ARTICLES

Biawak, 4(1), pp. 7-23

Geographical Distribution and Habitat Use of Monitor Lizards of the North Moluccas

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Abstract: Observations on the ecology and distribution of monitor lizards were made on three different field visits to Halmahera, Morotai, Bacan, Gebe and Obi islands. Data was collected on four species: *Varanus caerulivirens, V. rainerguentheri, V. cf. salvator* and *V. yuwonoi.* No specimens of *V. zugorum* were observed during the course of the study, and this species also appears to be virtually unknown even among local hunters and animal collectors. *Varanus caerulivirens, V. rainerguentheri* and *V. cf. salvator* are reported from Obi for the first time. Additionally, *V. caerulivirens* and *V. rainerguentheri* were recorded from Morotai and Bacan. The different species appear to avoid competition by differences in habitat use, body size, and foraging mode. *Varanus rainerguentheri* is largely restricted to the coasts, while *V. caerulivirens* and *V. yuwonoi* primarily occur in inland forest habitats.

Introduction

Currently, the *V. indicus* species group is, despite the efforts of several workers, quite possibly the least resolved group of varanoid lizards in the world. They occupy a vast and difficult to access geographical region from the Solomon Islands in the east, across New Guinea with its shelf islands and parts of northern Australia, through the Moluccas as far as Talaud in the northwest, as well as some remote Pacific Island groups. This is a region of unparalleled complex geological history consisting of thousands of variously sized islands where isolation and other evolutionary forces have driven populations to diverge and differentiate, resulting in a phylogenetic and ecological diversity that is still poorly understood.

The Moluccan islands (Maluku) of east Indonesia forms part of the biogeographical region known as Wallacea. Traditionally considered a transition zone between the Australian and Asian faunas, many of the islands also hold a considerable number of endemic species and have at least for some animal groups played an important role in speciation processes (How and Kitchener, 1997, Ziegler *et al*., 2007b). The number of identified species in the *Varanus indicus* species group in the Moluccas has risen from one to eight during the last decade (of which seven are endemic to this region), and more will inevitably be described (e.g., Weijola and Sweet, in press). Sweet and Pianka (2007) review the reasons for the high diversity of small monitors (less than 130 cm total length) east of Wallace´s Line, concluding that the historical absence of predatory placental mammals has played a fundamental role in the radiation of lineages such as *Euprepiosaurus.*

The numerous islands with their different communities provide the ideal natural experiment to study resource partitioning and ecological release in monitors. Since studies on varanid communities have historically been largely restricted to dry and seasonally wet Australian environments, it seemed relevant to compare these "dry communities" with ones in the wet tropics, such as in the Moluccas. It is particularly interesting since most of the species within Moluccan communities are very similar in size and more closely

related than within most Australian communities (where assemblies include species of several subgenera).

Despite the recent discovery boom of new species, there has been very little fieldwork involved, and all the descriptions, except for *V. lirungensis* Koch *et al*. (2009), have been based solely on museum or animal trade specimens. The first ecological observations of many of these species were made during this study on three separate field trips in 2008 and 2009. This paper concerns varanids of the larger islands of the biogeographical northern Moluccas: Halmahera, Morotai, Bacan, Kasiruta, Gebe and Obi. The Sula Islands are also included in the administrative unit, but group biogeographically with Sulawesi and are not considered further here.

Methods and Study Area

Field work was conducted during March 2008, December-February 2008-2009, mid April- mid June, and late October-mid November 2009. Investigations were made in coastal habitats (Fig.4), lowland forests (Fig.3), swamps (Fig.5), and hill forests (Fig.2) on Halmahera, Bacan, Morotai, Gebe and Obi (Fig.1). These are all climatologically rather similar and are, or have historically been, covered primarily by tropical rain- and evergreen forest. At present, much of the lowland forests are degraded, converted to plantations or even mined for minerals. Annual rainfall varies according to land topography, but averages between 1500 and 2000 mm. (Monk *et al*., 1997; Bacan Agricultural University, pers. comm. 2009), and lowland temperatures are 25-30 °C year-round. December through March tends to receive the heaviest rainfall, but most of the Moluccas rarely experience prolonged dry periods.

