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THE *Micropechis* SPECIES: SKIN, diet, cannibalism

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FOREWORD

Thanks to God the Lord of the world. I prayed to You, because of Your grace blessings I can complete a short note paper entitled "**THE MICROPECHIS SPECIES: SKIN, DIET, CANNIBALISM** in a timely manner. *Micropechis ikaheka* is endemic to New Guinea (the region of the Papua and Papua New Guinea). Internal histology of skin layer and the microtopography structure on the surface scales of *M. ikaheka* were the content of the paper. This paper also related to zoogeographical and color variation of the snake in Papua. The snake can be described in three groups, i.e. brown, yellow and black group. The three groups of the snake have specific zoogeography in the mainland of Papua and satellite islands to Papua New Guinea.

The paper addresses to all people in the world especially for who interested about ecology and anatomy of reptilians. Of courses all biology student, researcher, lectures and teachers can use this paper.

I would like to thank those who have helped in every way, so that the paper can be resolved. May God reward all your kindness. Amin.

Manokwari City, 5th January 2025

Dr. Keliopas Krey

TABLE OF CONTENTS

CHAPTER I

GENERALE INTRODUCTION

Figure 1. The Land of Papua, Indonesia

Papua is Indonesia's second largest island, encompassing 416.129 km^2. Papua makes up the western half of the great sub continental island of New Guinea (Beehler 2007). This region is known to support a diverse range of marine and terrestrial ecosystems, as well as an array of endemic species. The habitat mostly consists of tropical rainforest, providing ample opportunity for a diversity of species to flourish.

Eighty-three snake species have been recorded on Papua (Allison 2007), consisting of three percent of the worlds 2700 species (Taylor and O'Shea 2004). Only three hundred species of snakes in the world are dangerous to humans (Taylor and O'Shea 2004), one of which is *Micropechis ikaheka* (local name "white snake"; English name "New Guinea or the small-eyed snake ikaheka") (O'Shea

1996). This venomous snake is endemic to New Guinea and ranges from the lowlands up to about 1.500 m in the mountains.

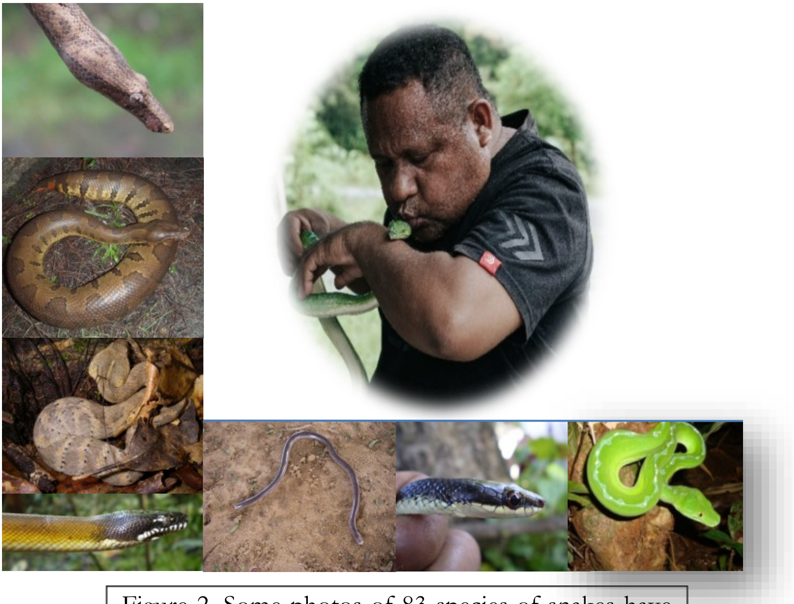

Figure 2. Some photos of 83 species of snakes have been recorded on Papua

Figure 3. *Micropechis ikaheka* (local name "white snake"; English name "New Guinea or the small-eyed snake ikaheka")

