventral side (character TN).

Compared with the melanistic *V. togianus* from Sulawesi, *V. marmoratus* has significantly higher mean ventral scale counts (characters T, N, and TN), but lower mean scale counts on the dorsal side (characters Y and XY).

Compared with the Philippine congener *V. cumingi*, mean values indicate that the nostrils of *V. marmoratus* are closer to the tip of the snout (character P). *V. marmoratus* exhibits a higher number of smaller-sized scales around the head, with no overlap between the dark morphotypes of both species in this character (character P for dark form of *marmoratus*: 53-65, x = 57.50, s = 3.96 versus *cumingi*, dark form: 47-51, x = 49.13, s = 1.55). The more numerous dorsal scales (character TN) of *V. marmoratus*, are statistically only weakly significant (p = 0.048).

In contrast, statistical differences to *V. nuchalis* occur with higher mean scale counts around the tail (character R); but a lesser mean number of scales around the midbody (character S). *V. marmoratus* additionally exhibits a greater mean number or smaller nuchal scales on the neck (character X).

Range:

V. marmoratus has a disjunctive distribution in the Philippines, inhabiting the northwestern islands of Luzon, Mindoro, Calamian, Palawan, Balabac as well as the Sulu Archipelago in the northeast of Borneo except for Basilan (Gaulke 1992a, b, 1995) (Fig. 5). Mertens (1942c: 256) disputed the existence of water monitors on the Pacific Caroline Islands (SMF 11572 from Yap, coll. by Poehl in 1887), tracing back this record to human dispersal or a mistake in the locality.

Taxonomic comments:

Due to its phenetic similarity to *V. salvator*, Wiegmann's *Hydrosaurus marmoratus* was used as a senior synonym for the former taxon over long periods in the taxonomic history of the water monitor (Boulenger 1885, Taylor 1922), until Mertens (1942a-c) recognized the morphological distinctiveness of Luzon's monitor lizards. Thereafter the taxon was treated as a subspecies of *V. salvator* (e.g., Gaulke 1989, Bennett 1998, Böhme 2003).

Until recently, there was confusion concerning the exact determination of the year in which Wiegmann's „Amphibien" section of Meyen's „Reise um die Erde" including *inter alia* the description of the taxon *marmoratus*, was published. The situation became more complicated as several versions of the paper about Meyen's published journey were distributed (Bauer & Adler 2001). Brygoo (1987), for example, dated the description to 1834 but referred to Nova Acta Acad. Caes. Leop.-Carol. Nat. Cur., XVII, p. 196 (see also Mertens 1942c, Bennett 1998, Böhme 2003). This publication, however, was possibly published one year later in 1835 (Bauer & Adler 2001). Consequently, Good et al. (1993) argued that the valid description should be dated to 1835. Eventually, Bauer & Adler (2001) corrected that the taxon *marmoratus* was used for the first time in the third volume of Meyen's "Reise um die Erde" published in 1834. In this paper, we follow these authors argumentation.

Interestingly, Gaulke (1991) recorded that the population of southern Luzon showed characteristics of two different taxa, displaying a colour pattern typical for *V. nuchalis*, and pholidotic characters typical for *V. marmoratus*. This potential zone of hybridisation may provide evidence for the close relationship of these two Philippine monitor species. The similarity of the white-headed colour pattern in both taxa may provide another indicator for this assumption. Published and unpublished results of genetic investigations of water monitors (Ast 2002, Kuch et al. in prep.) revealed the distinctiveness of this Philippine species, thus justifying (1) the original specific status of *V. marmoratus*, and at the same time, (2) the close phylogenetic relationship to *V. nuchalis*. Morphological investigations on the genitalia of *V. marmoratus* by Ziegler & Böhme (1997), however, could not identify any disparities in comparison with *V. salvator*. The apparent ossification of the hemibacula in *V. marmoratus* noticed by Böhme (1988) merely is the result of the preservation process (Ziegler & Böhme 1997).