Many of the *V. indicus* group monitors can be observed by searching on foot in suitable habitats. Alternatively, some of the shyer species can be attracted to bait (fish/meat). *Varanus yuwonoi* is particularly difficult to observe, and the author was forced to follow a professional animal collector at work in order to see this species at all. Locating monitor lizards in tropical wet forests presents particular difficulties since it excludes the possibility of using tracks as aid and the

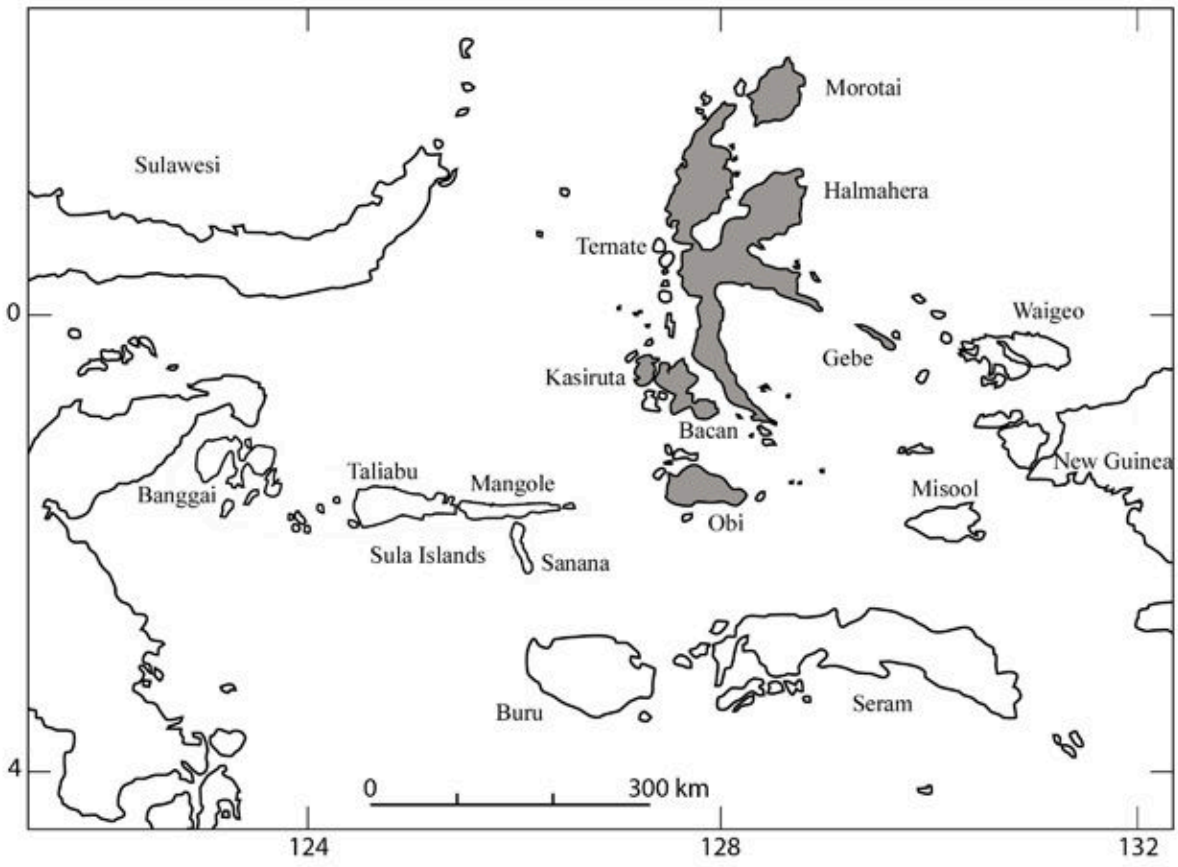

Fig. 1. Map of the Moluccas with the study area darkened.

dense vegetation provides ample cover and places to hide. Recurrent periods of rain and clouds often decrease activity levels of the animals, making observations difficult for days or weeks on end. For each observation, a set of data (most importantly: habitat use, location and activity etc.) were recorded. In a few cases, dead animals were encountered and stomach content and reproductive condition was analyzed.