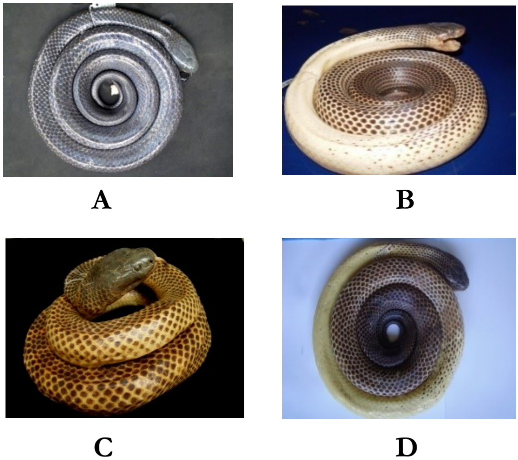

Figure 4. Colour variation of the adult of *M. ikaheka* in papua. A= black specimen, representative of the Waigeo and Batanta island population in northwestern Vogelkop; B= yellow specimen, representative of the Vogelkop region population; C= brown specimen, representative of Yapen island in the north and Aru island in the south, include mainland region from Waropen, Mamberamo, Jayapura, Jayawijaya, Mimika, Mindiptana to Papua New Guinea; D= transitional specimen between both the brown and the yellow specimen were found in southwest Vogelkop, Bintuni;

Micropechis ikaheka, a monotypic species, is a highly venomous elapid species native to New Guinea (Papua Indonesia and Papua New Guinea). Lesson first described it in 1830, from a single specimen collected at Dorery (Manokwari, West Papua Province, Indonesia) (Lesson 1830). The most recent study by Krey (2009) on colour variation and zoogeography of the species in Papua found three distinct colour patterns i.e. black, brown and yellow.

Two subspecies, *M.i. ikaheka* and *M.i. fasciatus*, have been recognised by some authors, but their distributional limits are unclear. Due to lack of diagnostic characters, the subspecific designations have often been ignored (O'Shea 1996).

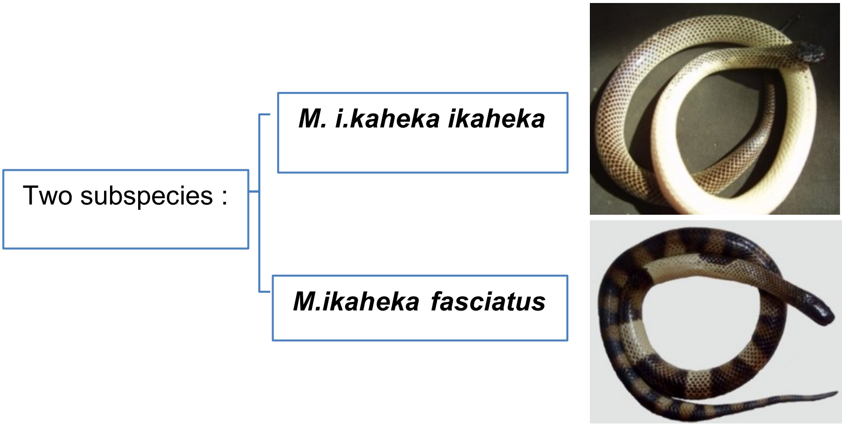

Figure 5.
Two subspecies, *M.i. ikaheka* and *M.i. fasciatus*

Figure 6.
The three distinct color patterns of the adult and juveniles of *M. ikaheka* found in Papua

Micropechis ikaheka can grow up to 2 m in length (O'Shea 1996). *M. ikaheka* has a fairly stocky body with a relatively short tail. The head is narrow and only slightly boarder and distinct from the neck, with very small eyes and a round pupil (O'Shea 1996). Coloration of *M. ikaheka* indicates variability by locally (O'Shea 1996; Krey and Farajallah 2013). In PNG, the northern population exhibits different coloration from the southern. The northern population has a light to dark grey head and distinct from the yellow or cream neck, while the southern population has a dark pigment scales, with the dark crossbands which increase in width and frequency posteriorly until the tail (O'Shea 1996).

