

HEADING EAST: A NEW SUBSPECIES OF *Varanus salvator* FROM OBI ISLAND, MALUKU PROVINCE, INDONESIA, WITH A DISCUSSION ABOUT THE EASTERNMOST NATURAL OCCURRENCE OF SOUTHEAST ASIAN WATER MONITOR LIZARDS

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The *Varanus salvator* population from the Central Indonesian island of Obi, Maluku Province, is described as a new subspecies representing the most easterly confirmed occurrence of the widespread Southeast Asian water monitor lizard. The new taxon differs from the four recognized subspecies by unique characters of coloration and pattern such as a distinct dorsal pattern on the head in combination with reduced transverse rows on the anterior back which stand in contrast to the distinct and black-bordered, large light spots on the hind part of the body. In addition, the eastern border of the distribution range of the *V. salvator* complex is critically discussed in the light of historical voucher specimens from the Moluccas, New Guinea and even Australia. The Obi island record which had long been published but has never since been scrutinized, confirms the recently observed sympatric occurrence of members of the *V. salvator* and *V. indicus* species groups on several islands of the Moluccas. Further field investigations are needed to understand the different niche occupation between both these ecologically similar monitor lizard groups. Once more, our findings demonstrate the importance of the Central Indonesian islands of Wallacea as a global hotspot of varanid diversity and endemism.

Keywords: Wallacea; Moluccas; Reptilia; Squamata; Varanidae; *Varanus salvator ziegleri* ssp. nov.; conservation; systematics; biogeography.

INTRODUCTION

The Southeast Asian water monitor lizard *Varanus salvator* (Laurenti, 1768) is among the largest extant squamate reptiles of the world. It is also the most widespread member of the genus *Varanus* (Böhme, 2003), ranging from Sri Lanka in the west through continental Southeast Asia, the Greater and Lesser Sunda Islands to Sulawesi and the Moluccas (Koch et al., 2007a). However, taxonomy and intraspecific diversity of this giant Asian monitor lizard species complex have long been neglected. A new era started in 2007, when the three traditionally recognized subspecies from the Philippine Archipelago were elevated to full species status due to significant morphological differences (Koch et al., 2007a). In another recent study, the Philippine species were re-investigated morphologically and it could be shown that

this vast archipelago harbors no less than five different species of the closely related *V. salvator* complex (Koch et al., 2010).

Another unresolved issue is the exact limit of the distribution range of *V. salvator* and its occurrence on the islands east of Sulawesi (see Koch et al., 2007a). De Rooij (1915), for instance, examined historical voucher specimens from Halmahera but also listed Bacan (Battjan) within the species range. Mertens (1930, 1942, 1959, 1963) reported *V. s. salvator* from the islands of Obi, Halmahera, and Bacan at the eastern boundary (Fig. 1), although no material from either of the latter two islands was available to him. Instead, he referred to earlier authors like Bleeker (1856, 1857, 1860a, 1860b), who had reported *V. salvator* from the Moluccas. Brandenburg (1983) adopted these earlier records from Halmahera and Obi. More recent authors, however, largely ignored the possible occurrence of water monitor lizards in the Moluccas (see, e.g., Eidenmüller, 2009). In contrast, other early sources even claimed that water monitor lizards had reached Northern Australia (e.g., Boulenger

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ger, 1885; Loveridge, 1934; Bustard, 1970). This, however, was doubted by Mertens (1963) and Cogger et al. (1983), although voucher specimens exist from New Guinea (ZMB 29619, one subadult, collected by Mencke and Heinroth, 1900 – 1901; ZMH 540, one subadult, collector unknown), from the Torres Strait islands (NMW 3656-75, one juvenile, collected by Gerrard, 1878), and from Somerset, Cape York, North Queensland, Australia (BMNH 78.1.31.14 collected by the Challenger Expedition, 1874 – 1876). These historical locality records which might be explainable by single displaced specimens or erroneous locality data urgently need confirmation.