Abbreviations for museum collections mentioned in this article are: BYU: Brigham Young University, Utah; RMNH: Naturalis, National Museum of Natural History, Leiden; MZB: Museum Zoologicum Bogoriense, Java

Halmahera

Halmahera is the largest and most geologically complex island in the Moluccas (Hall, 1998). It is of composite origin and consists of a younger, volcanic western part and an older eastern part. These collided somewhere between one and three million years ago (Hall, 1999), after having moved westwards for 15-20 million years. Their composite nature and historical proximity to New Guinea probably contributes to the high species diversity of this island. Four species have been confirmed (*V. caerulivirens, V. rainerguentheri, V. yuwonoi* and *V. zugorum*), which is more than on any other Moluccan island.

Observations were made around a number of sites on the northwestern, northeastern and eastern peninsulas in a variety of habitats from coastal mangrove swamps, *Nypa* swamps, coastal forests, sago swamps, plantations, secondary forest, disturbed forest, and primary forest, at elevations from 0 to 700 m.

Morotai

Morotai is a part of the East Halmaheran Crustal Fragment (Hall, 1999) and is at present separated from Halmahera by about 10 km of open sea. According to Voris (2000), Morotai would have been connected to Halmahera by land bridges repeatedly during Pleistocene glacial periods. Only one field site was visited on Morotai: the surroundings of Pilowo village on the southern end of the island. There are vast mangrove forests in this area but unfortunately the lowland forests are disturbed or secondary. Most observations were made in the mangroves.

Fig.2. Mangrove forest, Tetewang, Halmahera

Fig. 3. *Nypa*-palm swamp, Kasiruta.

Fig. 4. Freshwater stream and lowland forest, Sumahode, Halmahera.

Bacan Islands

The Bacan islands are geologically a part of western Halmahera (Hall, 1999) and were also periodically connected with southern Halmahera during the Pleistocene (Voris, 2000). Two field sites were based on the island of Kasiruta, one at Dobo (north east coast) and the other at Kasiruta Dalam (southern interior). The site at Dobo was poor since most of the surroundings were heavily converted to nutmeg and clove plantations. Kasiruta Dalam was reached by ascending the Kasiruta River by a small motorized canoe. It is a small village surrounded by sago swamps and disturbed lowland forest.

On the main island of Bacan, observations were made outside of Labuha and Wayamiga. Wayamiga lies at the foothills of the mountain Gunung Sibela, from where a day long excursion into the virgin hill forests was made.

Fig. 5. Hill forest on Gunung Sibela, Bacan; habitat of *V. caerulivirens*.

Gebe

Gebe is situated ca. 40 km southeast of the easternmost tip of Halmahera and 70 km west of Waigeo. The geology is mostly Tertiary limestone (raised reef) and ophiolitic red soils. The western part has been heavily mined for nickel and large areas have been destroyed during the past decades. Thus observations were concentrated in the eastern part where pockets of primary lowland forest, drier limestone forests and mangroves remain.

Obi

Large portions of Obi are composed of raised reef limestone (Monk *et al*., 1997). Field work was conducted at two sites in the northeastern part of the island. The coasts were heavily forested by mangroves, coconut groves and coastal swamps, with inland areas including cocoa plantations, disturbed hill forest, and limestone forests.

Fig. 6. Limestone forest, Air Mangga, Obi.

Results

Species accounts

Up to nine species have been reported to occur on these islands collectively; *V. caerulivirens*, *V. cerambonensis*, *V. doreanus, V. indicus*, *V. melinus*, *V. rainerguentheri*, *V. salvator*, *V. yuwonoi* and *V. zugorum*. Of these, *Varanus melinus* was erroneously reported from Obi (Böhme and Ziegler, 1997), but later omitted by Ziegler and Böhme (1999); the absence of *V. melinus* from Obi is supported by fieldwork (this study). Examination of photographs of voucher material (RMNH 3184) and fieldwork reveals that the record for *V*. *cerambonensis* from Obi in Philipp *et al*. (1999) is based on a misidentification of *V. rainerguentheri*, and thus Obi should be omitted from the range of this species. Based on four 19th century voucher specimens, Koch *et al*. (2007) included both Seram and Halmahera in the range for *V. salvator*; however, these records are not supported by fieldwork (this study; Edgar and Lilley, 1993; Setiadi and Hamidy, 2006) or interviews with locals and local dealers (T. Baadilla and B. Baadilla, pers. comm. 2009) and should be omitted until more substantial evidence is presented. *Varanus* cf. *salvator* is however here documented to be native to Obi. Yuwono (1998) mentioned a record of *V. doreanus* from Halmahera, and genetic studies by Ziegler *et al*. (2007b) include a specimen allegedly from that island, but fieldwork does not support such an occurrence. Thus five species are confirmed from within this region: *V. caerulivirens, V. rainerguentheri, V.* cf. *salvator, V. yuwonoi* and *V. zugorum.*