Despite distinct features in colour pattern of individual *V. marmoratus* populations and, as was evident, distinct variations compared to other taxa examined (see above), no significant differences in scalation or proportion characters between the light (spotted) and the dark morphotype of *V. marmoratus* could be identified.

Further differences noted in colour pattern of the disjunctive populations of *V. marmoratus*, and the phenotypical similarity to *V. nuchalis* will be discussed by us elsewhere.

***Varanus nuchalis* (Günther, 1872)**

Hydrosaurus nuchalis Günther, 1872. Proceedings of the Zoological Society of London, 1872: 145-146, pl. VIII.

Synonymy: No synonyms for this species are known (Böhme 2003).

Type material:

Holotype: BMNH 1946.9.1.17, adult, "Philippines", collected 1861 by J. G. Veitch.

According to Bayless & Adragna (1997), the *nuchalis* type specimen was collected by John G. Veitch (1839-1870) during his journey to the Philippines in 1861. After his return to England the specimen was deposited in his private collection. When J. G. Veitch passed away in 1870, his collections were donated to the British Museum (Natural History) by his brother Harry J. Veitch in 1871. One year later, the new taxon was described by Günther (1872).

Other material (25): Cebu (6): SMF 73916-7 (2 ad.; Taloot, coll. M. Gaulke, V. 1988, don. 29. VI. 1988), SMF 73918 (ad.; Argao, coll. M. Gaulke, V. 1988, don. 29. VI. 1988), SMF 73920-1 (2 ad.; Argao, coll. M. Gaulke, V. 1988, don. 29. VI. 1988), ZSM 611/0 (*V. s. bivittatus*, juv.; Cebu?; coll. Krapfenbaum, 1901); Masbate (7): SMF 73922-3 (2 ad.; Panal, coll. M. Gaulke, 6. IV. 1988, don. 29. VI. 1988), SMF 73925-9 (5 ad.; Panal, coll. M. Gaulke, 6. IV. 1988, don. 29. VI. 1988); Negros (6): SMF 73930-5 (6 ad.; Silliman Farm, Dumaguete, coll. M. Gaulke, VI. 1988, don. 29. VI. 1988); Panay (4): ZSM 592/2002 (juv.; Provinz Antique, Pandan, III. 2002), SMF 73936-8 (3 ad.; Antique, Lipata, Culasi, coll. M. Gaulke, II. 1989, don. 6. IV. 1989); Philippines (1): BMNH 1946.9.1.17 (ad.; Philippines, coll. J. G. Veitch, 1861, don. H. J. Veitch, 1871, type); Ticao Island (1): SMF 73924 (ad.; San Fernando, coll. M. Gaulke, 16. IV. 1988, don. 29. VI. 1988).

Diagnosis:
The best diagnostic characters for *V. nuchalis* are (1) the enlarged nuchal scales on the neck (except for those situated directly along the medio-dorsal line) leading to the taxon's name (character X) in combination with (2) the lowest mean scale counts on the dorsal side (character XY). Additionally, this Philippine species is characterized by the following combination of proportion and scalation features: (3) the nostrils position (index 2) at approximately one third the distance from eye to the tip of the snout; (4) low mean scale counts around the tail at one third of its length (character R: 44-61, x = 48.71, s = 4.04; (5) but high mean scale counts around midbody (character S: 137-169, x = 153.04, s = 9.74); (6) and on the ventral side (especially from the gular fold to the insertion of the hindlimbs, character T: 84-94, x = 87.75, s = 2.94); (7) mostly with white markings on the head; (8) occasionally a light medio-dorsal stripe on nape and dorsum; and (9) usually a reduction of the dorsal transverse rows of light spots with exception of pairs of two large oval spots or ocelli positioned immediately left and right along the backbone.

Variation:
The longest specimen of *V. nuchalis* examined (SMF 73920) from Cebu in the centre of the Philippines measures 1176 mm (SVL = 533 mm, TaL = 643 mm) but the tip of the tail is missing. According to Gaulke (1991), *V. nuchalis* is the smallest taxon of all three Philippine monitor lizard species reaching a maximum length of up to 1400 mm. However, the type specimen BMNH 1946.9.1.17 measured 1430 mm (Mertens 1959b).