Until now, the most widely accepted hypotheses of *M. ikaheka* relationships are based on analyses of external scale morphology. The species was described by Lesson in 1830, from a single specimen collected at Dorery (now known as Manokwari, West Papua Province, Indonesia) (Lesson 1830). In 1884 J.G. Fischer described *M. i. fasciatus* from the Aru Islands. The two subspecies, *M. ikaheka ikaheka* and *M. ikaheka fasciatus* (Fischer 1884) have been recognised by some authors, but their distributional limits are unclear. *M. i. fasciatus* has been considered an Aru endemic by some (e.g., Klemmer 1963), but others listed it from parts of Papua New Guinea (Loveridge 1948), restricting the *M. i. ikaheka* to Papua. Due to lack of clear diagnostic characters, the subspecific designations have often been largely ignored (e.g., O'Shea 1996).

This dangerous snake, *M. ikaheka*, displays extreme geographic variation in colours. The most recent study conducted by Krey (2009), investigated colour variation and zoogeography of the species in Papua. This study found three distinct colour morph: Black, Brown and Yellow. These are the main characteristics distinguishing populations in different areas of the distribution of *M. ikaheka*. This means that *M. ikaheka* exhibits prominent geographical variation along the mainland of New Guinea as well as some of its smaller satellite islands in scale color. The black colored group is the new group found in northwestern

Vogelkop Batanta and Waigeo islands. The yellow colored population is distributed in Vogelkop region starting from Bintuni, Manokwari, Sorong to the Salawati islands. Finally, the brown colored population is distributed from the Yapen islands to the mainland region from Waropen, Mamberamo, Jayawijaya, Mindiptana to Papua New Guinea. A hybrid color morph appears between the brown and the yellow populations in southwest Vogelkop, Bintuni. However, the taxonomic significance of this variation is not clear because the existing data do not distinguish between local adaptation, polymorphism or species-level differentiation.

Snakes serve an important role in nature, especially in a food chain. In Java, for example, snakes serve as predators controlling pest rodents that often attack rice plants (Whitten *et al.* 1999). However, human discrimination prevents snakes from fully fulfilling this role in the ecosystem. On the other hand, carnivorous birds may prey on snakes in nature. However, so far there has been no information about predatory snakes in Papua. Some reports have indicated that a group of elapid snakes may be the main predators of other snake species in New Guinea (Shine and Keogh 1996; O'Shea 1994a), and, even more than that, they are cannibals (O'Shea 1994b).

Very little is known about this venomous species, despite some available data from Papua New Guinea (PNG). A number of papers and notes on the diet of M. ikaheka have been published, but these were confined to the eastern half of New Guinea, which comprises the independent country of PNG. In PNG the snake had been reported to prey on lizards, snakes, frogs, and small mammals (O'Shea 1994a, 1994b; O'Shea 1996; Shine and Keogh 1996).

Micropechis ikaheka has a fairly stocky body with a relatively short tail. The head is narrow and only slightly boarder and distinct from the neck, with very small eyes and a round pupil (O’Shea 1996). Coloration of *M. ikaheka* indicates variability by locally (O’Shea 1996; Krey and Farajallah 2013). In PNG, the northern population exhibits different coloration from the southern. The northern population has a light to dark grey head and distinct from the yellow or cream neck, while the southern population has a dark pigment scales, with the dark crossbands which increase in width and frequency posteriorly until the tail (O'Shea 1996).

Micropechis ikaheka can grow up to 2 m in length (O'Shea 1996). The number of dorsal at midbody (DMB) scales 15, all smooth; 174-223 of ventral scales; subcaudals 37-55, diveded; anal plate divided; 6 supralabials with 3th and 4 th contacting eye and temporolabial between 5 th and 6 th; loreal and subocular scale absent (Lesson 1830; Fischer 1884; Rooij 1917; O'Shea 1996; Krey 2009).

Reptilian scales are generally very colorful and organized in an attractive pattern. The colour of terrestrial reptiles can be diverse and their pigmentation complex, but less so in fossorial groups (Withers and O'Shea 1993). The colours of snakes come from the pigments in the scales and from the way light reflects of the scales (Tylor and O'Shea 2004). Many elapids show great variation in the ground color (Shea *et al.* 1993), including the New Guinea elapid *Micropechis ikaheka*.