TABLE 1. Character Definitions and Abbreviations Used in This Study

Abbreviation	Definition of Characters
I. Morphometry	
SVL	Snout-vent length from tip of snout to cloaca
TaL	Tail length from cloaca to tail tip
ToL	Total length from tip of snout to tip of tail
A	Head length from tip of snout to anterior margin of ear
B	Head width (= maximum width between eyes and ears)
C	Head height above the eyes
G	Distance from anterior eye margin to middle of nostril
H	Distance from middle of the nostril to tip of the snout
Index 1 (= TaL/SVL)	Relative tail length
Index 2 (= G/H)	Position of nostril between tip of snout and eye
Index 10 (= A/B)	Relative head length in relation to head width
Index 11 (= A/C)	Relative head length in relation to head height
II. Scalation	
P	Scales across head from rictus to rictus
Q	Scales around tail base
R	Scales around tail at approximately one third from base
S	Scales around midbody
T	Transverse ventral scale rows from gular fold to insertion of the hind legs
N	Gular scales from tip of snout to gular fold
TN (= T + N)	Ventral scales from tip of snout to insertion of hind legs
X	Transverse dorsal scale rows from hind margin of tympanum to gular fold
Y	Transverse dorsal scale rows from gular fold to insertion of hind legs
XY (= X + Y)	Dorsal scales from hind margin of tympanum to insertion of hind legs
c	Supralabials exclusive the rostral scale
m	Scales around neck anterior to gular fold
U	Differentiated (= enlarged) supraocular scales

Recently, however, populations of *V. salvator* were encountered on several Moluccan islands such as those of the Sula Archipelago and Obi (Weijola and Sweet, 2010). Subsequent investigations of the varanid collection at the Senckenberg Museum, Frankfurt (SMF), revealed one juvenile specimen of *V. salvator* from the island of Obi, which was donated by the Museum Zoologicum Bogoriense on Java, Indonesia, in 1957. This voucher specimen formed the base for Mertens' (1959) novel island record for Obi. The specimen exactly matches in coloration and pattern with a live specimen from Obi as depicted by Weijola (2010). Due to unique characteristics in the color pattern of the Obi population, we here describe a new subspecies of the Southeast Asian water monitor lizard *V. salvator*.

MATERIAL AND METHODS

Field work on Sulawesi and adjacent islands was conducted between 2005 and 2007. In addition, voucher specimens of major European and Indonesian natural history museums were studied. Museum collection acronyms used follow Leviton et al. (1985).

Examination methods of standard morphometric and meristic characters used in this study are based on the works of Mertens (1942), which were later further developed and expanded by Brandenburg (1983) and Böhme et al. (1994). For each voucher specimen examined 21 external morphometric and meristic characters were recorded. In order to minimize the errors based on observer bias, all measurements and scale counts were made by the senior author. In addition, four proportion indices were calculated. Character definitions and abbreviations used are listed in Table 1. Head measurements were taken with a slide-caliper to the nearest 1 mm. Body and tail lengths of subadult and adult specimens were taken with a measuring tape. Scale counts were recorded using pins and with check marks. A binocular microscope or a magnifying-glass was used for juvenile specimens with very small scales. For the measurement of the scalation character Q, the 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 hind limbs (character T) were counted up to 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 stan-

standardized variable “n” for the number of voucher specimens examined.

RESULTS

Taxonomic account

Varanus Merrem, 1820

Soterosaurus Ziegler and Böhme, 1997

Varanus salvator (Laurenti, 1768)

Varanus salvator ziegleri ssp. nov.

(Figs. 1 – 4, Table 2)

Synonymy/Chresonymy

1959 *Varanus* (*Varanus*) *salvator salvator* — Mertens, partim. *Senck. biol.* **40**(5/6):235. (“Obi”).

1963 *Varanus salvator salvator* — Mertens, partim. *Das Tierreich*, **79**:16. (“Obi”).

Holotype. SMF 56442 (Figs. 2 – 4), a juvenile from Kali Telaga, Obi Island, Maluku Province, Central Indonesia, collected by A. M. R. Wegner, 25 – 31.X.1953. The specimen was exchanged with the Museum Zoologicum Bogoriense (MZB), on Java, in 1957 (Mertens, 1959).

Diagnosis. A new subspecies of *V. salvator* clearly distinguished from the remaining subspecies by the fol-

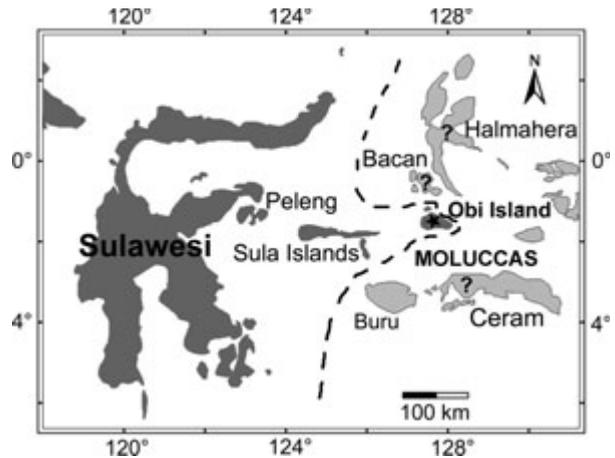


Fig. 1. Map showing the distribution of *V. salvator* in the northern Moluccas (dark gray areas). The type locality of *V. salvator ziegleri* ssp. nov. on Obi Island, Moluccas, is indicated by a black star. The dashed line represents the eastern border of the distribution range. Question marks denote islands with unconfirmed water monitor populations.

lowing combination of characters: (1) a distinct dorsal color pattern on the head in combination with a light olive-brown background color and dark-encircled large light spots arranged in transverse rows on the posterior half of the back.