Varanus caerulivirens

Despite having been described so recently (Ziegler *et al*., 1999), the turquoise monitor (Figs. 7 and 8) is widely distributed in the northern Moluccas and is actually often quite common in suitable habitats.

Distribution: The type locality for *V. caerulivirens* is the northern Moluccan island of Halmahera, and the only precise locality previously published is Patani at the far eastern tip of that island (Ziegler *et al*., 2004). A specimen collected on Morotai in 1944 (BYU 7477) confirms its presence on that island. Investigations on Halmahera found the species to be widely distributed throughout the lowlands up to about 700 m elevation in all but the most disturbed forested habitats. Several sightings were also made in primary forests in Gunung Sibela on the island of Bacan, and this species is expected to be widespread on that island. No observations were made on Kasiruta, a large island just west of Bacan, although considering the close proximity between these islands it is likely that they do occur there.

This species was also recorded in the field on Obi for the first time, an island separated from Halmahera by almost 60 km of open sea. On Obi, they are sympatric with *V. rainerguentheri* and *V.* cf. *salvator.* Investigations on Gebe strongly suggest that *V. caerulivirens* does not reach that island, most likely making east Halmahera and Morotai the eastern limit for its range.

Ecology: A total of 59 observations of *V. caerulivirens* were made during almost five months of work throughout

Fig. 7. *Varanus caerulivirens*. Tetewang, Halmahera.

Fig. 8. *Varanus caeurulivirens*. Air Mangga, Obi.

its range. This species is a forest generalist and occurs in most non-salt water influenced forest types: from coastal forest and beach vegetation, plantations, primary and secondary lowland forests, limestone-, alluvial-, hill- and mountain forests up to at least 600-650 m elevation. They are often found basking around small clearings. Occasionally, specimens are encountered while patrolling freshwater streams, and on one occasion, two specimens were observed near a lake at over 600 m elevation (Tables 1 and 2).

This species is most often encountered while actively foraging through the leaf litter layer of the forest floor, and stomach content analysis reveals that they consume burrowing animals such as earthworms, mole crickets, etc. They almost invariably seek refuge in trees when frightened by or pursued by humans and use tree cavities as night refugees, and probably for nesting as well. The claws and scales of the feet are well adapted for climbing and they make much use of tree trunks and canopies for basking, sometimes even jumping from one tree to the other.

No significant difference in habitat utilization could be observed between juveniles and adults - both were equally terrestrial and arboreal, though admittedly far fewer sightings were made of small vs. large individuals. It is possible that younger individuals make more extensive use of tree hollows.

Dissection of sexually mature specimens revealed males to have enlarged testes throughout the year, suggesting that reproduction takes place year-round. The largest adult specimen measured 110 cm in total length, which is probably near maximum size.

Varanus rainerguentheri

Varanus rainerguentheri (Figs. 9-14) was described as a cryptic species within the *V. indicus* complex based on molecular and morphological evidence (Ziegler *et al*., 2007a). Unfortunately, the genetic comparison of the new species with *V. indicus* in that paper was restricted to a single sequence of mtDNA from a *V. indicus* specimen without specific locality data. Additionally, the type locality of *V. rainerguentheri* (Jailolo, Halmahera) is disputed by the original collector (L. Wagner, pers. comm. November 2008), making the genetic and morphological argumentation a comparison between two unknown localities.