Proportion indices: index 1: 1.42 -1.71 (x = 1.61, s = 0.08), index 2: 1.78-2.20 (x = 1.94, s = 0.12), index 10: 1.64-2.29 (x = 1.86, s = 0.12), index 11: 2.39-4.18 (x = 2.75, s = 0.40). Scalation characters: 9 to 15 enlarged supraoculars on both sides; 58 to 66 supralabials excluding the rostral (for further scalation data see Tab. 7). Specimen SMF 72935 from Negros has a deformed head, resulting in an extraordinary high value for index 11 (4.18).

Colour pattern: As already indicated by the separation of the *V. nuchalis* population within the statistical analyses into a light and a melanistic form, this Philippine monitor lizard species exhibits a high variability in colour pattern. While specimens from Negros, Panay and Cebu mostly have more or less reduced transverse rows of light oval spots on the dorsal side (Fig. 18), the populations from Masbate and Ticao are usually unicoloured black without any light spots (Fig. 19). These features in colour pattern, however, are not consistent in all specimens of the respective *nuchalis* populations thus rejecting a geographic and therefore taxonomic correlation. With respect to the ventral side, *V. nuchalis* shows variations in colour patterns on the belly ranging from dark crossbands to reticulate markings. The throat in these varanids can be uniformly dark or exhibit dark markings of various extend or sometimes V-shaped lines.

Comparison with other taxa:
Colour pattern: Unique for the colour pattern of *V. nuchalis* is the reduction of the lateral light spots on the dorsal side. As already mentioned for *V. marmoratus*, the irregular white blotches of the head in *nuchalis* specimens from Negros, Cebu and Panay are another characteristic only related to both these taxa within the *V. salvator* complex.

Scalation and proportion characters: Main characters separating *V. nuchalis* from other taxa of the complex are given in Tab. 7: Besides striking differences in colour pattern, *V. nuchalis* differs from *V. s. salvator* in the position of the nostrils (index 2) with a mean further distance from the tip of the snout, significantly lower mean scale counts around the tail (character R), and larger scales on the dorsal side (characters X and XY). Compared with *V. s. macromaculatus* and *V. s. bivittatus*, the diagnostic differences similarly apply for proportion index 2, as well as pholidotic features R, X, Y, and XY. In addition, *V. nuchalis* differs statistically from both taxa by its higher mean

Fig. 18. Dorsal view of *V. nuchalis* (SMF 73933) from Negros, Philippines: light (spotted) phenotype.

Fig. 19. Dorsal view of *V. nuchalis* (SMF 73928) from Masbate, Philippines: dark phenotype.

scale counts along the belly (character T) and fewer mean supralabials (character c for *nuchalis*: 58-66, x = 60.39, s = 2.37 versus *macromaculatus*: 58-74, x = 65.30, s = 3.01 and *bivittatus*: 52-71, x = 65.29, s = 3.14). Compared with the Sulawesi varanids, *V. nuchalis* differs most noticeably from the melanistic *V. togianus*. This is displayed by significant variations of eight scalation characters (characters R, S, T, N, TN, X, Y, and XY; see Tab. 7) and proportion parameter 10; resulting in shorter mean head lengths relative to head width, significant for Philippine monitor lizards (index 10 for *nuchalis*: 1.64-2.29, x = 1.86, s = 0.12 versus *togianus*: 1.78-2.29, x = 2.05, s = 0.19). Of the remaining monitor lizards of Sulawesi (*V. salvator* ssp.), *V. nuchalis* is distinguished by characters R, S, T, X, Y, XY, and c (character c for *nuchalis*: 58-66, x = 60.39, s = 2.37 versus *salvator* ssp.: 59-73, x = 63.56, s = 3.38).