Fig. 2. Dorsal view of the juvenile holotype specimen (SMF 56442) of *V. salvator ziegleri* ssp. nov. showing the characteristic dorsal color pattern on the head in combination with a light olive-brown background color and dark-encircled large light spots arranged in transverse rows on the posterior half of the back. Photograph by André Koch.

organ, which is surrounded by a dark brown area and indistinct dark crossbands on the snout; (2) an unusual light olive-brown background color particularly on the neck; (3) a distinct longitudinal stripe along the lateral side of the neck is missing; (3) a reduced and fading transverse row of large light spots on the anterior back behind the forelimbs, which stands in contrast to (4) the distinct and black-bordered, large light spots arranged in three to four transverse rows on the second half of the dorsum; (6) at least adults have an indistinctly light and dark patterned tail; and (7) the tongue is light bluish-gray above becoming slightly darker towards the bifurcation area, and nearly flesh-colored below.

Differential comparison with the other subspecies of *V. salvator*. Although Mertens (1959:237) did not recognize differences in coloration and pattern between water monitor specimens of the nominotypic population from Sri Lanka and the holotype from Obi, there are



Fig. 3. Lateral view of the holotype specimen (SMF 56442) of *V. salvator ziegleri* ssp. nov. Note the light bluish-gray tongue. Photograph by André Koch.

clear differences detectable. They concern the background color, which is darker in *V. s. salvator*, particularly on neck and head; in turn, the symmetric markings on the head are less distinct and symmetric in *V. s. salvator*, if present at all; the characteristic dorsal pattern of transverse rows of ocelli and thin lines of light dots within the interspaces is not expressed in the Obi population, which also lacks numerous larger and smaller spots on the neck; in addition, the tongue is darker bluish-gray in the nominotypic subspecies, particularly on the underside; and the lateral dark pointed bars do not meet ventrally in *V. s. ziegleri* ssp. nov.

Compared to *V. s. macromaculatus* Deraniyagala, 1944 from mainland Southeast Asia and the Greater Sunda Islands, *V. s. ziegleri* ssp. nov. shows less bright markings in between the dorsal transverse rows of large spots (vs. ocelli) and on the neck, a brighter background color on the anterior half of the body, a distinct symmetric pattern on the head (absent in *V. s. macromaculatus*), and a brighter colored tongue (vs. dark bluish-gray).

In contrast to *V. s. andamanensis* Deraniyagala, 1944 endemic to the Andaman Islands, *V. s. ziegleri* ssp. nov. shows a clearly defined dorsal pattern of transverse rows of large bright spots (absent in *V. s. andamanensis*, particularly in adults) and a distinct pattern on the head; also, the alternating bright and dark bars on the tail are nearly missing in the Andamanese subspecies.

In overall appearance, some populations of *V. s. bivittatus* (Kuhl, 1820) from Java and the Lesser Sunda Islands resemble the new water monitor lizard subspecies from Obi in the generally brighter colored head and neck regions. There are, however, some important differences. Dorsally, *V. s. bivittatus* often shows ocelli with a dark center (vs. spots) and a tendency towards fused cross bands instead of distinct transverse rows of



Fig. 4. Ventral view of the holotype specimen (SMF 56442) of *V. salvator ziegleri* ssp. nov. Photograph by André Koch.

large spots; in addition, the characteristic dark lateral longitudinal spots or stripes along the neck are missing in *V. s. ziegleri* ssp. nov. On the other hand, certain enigmatic populations of *V. s. bivittatus* from the Lesser Sunda Island chain show similarity with the Obi population in the phenotype such as a richly contrasting head pattern and dark encircled bright spots on the back. However, at least in juveniles, these Lesser Sundas water monitor lizards exhibit usually distinct (vs. reduced) transverse rows of light spots towards the forelimbs and on the neck region; adults of these island populations sometimes tend to develop a melanistic appearance largely lacking any light dorsal markings.