Two of the characteristic morphological features of the holotype were the blunt snout and occurrence of a light postocular stripe. The blunt snout was never

Fig. 9. *Varanus rainerguentheri*. Ibu, Halmahera.

Fig. 10. Head and tongue of *V. rainerguentheri*. Tetewang, Halmahera.

Fig. 11. *Varanus rainerguentheri*. Pilowo, Morotai.

Fig. 12. *Varanus rainerguentheri.* Air Mangga, Obi.

Fig. 13. Adult *V. rainerguentheri*. Gebe Island.

Fig. 14. Juvenile *V. rainerguentheri.* Gebe island.

observed in the field and appears to be unique to that particular specimen. Field investigations of larger sample sizes also show that the postocular stripe is variable among Halmaheran and north Moluccan populations of *V. rainerguentheri*, and usually fades with age. For example, the two specimens depicted in Setiadi and Hamidy (2006) as *V. indicus* and *V. rainerguentheri* appear to only show intraspecific variation, and cannot be allocated to different species based solely on the occurrence of a temporal stripe. The temporal stripe is usually less pronounced on specimens from Obi and Gebe compared to Halmahera and Morotai, though based on external features, the populations on these islands are very difficult to distinguish. Specimens from Obi do appear to have dark pigmentation further back on the tongue.

Despite the potential weaknesses in the original description, I have opted to use the name *V. rainerguentheri* for populations of the *V. indicus*-type monitors in the northern Moluccas included in this paper. A more detailed taxonomic investigation of animals from verifiable localities and with larger sample sizes is much needed to confirm the taxonomy and specific characteristics of this species, particularly since the description of *V. rainerguentheri* failed to make a comparison with the very similar animals of nearby Waigeo, which were described as *V. chlorostigma* by Gray (1831). This name was synonymized with *V. indicus* by Böhme *et al.* (1994) and earlier authors, but the subsequent redefinition of *V. indicus* (Philipp *et al*. 1999) excludes animals from Waigeo on several characteristics (such as throat markings, tongue color and scalation). The redefinition of *V. indicus* invalidates this earlier synonymization, and makes *V. chlorostigma* a potentially available name for *V. rainerguentheri*.

Distribution: *Varanus rainerguentheri* is widely distributed, particularly around the coastlines, on Halmahera, Ternate (RMNH voucher), Tidore (MZB voucher), Morotai, Bacan, Kasiruta, Gebe and Obi (and probably on many of the smaller islands of this region).

Ecology: One hundred and twelve (112) observations were made during the course of fieldwork. On all islands except Gebe, they are mostly restricted to coastal areas and mangrove swamps (Tables 1 and 2).

Table 1. Habitat use of monitors on Halmahera, Morotai and Bacan.

Habitat	*V. caerulivirens*	*V. rainerguentheri*	*V. yuwonoi*
Mangrove	-	13 (38.2%)	-
Beach, littoral vegetation/swamp	1 (1.8%)	6 (17.7%)	-
Nypa swamp	-	3 (8.8%)	-
Sago swamp	-	-	-
Brackish water river delta	-	6 (17.7%)	-
Freshwater stream and river	5 (8.9%)	3 (8.8%)	-
Inland lake	2 (3.6%)	3 (8.8%)	-
Secondary lowland forest 2-50 m.a.s.	20 (35.7%)	-	2 (66.7%)
Primary lowland forest 2-50 m.a.s	-	-	1 (33.3%)
Hill forest 50-200 m.a.s	11 (19.6%)	-	-
Hill forest over 200 m.a.s	15 (26.8%)	-	-
Plantation	2 (3.6%)	-	-
Total # of observations	56	34	3

Table 2. Habitat use of monitors on Obi.