Every part of a snake's body is covered by a layer of skin scales. The scales, like reptiles in general, grow from the top layer or the epidermis (Abdel-Aal *et al.* 2011), and usually made of a horny substance called keratin (Hildebrand and Goslow 2001). The skin plays a particularly important role in protecting them from desiccation, abrasion dehydration, ultraviolet radiation, and in providing an impermeable barrier to exogenous organism, including potential pathogens (Cooper 2006).

Like many vertebrates, reptilian skin has two principal layers i.e. the dermis and the epidermis. The deeper layer, the dermis, provides connective tissue with a rich supply of blood and lymphatic vessels, nerves and chromatophores (Cooper 2006), while the *epidermis* has no blood supply and forms the outer protective coating of the body (Rossi 1996). There are seven epidermal layers (Figure 7), the *"stratum germinativum"*, the deepest layer lining cells which have the capacity for rapid cell division, and the six layers which form each "*epidermal generation*", the old and the new skin layers (Abdel and Mansori 2009; Abdel-Aal *et al.* 2011). The epidermis of snakes (Figure 8) now consists of six main layers (Klein and Gorb 2012). From the outer scale surface towards the dermis are known the "*oberhautchen*" layer, (β)-layer, mesos-layer, (α)−layer, lacunar layer and the clear layer (Hildebrand and Goslow 2001; Abdel-Aal *et al.* 2011; Klein and Gorb 2012).

The structure of the male genitalia of snakes was first used for systematics by Edward Drinker Cope (Cope 1894) 120 years ago. Hemipenes are used regularly to study taxonomy, as new techniques of preparation are regularly proposed (Myers and Cadle 2003; Zaher and Prudente 2003). Recent papers have described hemipenial morphology from different snake species from many areas of the world (e.g. Keogh 1999; King *et al.* 2009; Jadin *et al.* 2010; Jadin and Parkhill 2011; Smith *et al.* 2012).

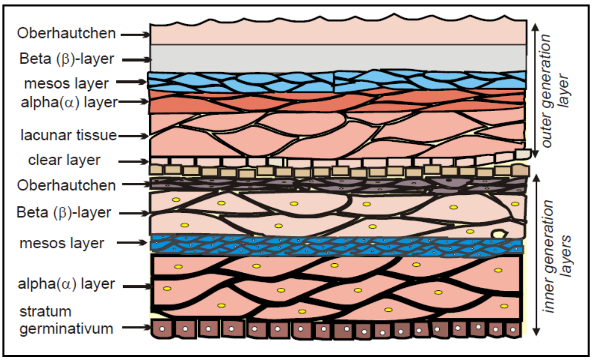

Figure 7. Generalized epidermis of a squamate reptile.
Source: Abdel-Aal and Mansori (2009).

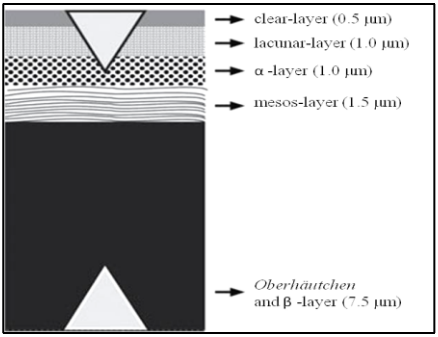

Figure 8. Diagram of the cross section of snake integument.
Source: Klein and Gorb (2012)

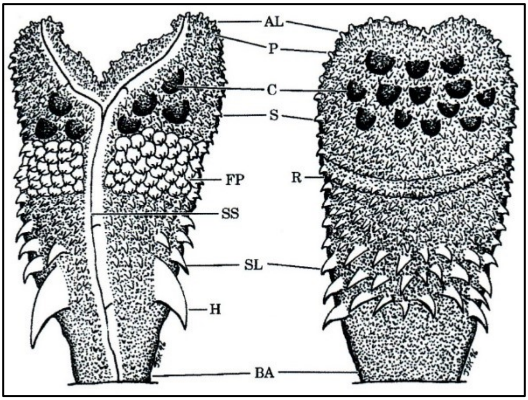

Figure 9. Sulcate (left) and asulcate (right) morphology illustrate of snakes hemipenis. This hemipenis structure to illustrate the relevant morphological features found among Australian terrestarial elapid snakes. AL=apical lobes, P=papillae, C=calyses, S=spines, FP=fleshy protuberances, R=ridges, SS=sulcus spermaticus, SL=spine line, H=basal hooks, BA=base. Source: Keogh (1999).