Geographically closer to *V. s. ziegleri* ssp. nov. than the Lesser Sunda Islands are the *V. salvator* ssp. and *V. togianus* (Peters, 1872) populations from Sulawesi and neighboring smaller islands. While the melanistic *V. togianus* shows no traces of a dorsal pattern of transverse rows (in contrast to the partly distinct pattern of the Obi population), the typically-colored, i.e., spotted populations from the northern peninsula of Sulawesi, which are referable to a distinct taxon, *V. s. celebensis* (Schlegel, 1844), are distinguished by having a darker background color, more mottling in between the dorsal transverse rows, and a less rich in contrast pattern on the

head. Phenetically more similar are the Banggai water monitors. Specimens of this island population also show distinct markings on the head and well-developed dorsal transverse rows of large light spots. They exhibit, however, a much darker background color than *V. s. ziegleri* ssp. nov., which also applies to the melanistic populations recently discovered on the Sula Islands (Weijola and Sweet, 2010).

Description of the holotype. A juvenile specimen, the umbilicus is not yet entirely closed, the habitus is slender (Fig. 2). Total length 349 mm (SVL = 139 mm, tail length = 210 mm, index 1 = 1.51), head length 38 mm, head width 18.5 mm, head height 13.3 mm. The nostrils are closer to the tip of the snout than to the eye (index 2 = 1.75). Distance from anterior margin of eye to middle of nostril 10.7 mm, distance from middle of nostril to tip of snout 6.1 mm. Nasal regions slightly swollen. The tympanum is oval-shaped. Digits with strong curved claws, fourth toe longest. Tail is laterally compressed after its base with a well-developed double keel on the dorsal ridge. The teeth are slender, relatively pointed and slightly curved.

Scalation. The body scales are small and heterogeneous. Dorsal scales on the back are oval in shape, not keeled, and surrounded by a row of granules only at the

TABLE 2. Descriptive Statistics of Main Morphometric and Meristic Characters of *V. salvator ziegleri* ssp. nov. as Compared with the Remaining Subspecies of the Southeast Asian Water Monitor and *V. togianus* from Sulawesi

Character	<i>V. s. salvator</i>	<i>V. s. macromaculatus</i>	<i>V. s. bivittatus</i>	<i>V. s. celebensis</i>	<i>V. togianus</i>	<i>V. s. ziegleri</i> ssp. nov.
n	13 – 15	92 – 163	63 – 65	17 – 18	7	1
Distribution	Sri Lanka	Mainland Southeast Asia, Sumatra, and Borneo	Java and Lesser Sunda Islands	North Sulawesi	Sulawesi except the northern peninsula	Obi Island, Moluccas
Index 2	2.17 – 2.91 $x = 2.47 \pm 0.19$	1.82 – 3.46 $x = 2.30 \pm 0.26$	1.67 – 2.88 $x = 2.21 \pm 0.25$	1.90 – 2.64 $x = 2.17 \pm 0.2$	1.82 – 2.70 $x = 2.24 \pm 0.29$	1.75
P	48 – 56 $x = 51.93 \pm 2.10$	49 – 65 $x = 57.43 \pm 3.34$	47 – 63 $x = 55.75 \pm 3.12$	50 – 68 $x = 57.33 \pm 4.10$	44 – 58 $x = 51.71 \pm 4.39$	59
Q	92 – 108 $x = 98.73 \pm 4.65$	88 – 126 $x = 103.68 \pm 7.40$	79 – 128 $x = 102.70 \pm 7.93$	83 – 107 $x = 97.29 \pm 6.42$	87 – 112 $x = 97.57 \pm 9.00$	106
R	55 – 67 $x = 62.13 \pm 3.50$	41 – 82 $x = 60.84 \pm 6.42$	51 – 71 $x = 59.60 \pm 4.66$	51 – 68 $x = 59.61 \pm 4.89$	54 – 63 $x = 57.57 \pm 3.05$	53
S	142 – 165 $x = 153.73 \pm 6.12$	135 – 178 $x = 151.24 \pm 9.05$	101 – 175 $x = 150.58 \pm 10.62$	116 – 162 $x = 143.12 \pm 10.92$	120 – 142 $x = 129.86 \pm 8.25$	140
T	86 – 93 $x = 89.85 \pm 2.23$	75 – 95 $x = 84.60 \pm 4.06$	75 – 97 $x = 84.78 \pm 4.19$	77 – 89 $x = 82.65 \pm 3.30$	77 – 82 $x = 79.00 \pm 1.83$	88
TN	164 – 172 $x = 168.69 \pm 2.59$	152 – 187 $x = 165.71 \pm 8.51$	145 – 183 $x = 164.56 \pm 7.14$	149 – 172 $x = 160.76 \pm 6.73$	145 – 157 $x = 152.57 \pm 4.43$	177
X	26 – 36 $x = 32.40 \pm 3.16$	29 – 50 $x = 37.75 \pm 4.66$	28 – 52 $x = 38.59 \pm 5.02$	30 – 47 $x = 37.28 \pm 4.78$	31 – 42 $x = 34.43 \pm 4.20$	30
XY	118 – 135 $x = 125.67 \pm 5.34$	116 – 182 $x = 150.20 \pm 13.07$	123 – 189 $x = 150.41 \pm 13.40$	127 – 171 $x = 144.76 \pm 11.20$	117 – 172 $x = 139.00 \pm 18.34$	126
m	94 – 109 $x = 102.43 \pm 4.57$	81 – 127 $x = 102.34 \pm 11.30$	82 – 122 $x = 101.40 \pm 9.22$	73 – 115 $x = 96.82 \pm 10.71$	78 – 107 $x = 86.86 \pm 10.25$	109