Habitat	*V. caerulivirens*	*V. rainerguentheri*	*V. cf. salvator*
Mangrove	-	17 (73.9%)	3 (60%)
Beach, littoral vegetation/swamp	-	3 (13.0%)	2 (40%)
Nypa swamp	-	1 (4.4%)	-
Sago swamp	-	-	-
Brackish water river delta	-	-	-
Freshwater stream and river	1 (33.3%)	1 (4.4%)	-
Inland lake	-	-	-
Secondary lowland forest 2-50 m.a.s.	-	-	-
Primary lowland forest 2-50 m.a.s	-	-	-
Hill forest 50-200 m.a.s	-	-	-
Hill forest over 200 m.a.s	1 (33.3%)	-	-
Plantation	1 (33.3%)	1 (4.4%)	-
Total # of observations	3	23	5

High densities are also reached in brackish water river deltas and *Nypa* swamps. Occasionally, individuals are found further inland along freshwater streams, lakes and smaller swamps where they occur syntopically with *V. caerulivirens*. One individual on Bacan was encountered at an elevation of more than 200 m in a small mountain swamp. This species was only once (on Gebe) encountered in sago swamps, despite several searches in that habitat. They heavily utilize trees for basking and nighttime refuges. Diet consists of crabs (Tanner, 1950) as well as other suitable aquatic and terrestrial prey and carrion. One individual was seen chasing aquatic prey in a small stream, while another individual was observed digging for food in a steep riverbank. On Obi and Gebe, they were also frequently seen foraging around human waste heaps at the margins of villages. The ecology of *V. rainerguentheri* appears to be more generalized on Gebe, where it occurs alone, from that of Halmahera and Obi where they face competition from other monitor species, probably indicating niche release (Weijola, in prep.). The largest specimen measured was 133 cm in total length, however, animals estimated to be nearer to 150 cm were observed on Obi.

Varanus yuwonoi

Distribution: The black-backed mangrove monitor was only observed around the villages of Akesahu and Kao, both in the western part of Teluk Kao (Kao Bay) on Halmahera. The type series was collected near Jailolo (Harvey and Barker, 1998). Interviews with locals and animal dealers suggest that this species is widespread throughout the island. Eyewitness accounts of *V. yuwonoi*-like animals from Morotai, Bacan, and even Obi exist, but still need confirmation.

Ecology: *Varanus yuwonoi* (Figs. 15 and 16) is a difficult species to study. Despite frequent observations by local hunters, specimens are very rarely encountered out in the open. Considering the difference in size, which is presumably also reflected in trophic level, this species probably does not reach population densities as high as *V. caerulivirens.* A less active mode of hunting (sit and wait/ambush) may also result in the fewer encounters with *V. yuwonoi.*

Traps used by locals specifically for this species are always set up around megapode bird (scrubfowl) nests in inland forests. The unusual pigmentation of the tail, body and neck breaks up the silhouette of the animal very well as they lie on the forest floor. Considering that the smaller and more predator-vulnerable species in the Moluccas have not evolved such an elaborate camouflage, it may have evolved rather as a means to escape detection from potential prey. The head is comparatively powerfully built and the teeth proportionately longer than any of its close relatives (Fig.16), even in comparison to most other more distantly related varanids. Considering these facts, the author hypothesizes that *V. yuwonoi* is an ambush predator, favoring sites in the forest such as megapode nests, that are frequented by a variety of potential prey items. It is uncertain whether large individuals can kill adult scrubfowl, but the large nest mounds attract a number of smaller birds such as pigeons, and also lizards, snakes, and invertebrates, as well as the frequently hatching megapode chicks. According to local people, this species is also occasionally seen digging into these nests in search of eggs. Additionally, observations of intraspecific aggression within the *V. yuwonoi* and *V. doreanus* clade (Ast, 2001) in captivity would support a hypothesis that *V. yuwonoi* could be an

Fig. 15. Large *V. yuwonoi.* Akesahu, Halmahera.

Fig. 16. Head and teeth of *V. yuwonoi* at a trader in Dumdum, Halmahera.

ambush predator. With few exceptions (Sweet, 1999, 2007), widely foraging monitor (and other scleroglossan lizards) species are not territorial; however, the two species (*V. scalaris* and *V. glebopalma*) known to be territorial are both ambush hunters. For a sit and wait predator favoring prey "hotspots", a certain degree of territoriality could be expected to evolve.

The largest individual measured 146 cm in total length; this specimen however did not appear to be fully grown, and according to locals they occasionally grow much larger.