In contrast, statistically significant differences between *V. nuchalis* and both other Philippine taxa are scarce: Compared with *V. cumingi* the nostrils of *V. nuchalis* are situated further from the tip of the snout (index 2). *V. nuchalis* exhibits more mean scales around the head (character P), around midbody (character S), and along the belly (character T), but significantly less supralabials (character c for *nuchalis*: 58-66, x = 60.39, s = 2.37 versus *cumingi*: 58-72, x = 64.00, s = 4.26). Along with the phenotypic similarities in colour pattern between certain populations of *V. nuchalis* and *V. marmoratus*, diagnostic differences between these taxa are displayed only by the mean scale counts for characters R, S, and X (for values see Tab. 7).

Range:
The Rough necked water monitor, *V. nuchalis*, occurs on Cebu, Ticao, Negros, Panay, and Masbate within the western Visayas in the centre of the Philippine archipelago (Gaulke 1992a, 1992b).

Taxonomic comments:
Due to its characteristic scalation features, no synonyms of the Philippine taxon *nuchalis* have ever been scientifically described. Nevertheless, the question arose whether this monitor lizard represents a subspecies of the water monitor *V. salvator*, or a closely related but distinct Philippine species. The diagnostic differentiations between the Philippine taxon *nuchalis* and all other members of the *V. salvator* complex mentioned above provide meaningful reasoning for the revaluation of the original specific status of Günther's taxon.

Despite the high variability in colour pattern, no strict geographically correlated features could be found in the *V. nuchalis* populations under investigations. Nevertheless, the tendency towards a melanistic and a spotted morphotype is apparent. The sympatry and syntopy of spotted and melanistic specimens within the same population provide clear evidence that neither a geographic nor a reproductive barrier exists between both morphotypes of *V. nuchalis*, and thereby a taxonomic separation at the subspecific level according to O'Brien & Mayr (1991) is not justified.

***Varanus cumingi* Martin, 1838**

Varanus cumingi Martin, 1838. Proceedings of the Zoological Society of London, 1838: 68-70.

Synonymy: No synonyms of this species are known (Böhme 2003).

Type material:
Lectotype: BMNH 1946.8.31.5 (dried skin), adult, "Mindanado" (= Mindanao), Philip-

pines, collected by H. Cuming.

In the description of *Varanus cumingi*, Martin (through Bell 1838: 70) mentioned three specimens of the type series deposited in the collection of the Zoological Society of London. As Martin (1838) did not distinguish between holotype and paratypes, all three original specimens should be regarded as syntypes. Only the length of the largest specimen was given as three feet ten inches (see above). According to C. McCarthy (BMNH London, pers. comm.), only one specimen of the original type material (BMNH 1946.8.31.5) still exists. Therefore, this specimen should be designated as the lectotype of the taxon *cumingi* Martin, 1838, since the other type specimens appear to be lost.

Important for this discussion is the assertion by Günther (1872), almost 35 years after the description by Martin (1838), that the "typical specimen" was discovered in the collection of the British Museum (of Natural History). According to Günther (1872) this specimen was purchased by the British Museum in 1857 and still had its original labels at that time: one with Cuming's handwriting, stating "Isle of Mindanado", the other one written by Martin which was labelled with the date of donation to the Zoological Society's collection and the names of the collector and species.

Mertens (1959b: 238) mentioned only four specimens of *V. cumingi* he examined in the British Museum (of Natural History) without making any statement about the type specimen.

Other material (14): Bohol (2): SMF 73940 (ad.; Loboc, coll. M. Gaulke, 30. V. 1988, don. 29. VI. 1988), SMF 73941 (ad.; Isidro, Talibon, coll. M. Gaulke, 30. V. 1988, don. 29. VI. 1988); Leyte (4): SMF 73942 (ad.; Bay Bay, don. M. Gaulke, 6. IV. 1989), SMF 73943 (ad.; Cabalian, Santa Cruz, don. M. Gaulke, 6. IV. 1989), SMF 73944 (ad.; Bay Bay, don. M. Gaulke, 6. IV. 1989), ZFMK 52923 (subad.; Buena Vista, near Baybay, coll. M. Gaulke, 1989, don. H. G. Horn, X. 1991); Mindanao (6): BMNH 1946.9.1.17 (Mindanado = Mindanao, Philippines, coll. Cuming, type); SMF 73945-6 (2 ad.; Polanco, Zamboanga del Norte, coll. M. Gaulke, 18. V. 1988, don. 29. VI. 1988), SMF 73947-8 (2 ad.; Ladtingan Pikit, N-Cotabato, coll. M. Gaulke, 12. VI. 1988, don. 29. VI. 1988), SMF 73949 (ad.; Polanco, Zamboanga del Norte, coll. M. Gaulke, 18. V. 1988, don. 29. VI. 1988); Samar (2): ZFMK 64712-13 (2 spec.; Tiomonan, coll. M. Gaulke, 1989, don. H. G. Horn, V. 1997).