Note. Data of latter species and *V. salvator* ssp. are taken from Koch et al. (2007a). Note that morphological data of *V. salvator andamanensis* were not available.

posterior margin. 140 scales around midbody, with 69 enlarged, rectangular ventrals. 109 scales around the neck anterior to the gular fold. The scales of the head are flat, irregularly pentagonal to heptagonal with each up to 10 small groves or pits; 59 scales from rictus to rictus across the head; 69 (34 right/35 left) supralabials, plus one enlarged rostral. The scales around the eyes are granulous with five and six enlarged supraoculars above the eyes, respectively, which are distinctly broader than long. Pileus scales between supraoculars enlarged. The scale covering the pineal organ is enlarged and flanked with two areas of distinctly smaller scales posteriorly. The nuchal scales of the nape are domed, smooth, oval to roundish, and slightly larger than dorsals, arranged in 30 transverse dorsal scale rows from a line connecting the hind margins of the ear openings to opposite of gular fold, and in 96 transverse rows from gular fold to the insertion of the hind legs. The limbs are covered with oval smooth or slightly keeled scales particularly towards the lateral sides. 29 irregular scale rows under fourth toe, with 13 enlarged scales laterally on the first half of the toe. 24 scale rows under fourth finger. The caudal scales are rectangular, above slightly keeled, below with prominent keels, four times larger than dorsally, 106 scales around the base of the tail, 53 after approximately one third of the tail length. The two median rows of dorsal tail scales form a double crest starting after the base of the tail. The gular scales are smooth, rectangular under head and roundish to oval in the medial part. 89 scales from tip of snout to gular fold decreasing in size towards the gular fold. The ventrals of the belly are rectangular, arranged in 88 regular transverse rows between the gular fold and the insertion of the hind limbs. Anterior to the cloaca, are located two glandular areas of one scale each.

Color pattern (in preservative). The dorsal side is medium to dark brown with four distinct transverse rows of large, roundish, cream-colored spots between the fore and hind limbs which continue on the base of the tail (Fig. 2). Each dorsal transverse row includes six to eight distinct light roundish spots. Between the last two transverse rows of large spots towards the hind limbs, there is another row of about six smaller spots. The light dorsal spots are encircled by black margins. The interspace between two distinct transverse rows is covered with partly light brown scales. After the base, the tail is striped with black and cream on the dorsal side. The about eleven bright blocks decrease in width towards the tip of the tail, and are connected by two to three thin dark longitudinal lines only on the first two half of the tail length. The limbs are blackish-brown and regularly spotted with small bright dots comprising usually less than four

scales. On the hind limbs the dots may consist of more bright scales. Digits with bright crossbands of two to three scale rows, first scale after each claw entirely brightly colored. The neck is medium brown scattered with few single bright scales or small dots. The head is light brown and shows a symmetric dark brown pattern dorsally. The enlarged scale covering the pineal organ and immediately surrounding scales are light brown, while the remaining upper side of the head is dark brown colored. The enlarged supraoculars are dark brown and encircled by light brown scales (Fig. 2). The snout is light brown marked with three indistinct dark crossbands. The tongue is light bluish-gray above becoming slightly darker towards the bifurcation area. The tips are lighter again as is the underside, which is flesh-colored on its first half (Fig. 3). Laterally, a dark brown temporal streak extends from the eye to the upper side of the tympanum. It is bordered above and below by light brown bands. Ventrally cream-colored, belly with about eight dark pointed bars laterally between the fore and the hind limbs, further extending on the chest where they form interrupted cross lines. The limbs also show dark pointed bars laterally. Throat and chin are bright with four dark but partly interrupted crossbands. Proximad, the tail shows only lateral dark bars changing gradually to an alternating pattern of bright and black bars towards the end (Fig. 4).