Varanus* cf. *salvator

The distribution of *V. salvator* (Fig. 17) in the Moluccas has been uncertain for a long time, probably starting with what appears to be an erroneous record for Halmahera in de Rooij (1915), widely cited since (for example Bennett, 1995, Harvey and Barker, 1998). Obi, Seram and Bacan were mentioned by Mertens (1930, 1942, 1959), and Buru by Bleeker (1857). Since recent fieldwork, including this study, has not found support for many of these localities, it is suggested that all except Obi be omitted from the range of *V. salvator*.

Since the animals on Obi do not completely correspond with any of the described *V. salvator* group taxa, it is here employed with a cf. (meaning "compare with").

Distribution (in the north Moluccas): Obi Island, probably also on nearby Bisa, but not confirmed.

Ecology: Five observations were made of this species during two weeks on Obi. The sympatry between members of *Soterosaurus* and *Euprepiosauris* is interesting, since some authors have presumed that they might be ecologically exclusive (Mertens, 1942, Sprackland, 2004, Ziegler *et al*., 2007b). This proves to be incorrect since this study confirms sympatry of *V.* cf. *salvator* with *V. rainerguentheri* and *V. caerulivirens* on Obi, as well as two other species in the Sula islands (Weijola and Sweet, in press).

All observations of *V.* cf. *salvator* on Obi occurred in coastal mangrove forest and periodically flooded littoral vegetation (Table 2), where it is widely syntopic with *V. rainerguentheri*. They most likely also occur in inland forests and around freshwater streams side by side with *V. caerulivirens*. On Obi, they appear less numerous than

Fig. 17. *Varanus cf. salvator*. Air Mangga, Obi.

V. rainerguentheri (5 vs. 22 observations), and similarly on Sanana, many fewer *V.* cf. *salvator* were observed compared to a sympatric member of the *V. indicus* complex during the course of fieldwork.

Varanus zugorum

This is the only species which was not observed during fieldwork. It appears to be almost completely unknown by locals, and only two reasonably reliable local eyewitness accounts were collected, in Akesahu (lower western side of Kao Bay) and Labi Labi (northeast Halmahera). Searches and interviews around the type locality Pasir Putih were unproductive. The holotype was collected in December 1980 by a villager, so further details from the initial discovery remain unknown (Adam Messer, pers. comm. 2008).

Discussion

Monitor communities and niche segregation by sympatric species have been studied by several workers, including Pianka (1994), Shine (1986), Sweet (1999, 2007) and Philipp (1999). Communities range from simple one species systems up to as many as 11 species in certain areas of northern Australia (Sweet, 2007). These studies have shown that interspecific competition is typically minimized by differing use of habitat, different body sizes, and foraging mode. Additionally, phylogenetic distance may aid in reducing niche overlap in the most diverse communities of Australia and New Guinea.

A community comparable to the one on Halmahera, though slightly less diverse, was studied by Philipp (1999) in West Papua. He investigated the habitat use of three closely related species of the *indicus*-group (*V. doreanus, V. indicus* and *V. jobiensis*), and concluded that competition and interaction is largely avoided by the use of different habitats and/or microhabitats.

This study found that on Halmahera and Obi, *V. rainerguentheri* is similar in habitat use to that of *V. indicus* on New Guinea (Philipp, 1999), while *V. caerulivirens* appears to fill a similar niche to that of *V. jobiensis. Varanus yuwonoi* overlaps widely in habitat use with *V. caerulivirens* but grows significantly larger, may use a different hunting strategy, and concentrate on larger prey items. Thus there seem to be clear niche separations in communities of *V. indicus* group animals in Moluccan multi-species communities as well. The ecological separation where members of *Euprepiosaurus*

and *V. salvator* overlap is not equally obvious.

Acknowledgements- I especially wish to thank Dan, Baba, Mayur, Mastur and Nelson for help in the field. Sam Sweet, Daniel Bennett and two anonymous reviewers provided valuable comments on an initial draft. Travel support was provided by the National Geographic Society, Svenska studiefonden, Nordenskiöld Samfundet, Svensk-Österbottniska Samfundet and Åbo Akademi University. I am also grateful to Mikael von Numers and Erik Bonsdorff at Åbo Akademi, and my parents, grandparents and friends for support and encouragement.

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Received: 20 February 2010; Accepted: 16 March 2010