Diagnosis:
As a conspicuous member of the *V. salvator* complex, *V. cumingi* can be identified by two main features: (1) the intensive yellow colour pattern of head and body in combination with the black background colour and (2) the possession of enlarged occipital scales around the pineal organ (character P: 47-57, $x = 49.92$, s = 2.99). Further diagnostic scalation characters are (3) enlarged dorsal scales (parameters X, Y, and XY; see Tab. 7) and (4) low scale counts around the tail at one third of the tail length (character R: 44-55, $x = 49.25$, s = 3.44). Additional characteristics of the colour pattern of *V. cumingi* are (5) black ocelli on the ventral side of the tail, (6) a black streak extending from the eye to the upper margin of the tympanum, (7) usually a unicoloured yellow chin without dark bars or crossbands, and (8) 8 to 15 dark crossbands on the belly.

Variation:
The longest specimen examined (SMF 73944) measures 1405 mm (SVL = 535 mm, TaL = 870 mm).

Proportion indices: index 1: 1.48-1.80 (x = 1.61, s = 0.08); index 2: 2.17-2.91 (x = 2.47, s = 0.19); index 10: 1.70-2.27 (x = 1.87, s = 0.14); index 11: 2.31-3.09 (x = 2.69, s = 0.17). Scalation characters: 10 to 13 enlarged supraoculars on both sides; 60 to 70 supralabials excluding the rostral. Sometimes one or two of the enlarged occipitals are separated into numerous tiny scales resulting in a significantly higher mean scale count compared with other specimens lacking this feature (see Tab. 7 for further scalation data).

Mertens (1942c) mentioned that specimens of *V. cumingi* varied considerably in their colour pattern. However, he could not determine a geographic correlation due to the lack of material with precise locality data. Gaulke (1991, 1994) also noticed the tendency of a dark colour phenotype in *V. cumingi*, stating that specimens from Basilan, Samar, and Leyte exhibit less distinctive yellow markings than the population from Mindanao (Fig. 20). Monitor lizards from Bohol examined by Gaulke (1992a), showed a whitish rather than yellow throat, but she made the admission that "only few animals could be obtained from Bohol, so it is not known whether this feature is characteristic for the entire Bohol population."

Our investigations confirmed the existence of variations in the colour pattern of *V. cumingi*.

Comparison with other taxa:
Apart from the striking differences in colour pattern (see ‚Diagnosis'), *V. cumingi* can be statistically distinguished from *V. s. salvator* only by the lower mean scale counts around the tail (character R), around midbody (character S) and between the gular fold and the insertion of the hindlimbs (scalation feature T).

In contrast, there are numerous significant differences between *V. cumingi* and *V. s. macromaculatus*, *V. s. bivittatus* and the spotted monitor lizards of Sulawesi (*V. salvator* ssp.). These differences occur in scalation characters P, R, S (except for Sulawesi's

Fig. 20. Dorsal view of *V. cumingi* (SMF 73946) from Polanco, Mindanao, Philippines: light phenotype.

monitors), X, Y, and XY showing that *V. cumingi* has a larger mean scale size, especially on the dorsal side, and consequently lower values for the respective parameters (see Tab. 7). Interestingly, statistical differences between *V. cumingi* and the melanistic *V. togianus* of the Sulawesian region can only be found in scalation parameters R, X, and XY. The intensive yellow colour pattern, however, is only characteristic for the Philippine species.