Variation and coloration in life. The two known specimens of *V. salvator ziegleri* ssp. nov. available to us either from the voucher specimen or photographs of a live specimen allow some remarks about variation in color pattern of this endemic Moluccan water monitor subspecies.

Photographs of a subadult live specimen from the type locality (published by Weijola, 2010) show that the dorsal pattern of distinct large light spots may fade with age. Also, the alternating pattern of distinct bright and dark bars on the tail as seen in the juvenile holotype becomes blurred with increasing body size. On the other hand, augmented light marbling may fill the areas between the characteristic dorsal transverse rows of spots and, thus, leads to a brighter overall appearance.

Etymology. We dedicate this new water monitor to our colleague and friend Dr. Thomas Ziegler, in recognition of his numerous contributions to the exploration of Indo-Australian monitor lizard diversity. As vernacular name we propose Ziegler's water monitor lizard.

Distribution and natural history. Currently, *V. salvator ziegleri* ssp. nov. is only known from the type locality Obi Island, Central Indonesia (Fig. 1). It also probably occurs on smaller nearby islets like Pulau (= island) Bisa and Pulau Obilatu. Only little information is

available about the biology of the Obi Island population. Recent field investigations by Weijola (2010) showed that on Obi water monitor lizards are found in the same habitats (i.e., mangroves, coastal areas and swamps) as on other islands of the wide *V. salvator* distribution range. These preferred habitats of *V. salvator* are also inhabited by the sympatric *V. rainerguentheri*, which is the most common monitor lizard species on Obi Island (Weijola, 2010). Even less frequent than *V. salvator ziegleri* ssp. nov. is *V. caerulivirens* that seems to prefer inland areas such as plantations, forests and freshwater influenced habitats (Weijola, 2010).

Conservation status. Due to its restricted distribution range on the island of Obi, the endemic *V. salvator ziegleri* ssp. nov. deserves special attention by conservationists. Water monitor lizards are highly sought after by the international reptile leather and pet trade industries with about 500,000 specimens (varying between 126,506 skins in 1981 and 1,605,104 skins in 1989) being legally exported each year alone from Indonesia since 1981 (CITES, 2009). Although live water monitor lizard specimens make up only about 1% of the annual trade volume with *V. salvator*, new, colorful, and rare reptile taxa often demand a higher interest and are traded at several times the usual prize of a closely related or widespread taxon. Therefore, local reptile dealers could specifically visit Obi Island in order to catch as many specimens as possible for the international pet market. This alarming process has been documented in other recently described reptile species (see, e.g., Stuart et al., 2006; Kuchling et al., 2007). As a subspecies of *V. salvator*, the new taxon from Obi Island is automatically included in CITES Appendix II which means that any international export of *V. salvator ziegleri* ssp. nov. to a CITES signatory country requires an export permit from the Indonesian government (CITES, 2009). This legal requirement will hopefully prevent the new subspecies from Obi from over-exploitation by commercial traders in reptile leather and live animals. National conservation legislation and export quotas urgently need adjustment for a sustainable exploitation of the endemic Obi water monitor lizard population.

DISCUSSION

Delimiting the easternmost occurrence of the *V. salvator* complex

In the absence of confirmed locality records east of Sulawesi, the exact eastern distribution limit of the *V. salvator* complex remained unknown until recently and was considered to exclude Maluku Province, which

is inhabited by various representatives of the ecologically similar *V. indicus* species group (Ziegler et al., 2007b). Recent field work on several Moluccan islands, however, revealed the most eastern occurrence of *V. salvator* to be on the island of Obi (Weijola, 2010), which is linked by populations on the Sula Island group with the Sulawesi region and the remaining distribution range of this widespread Southeast Asian monitor lizard species complex (Fig. 1). Therefore, colonization of Obi Island almost certainly took place starting from Sulawesi via the Banggai (Peleng) and Sula Island groups, which formed a larger landmass during climate-induced Pleistocene sea level low stands (Voris, 2000). Obi Island, however, remained geographically isolated during the repeated glacial periods of the global ice ages and was surrounded by the strong sea currents of the Indonesian throughflow between the Pacific and the Indian Ocean (Gordon and Fine, 1996). Nevertheless, water monitor lizards successfully crossed the straits between Sulawesi and Obi in the past and founded a new population which experienced an independent evolution acquiring several idiosyncratic features of coloration and pattern over time. The probable ability of water monitors to reproduce parthenogenetically, as demonstrated for several other varanid species in recent years (Lenk et al., 2005; Watts et al., 2006; Hennessy, 2010), may have facilitated the successful establishment of new allopatric island populations on the oceanic islands of Central Indonesia. Although no tissue samples were available for molecular investigations, it is to be expected that the distinct color pattern of the Obi population has a genetic basis. This connection has recently been elaborated for the various endemic and distinctly colored *V. salvator* populations confined to single off-shore islands of the Sulawesi region (Koch et al., unpublished data).