The complete description of a hemipenis (Figure 9) for systematic purposes includes recording information on its length, shape, condition of sulcus spermaticus, hooks, nature and pattern of ornamentation (spin, calyces, papillae) and type of apex. This technique follow Cope (1894), Dowling and Savage (1960) and the most useful and comprehensive for the Australia-New Guinean region snakes, Keogh (1999). Reptilian, to make their skin airproof (Hildebrand and Goslow 2001). Snake scales, like other reptiles, grow from top layer or the epidermis (Abdel-Aal *et al.* 2011). In lepidosaurians (lizards, snakes, and sphenodontids) germinal layer of the epidermis spinosus-like keratinocytes alternate to hard (beta) and soft (alpha) layers (Toni *et al.* 2007; Chang *et al.* 2009). The whole skin of lepidosaurians is covered by overlapping epidermal scales that protect them from abrasion and dehydration. The epidermis of lepidosaurs is of particular complexity and interest (Hildebrand and Goslow 2001), moreover with very colorful scales and organized in an attractive pattern. The color of terrestrial reptiles can be diverse and their pigmentation complex, marked with colorful patches.

Reptilian skin has two principal layers i.e. the dermis and the epidermis. The epidermis of snakes now consists of six main layers (Klein and Gorb 2012). From the outer scale surface towards the dermis are known the “oberhautchen” layer, (β)-layer, mesos-layer, (α)−layer, lacunar layer and the clear layer (Hildebrand and Goslow 2001; Abdel-Aal *et al.* 2011; Klein and Gorb 2012).

A number of the larger elapids (venomous snake) show great variation in the ground color as shown as a New Guinea elapid *Micropechis ikaheka*. These colour patterns are the main characteristics distinguishing populations of the distribution of *M. ikaheka*.

Micropechis ikaheka (local name "white snake"; English name "New Guinea or the small-eyed snake ikaheka") is endemic to New Guinea ranges from lowlands to about 1.500 m in the mountains. The species is a venomous snake widespread across the mainland island of New Guinea as well as some of its smaller satellite islands (O'Shea 1996).

CHAPTER II

ZOOGEOGRAPHICAL DISTRIBUTION OF *M. IKAHEKA*

Field observations in Papua and specimens study were carried out very interesting specific pattern distribution of *M. ikaheka* (Figure 10). Three groups of the snake i.e. brown, yellow, and black have specific zoogeography in mainland of Papua and its satellite islands (such as Yapen Island, Batanta, and Waigeo Island). All altitude observations showed the species spread from 5 to 305 m ASL. However, specimen from Kelila and Baliem valley showed these snakes also live in the sea level to approximately 1700 m ASL.

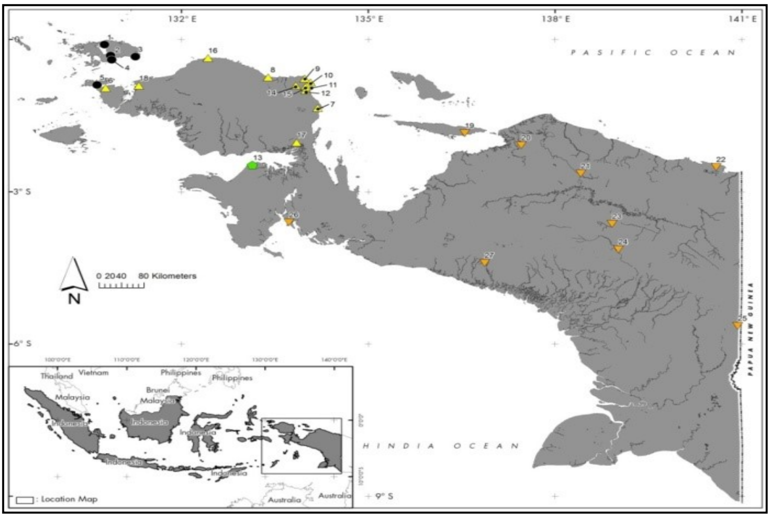

Figure 10. Map of distribution of *M. ikaheka* in Papua, showing specific zoogeographical. The yellow group (yellow triangle), brown group (reversed triangle), new group (black circle) and intermediate individual (green pentagon).