The intraspecific variation and comparative analysis of the three Philippine monitor lizard species of the *V. salvator* complex will be dealt with in more detail elsewhere.

Range: (Fig. 5)
This monitor lizard species inhabits the southeastern Philippine islands of Mindanao, Samar, Leyte, Bohol and Basilan (Gaulke 1992a, 1992b).

Taxonomic comments:
Prior to Mertens' (1942a-c) revision of the Varanidae, Martin's (1838) taxon *cumingi* was treated as a separate species (Taylor 1922), although earlier works had already recognized a distinct similarity between Martin's *cumingi* and *V. salvator* (Boulenger 1885). Following this reasoning Mertens (1942c) placed the Philippine taxon within the water monitors' subspecies complex as *V. s. cumingi*.

Gaulke (1989, 1991) recognized that *V. cumingi* is similar to the nominate form of the water monitor with respect to scalation characters and their relative size (referring to the former entire range of *V. s. salvator*), but also noted that the taxon can be distinguished by its larger scales. According to Gaulke (1989, 1991), this was apparent for the low counts for characters T, S, P and U (see Tab. 7). Gaulke's assumptions were proven correct during the course of the present study when the HCA analysis placed *cumingi* and *s. salvator* from Sri Lanka into a sister group relationship within the comparative dendrogram, as outlined above.

Statistical analyses identified only slight morphological differences between *V. cumingi*, *V. marmoratus* and *V. nuchalis* respectively, showing that the three Philippine species form a closely related group within the water monitor complex. Nevertheless, *V. cumingi* exhibits differential diagnostic characteristics, especially in colour pattern (see above), and there is no evidence for a sympatric occurrence of *V. cumingi* and any of the remaining Philippine species.

Although Ziegler & Böhme (1997) did not observe particular differences in genital morphology between *V. cumingi* and *V. salvator*, they remarked that the well-developed, fine spinose scalation of the integument is noticeable. This character may represent the initial state of a differentiation in the genital morphology of *V. cumingi* but at the same time displays the close relationships among all water monitors.

The results of the molecular genetic analysis by Ast (2001), where the taxon *cumingi* is most basically situated within the monophyletic lineage of the water monitor complex, provides crucial support for the suggested species status of *V. cumingi*. Although Ast (2001) drew no specific taxonomic conclusions, she did comment that the subspecies of *V. salvator* "may represent distinct species."

The geographically correlated colour pattern differences of various *V. cumingi* populations provide further evidence for the specific status of this taxon which may actually include other distinct taxa. Taxonomic implications of these findings will be discussed by us in a forthcoming paper.

Discussion

Biogeography

The palaeobiogeographic history of the Indo-Malayan Archipelago suggests that the extant established and isolated populations of *V. salvator* on the Sunda Shelf descended from a previously more widespread species with metapopulations in reproductive contact. During the Pleistocene (1.5 M to 17,000 years BP), the world's climate was affected by alternating periods of cooling and heating and thereby succeeding phases of glacials and interglacials with severe global sea level changes of approx. 120 m lower than during the Holocene (Fairbanks 1989). South East Asia was repeatedly affected by the emergence of large landmasses when huge amounts of water were frozen in the glacial ice sheets of the northern hemisphere during cool periods. These climatic conditions resulted in land connections joining Sumatra, Borneo and Java with continental South East Asia which today form the Sunda shelf (Voris 2000). The deep water trenches surrounding Sulawesi appears to have maintained the islands isolation since millions of years. Indeed, Hall (1998) and Moss & Wilson (1998) argue that Sulawesi has probably not been connected with any other landmass since the Eocene, approximately 42 M years ago. Its very high degree of faunal and floral endemics supports a view of independent evolution of Sulawesi (cf. Iskandar & Nio 1996, Whitten et al. 2002, Vane-Wright & de Jong 2003). Separated by the Macassar Strait, the marine barrier between Borneo and Sulawesi indicates the eastern edge of Indo-Malayan faunas. Hence the faunal composition east of this barrier reflects many species of Australian origin (Wallace 1860, Mayr 2002). The separation of these two faunas through "a near magical faunal boundary" was marked by an imaginary line, and since Huxley (1868), this boundary is termed the "Wallace Line".