Due to the autochthonous *V. salvator ziegleri* ssp. nov. population on Obi and the minor geographic distance between Obi and Halmahera (both islands are separated by ~50 km, which is only half the distance between Obi and Pulau Lifamatola, the most easterly extension of the Sula Archipelago), historical records of *V. salvator* from latter island as published by Müller and Schlegel (1845), Bleeker (1856), and de Rooij (1915) appear likely. The only voucher specimens from Halmahera are deposited in the Leiden collection (RMNH 3170 and 3177). Authors like de Rooij (1915) based their island record on these two specimens which were allegedly collected by E. A. Forsten on Gilolo (= Halmahera) in 1841. It seems, however, that Forsten himself never visited the island (van Steenis-Kruseman, 1950). Instead, several times he sent out local hunters to Halmahera while Forsten stayed for some months on the



Fig. 5. A specimen of *V. salvator* ssp. (RMNH 3170) allegedly from Halmahera. Photograph by André Koch.

smaller adjacent island of Ternate due to ill health. Therefore, the locality data of Forsten's voucher specimens are not reliable and it is quite possible that the two water monitor specimens were caught on another neighboring island such as Tidore or Bacan. For the latter island *V. salvator* was already mentioned by Bleeker (1857). Interestingly, the Halmahera voucher specimens show some phenetic similarity with the typically-colored, i.e., spotted populations of *V. salvator* from North Sulawesi (Fig. 5), thus rendering a natural occurrence on Halmahera unlikely. Beyond that, several expeditions to Halmahera in recent years could not trace *V. salvator* (e.g., Setiadi and Hamidy, 2006; Weijola, 2010; A. Riyanto, personal communication). Thus, the origin of Forsten's Halmahera specimens can not unequivocally be determined.

Another Moluccan island from which *V. salvator* (under the name *V. bivittatus*) has been reported is Ceram situated southeast of Obi (Bleeker, 1860a). Bleeker (1860b) also listed the water monitor lizard for the herpetofauna of Ambon (Amboina). Bleeker's (1860a, 1860b) historical records, however, can not be verified because he mentioned no voucher specimens. There are, however, two specimens (ZMB 47902 and ZSM 69/1996) from Ceram in major German natural history collections. Both were collected by Erwin Stresemann in 1911 during the Second Freiburg Moluccas Expedition (1910 – 1912). As Stresemann certainly is a reliable collector (in 1924 he became curator for ornithology at the

Berlin museum), these voucher specimens may have either been transported to Ceram by man or may have been drifted to this island by sea currents since *V. salvator* was not reported from that island by Edgar and Lilley (1987). One of these voucher specimens, ZMB 47902, was recently depicted by Koch et al. (2007a:154). It shows an extraordinary color pattern of distinct dorsal ocelli, closely resembling the water monitor population which was recently discovered on Kalaotoa Island located between Southwest Sulawesi and Flores (Koch et al., 2007b:47). Because Kalaotoa lies on the way between Bali (where the Moluccas expedition had to stay involuntarily for three months) and Ceram, it is also possible that the specimen was actually collected on that island. We could, however, not find any indications for such a short stop-over (Stresemann, 1914). In contrast to the latter ocellated specimen, the second Ceram specimen (ZSM 69/1996) exhibits a reduced dorsal color pattern. With its melanistic appearance it resembles adult specimens from Sumba in the Lesser Sundas (Koch, personal observation).

At present we can not exclude that giant water monitor lizards naturally reached Ceram, Halmahera or any of its numerous smaller off-shore islands. However, a natural occurrence of *V. salvator* further east on New Guinea or even the Australian continent can be excluded. ZMB 29619, one of only two known voucher specimens from New Guinea (both without exact locality data), was collected by Bruno Mencke and Oskar

Heinroth between 1900 – 1901 during the first German South Sea Expedition (see Heinroth, 1902). Originally, the specimen had been allocated to *V. indicus* but was later redetermined as *V. salvator* by R. Sprackland (F. Tillack, personal communication). The provenance of this specimen remains dubious. This also applies to ZMH 540, a subadult from New Guinea by an unknown collector. Mertens (1942) listed the latter specimen under the material studied but doubted the correctness of the locality data. Both specimens were not examined by us.

Among the material of *V. salvator* in the NMW collection there is a juvenile specimen (NMW 14866, formerly NMW 3656-75) from the Torres Strait, allegedly collected by Gerrard in early 1878. The supposed collector Gerrard, is most probably Edward Gerrard, a London-based taxidermist and trader of natural history items who also worked for the British Museum. It is unclear, however, if Gerrard himself traveled the Torres Strait. Numerous specimens from all around the world were purchased from Gerrard by the Natural History Museum in Vienna in the late 1870s and 1880s. In 1879, a collection from the Murray Islands is mentioned in the catalogue entries. Loveridge (1934), for instance, referred to specimens collected by Gerrard from the Torres Strait and Murray Island. Mertens (1942) doubted the validity of this island record and we agree with him.

Historical records from Queensland, Northern Australia, as reported by Boulenger (1885), for example, most probably refer to erroneous locality data (Cogger et al., 1983). Specimen BMNH 78.1.31.14 collected by the marine Challenger Expedition belongs to a small collection of reptiles which mainly originated from Ternate in the northern Moluccas. Only two specimens of this batch, a Southeast Asian water monitor lizard and an Australian snake *Demansia psammophis reticulata* (Gray, 1842) (reported as *Diemenia reticulata*), have both the locality data “Somerset, Cape York” (C. McCarthy, personal communication). As *V. salvator* is also unknown from the island of Ternate, west of Halmahera, the origin of this specimen remains doubtful.

In sum, the eastern border of the natural occurrence of Southeast Asian water monitor lizards in the Moluccas remains unresolved.

Wallacea — a global hotspot of monitor lizard diversity and endemism

The fact that *V. salvator ziegleri* ssp. nov. remained so long ignored and undiscovered is probably due to the mainly unexplored nature of the fauna and flora of the remote Moluccan Islands in Central Indonesia. They are

part of the Wallacea subregion which is known for its oceanic (i.e., depauperate) but highly endemic species diversity (e.g., Myers et al., 2000; Wilson et al., 2006). During the last 15 years, several monitor lizard species have been discovered from various Central Indonesian islands such as Ambon and Seram (*V. cerambonensis*: Philipp et al., 1999), Halmahera (*V. yuwonoi*: Harvey and Barker, 1998; *V. caerulivirens*: Ziegler et al., 1999; *V. zugorum*: Böhme and Ziegler, 2005; *V. rainerguentheri*: Ziegler et al., 2007a), or the Sula Islands (*V. melinus*: Böhme and Ziegler, 1997; *V. obor*: Weijola and Sweet, 2010). *V. melinus* was initially reported to originate from Obi (Böhme and Ziegler, 1997), but later it became obvious that this island record was based on incorrect information (Ziegler and Böhme, 1999). Today, the Moluccas are home to a total of nine different monitor lizard species and, thus, represent a major center of varanid diversity and endemism in Southeast Asia (Ziegler et al., 2007b). This conclusion was earlier drawn for Indonesian snakes and for birds (How and Kitchener, 1997; Cotes and Bishop, 1997), thus, confirming the worldwide importance of the Wallacea region as biodiversity hotspot in the Indo-Australian Archipelago (Mittermeier et al., 2004).

Although the Obi Island record had long been published by Mertens (1959) but was never since scrutinized, it confirms the recently observed sympatric occurrence of members of the *V. salvator* and *V. indicus* species groups on the islands of the Moluccas, Central Indonesia. Currently, two species of the *V. indicus* species group are known from Obi Island. These are *V. caerulivirens* and *V. rainerguentheri* (Weijola, 2010; Koch, unpublished data). The only record of *V. cerambonensis* from Obi (RMNH 3184) turned out to represent *V. rainerguentheri* (Weijola, 2010). While *V. melinus* was at first erroneously reported to originate from Obi Island, two further monitor lizard species, viz. *V. indicus* and *V. yuwonoi*, could indeed occur on that Moluccan island. Further field investigations are needed to understand the different niche occupation between the partly co-distributed and ecologically similar monitor lizards of the *V. salvator* and the *V. indicus* species groups, respectively.

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