How & Kitchener (1997) demonstrated that land bridges between the present islands of the Lesser Sunda region were generated as a consequence of lowered sea levels during the Pleistocene. These geographical fusions of adjacent islands could have served as "stepping stones" for the colonization of the Lesser Sunda Islands by water monitors. Subsequent isolation caused by increasing sea levels gave rise to the observed variability in colour pattern of the various *V. s. bivittatus* populations within the Lesser Sunda Island arc. A similar scenario was inferred by Heaney (1985) for the Philippine archipelago. Today, the distribution of the three Philippine taxa *marmoratus*, *nuchalis* and *cumingi* represents former Pleistocene boundaries of recognized biogeographic subregions within this archipelago (Fig. 5).

Relationships of South East Asian water monitors

Based on morphological comparisons, two geographically correlated groups can clearly be identified within the range of water monitors. On the basis of the arguments outlined above, the *V. salvator* complex must undergo conclusive taxonomic changes resulting in an essential systematic splitting. Both taxonomic divisions, however, represent closely related groups within a proposed *V. salvator* complex.

The first division includes *V. salvator* and the examined subspecies (described above as *salvator* typically-coloured taxa) *salvator* (*sensu strictu*), *macromaculatus*, *andamanensis*, *bivittatus* and some populations of Sulawesi (*incertae sedis*). All these taxa are characterized by their colour pattern of more or less distinctive dorsal transverse rows of spots or ocelli and small nuchal scales. Further studies will show whether the melanistic *V. togianus* and the spotted Sulawesian monitor lizards belong to this group or form a separate genealogical lineage.

The second group consists of the Philippine species *V. marmoratus*, *V. nuchalis* and *V. cumingi* characterized by enlarged dorsal scales, especially in the nape region, and a reduction or modification of the dorsal colour pattern. At present, this group consists of three monotypic species, but ongoing systematic investigations will reveal the existence of further taxa. In this group, *V. cumingi* is the most differentiated by its combination of the pronounced yellow colouration and the enlarged occipital and nuchal scales. As demonstrated above, some but not all populations of *V. marmoratus* and *V. nuchalis* are rather similar in scalation features and colour pattern. Due to their morphological similarity and the geographic proximity, both species are regarded to represent a proposed *marmoratus-nuchalis* complex within the Philippine archipelago.

Currently, there are numerous issues that remain unsolved. Firstly, the distribution of *V. salvator* towards the eastern parts of its range (the Moluccas) requires verification. The status of Sulawesi's monitor lizards and from some Philippine Islands (e.g. Palawan and the Sulu archipelago), and Lesser Sunda Islands (Lombok, Sumbawa, Flores, and Sumba) needs to be investigated in much greater detail. Furthermore, a recent phylogeny of varanids based upon mtDNA (Ast 2001) did not include representatives of all taxa recognized in this revision. These results will be published elsewhere.

Acknowledgements

This study could not have been completed without the generous help of numerous associates, friends and colleagues. We are grateful to all of them.

In general, we would like to thank Hans-Georg Horn (Sprockhövel) for stimulating this study.

In particular, the senior author would like to express his gratitude to the institutions, curators and staff of the respective herpetological divisions who gave permission to examine their collections and for generous and manifold assistance of their staff. These are Rainer Günther and Detlef Langer (ZMB), Gunther Köhler and Monika Laudahn (SMF), Miguel Vences, Isaac Isbruecker and Pieter Michels (ZMA), Pim Arntzen and Eulàlia Gasso-Miracle (RMNH), and Frank Glaw (ZSM). Colin McCarthy (BMNH) provided information and photographs of the type specimens of *V. nuchalis* and *V. cumingi*; as did Ivan Ineich and Sebastian Soubzmaigne (both MNHN) for the type specimens of *V. s. macromaculatus*. Furthermore, AK would like to thank Steffanie Kühn (Berlin), Stella Gesthuysen (Munich), and Daniel Walz (Frankfurt) who generously offered accommodation. Bernhard Misof and Marcel Peters (both ZFMK) provided invaluable advice and assistance on statistical procedures and interpretations. Moreover, we thank Michael Stanner (Tel Aviv) for translating the original Thai description of *V. s. komaini*. Patrick Krause and Fabian Herder (both ZFMK) made helpful suggestions on the diploma's thesis of AK. In addition, we would like to express our gratitude to Maren Gaulke (Munich) for the interesting discussion and photographs of Philippine varanids. Stefan Meyer (Oldenburg) provided a photograph of a monitor lizard from Bali, and Tjaldo Brandenburg (Leiden) kindly provided a copy of his thesis. We thank them both and Jennifer Ast (Michigan) who provided unpublished data of their genetic investigations on the water monitor. Ursula Bott (ZFMK) helped to scan some photographs. Finally, we appreciate the help of Robert Neal (Brisbane, Australia) for numerous insightful comments on an earlier draft.

Zusammenfassung

Der Südostasiatische Bindenwaran, gelegentlich als *Varanus salvator*-Komplex bezeichnet, besitzt das weiteste Verbreitungsgebiet aller Warane. Trotz seiner enormen geographischen Ausdehnung und augenscheinlicher Unterschiede im Farbmuster verschiedener Unterarten, und selbst innerhalb einzelner (Insel-) Populationen, ist der Bindenwaran seit über 60 Jahren nicht

taxonomisch bearbeitet worden. Um die ungelöste Situation dieses Unterartenkomplexes aufzuklären, wurde eine detaillierte Analyse morphologischer und morphometrischer Merkmale durchgeführt, die grundlegend neue Daten zur Systematik von *V. salvator* liefert. Hierfür wurden über 330 Exemplare von 41 Lokalitäten aus nahezu dem gesamten Verbreitungsgebiet auf Merkmale der Beschuppung, des Farbmusters und Längenabmessungen hin untersucht. Die Ergebnisse dieser eingehenden morphologischen Untersuchungen sind Gegenstand einer fundamentalen Revision des Bindenwarans: Dieser erste Teil behandelt alle nominotypischen Populationen von *V. salvator* (Laurenti, 1768), welche bei weitem das größte Verbreitungsgebiet aufweisen, und bietet einen generellen taxonomischen Überblick über alle validen Unterarten. Der ursprüngliche Artstatus der philippinischen Taxa *marmoratus*, *nuchalis* und *cumingi* wird aufgrund statistisch signifikanter Unterschiede in charakteristischen Beschuppungs- und Zeichnungsmerkmalen revalidiert.

Da der Holotypus von *V. salvator*, d. h. die Vorlage für Albertus Sebas (1735) Abbildung des Ikonotypus, als verloren oder niemals existent angesehen werden muss, wird ein Neotypus designiert, um die Stabilität der zoologischen Nomenklatur zu gewährleisten. Zugleich wird die Eigenständigkeit der Bindenwarane von Sri Lanka im Vergleich zu den übrigen nominotypischen Populationen bewiesen, so dass die Unterart *V. s. salvator* auf diese Insel beschränkt bleiben muss. Für die verbleibenden Populationen des ehemals nominotypischen Verbreitungsgebietes ist der Name *macromaculatus* Deraniyagala, 1944 verfügbar. Währenddessen kann die Validität des rein melanistischen Taxons *komaini* Nutphand, 1987 aufgrund umfassender morphologischer Übereinstimmungen nicht bestätigt werden; wir betrachten es somit als Junior-Synonym von *V. s. macromaculatus*. Im Gegensatz hierzu wird das teil-melanistische Taxon *togianus* Peters, 1872 aufgrund eindeutiger diagnostischer Merkmale zur eigenständigen Art aufgewertet. Der taxonomische Status der übrigen, gefleckten Bindenwaranpopulationen Sulawesis muss jedoch gegenwärtig als ungeklärt angesehen werden.

Schlüsselwörter: Squamata: Varanidae: *Varanus salvator*-Komplex; Morphologie, Systematik, Taxonomie; Südostasien.

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