Micropechis ikaheka that was found in the field observations confined to terrestrial rainforest areas. The snakes also found in the monsoon areas and the swamps. *M. ikaheka* was a nocturnal and secretive semi-fussorial snakes which inhabits leaf litter, loose soil or piles of decaying vegetation, husks of cocoa, coconut or palm oil. Several individuals were also observed in the hole of a fallen palm tree, under the tree buttresses and also in the rock crevice (Figure 11).

Figure 11. Representation of *Micropechis ikaheka* terrestrial habitat

According to the most generally accepted classification (O'Shea 1996), the yellow population is the subspecies of *M.i. ikaheka* with the distribution throughout Vogelkop region, including Salawati Island in north-western Papua.

The brown group with dorsal banding pattern (*M.i fasciatus*) inhabits Yapen Island in northern Papua, and most of the New Guinea mainland: northern, southern and central region to Papua New Guinea. Surprisingly, an intermediate color appears between both groups (sub-species) in southwest Vogelkop, Tanah Merah, lowland forest of Bintuni, plus a new group (black group) from Batanta and Waigeo Island (Krey 2009). The intermediate individual might indicated the Bintuni as the hybrid zone of *M.i. ikaheka* from the Vogelkop region with *M.i. fasciatus* from the other regions (Figure 13).

Figure 13. Zoogeographical Distribution and Habitat of *M. ikaheka* in Papua

Coloration of *M. ikaheka* indicated a variable locally. No sufficient data to explain the variation in color pattern of the *M. ikaheka* in Papua. However, it explained the possibility of the current population of *M. ikaheka* founded following colonization events (dispersals) or the occurrence connections between formerly populations (vicarians).

Yapen Island is a small fraction of the Van Rees Mountains on the mainland of New Guinea (Polhemus and Allen 2007), which led to the fauna include *M. ikaheka* on the island joined with the northern coast of Papua (Figure 14). Discontinuous local biogeography by Sagawin Strait that separates the Batanta and Salawati Island (approximately 5 km) result a fraction vicarian for paradise bird species (*Paradisaea minor* and *Cicinnurus magnivicus*) where both species does not exist in Batanta and also Waigeo Island (Beehler 2007).

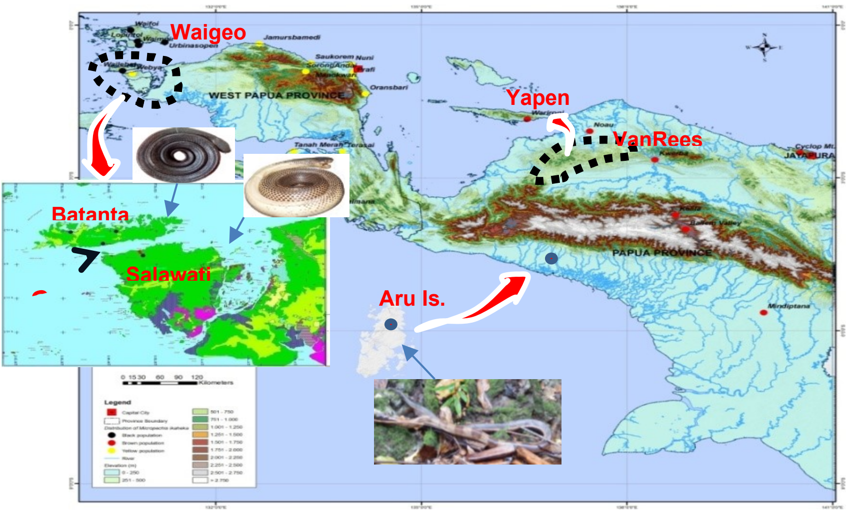

Figure 14. Discontinuous local biogeography of Batanta with Salawati island, Yapen island and Vans Reses mountain also Aru to Mimika

Figure 15.
A adult of *M. ikaheka*,
Bintuni

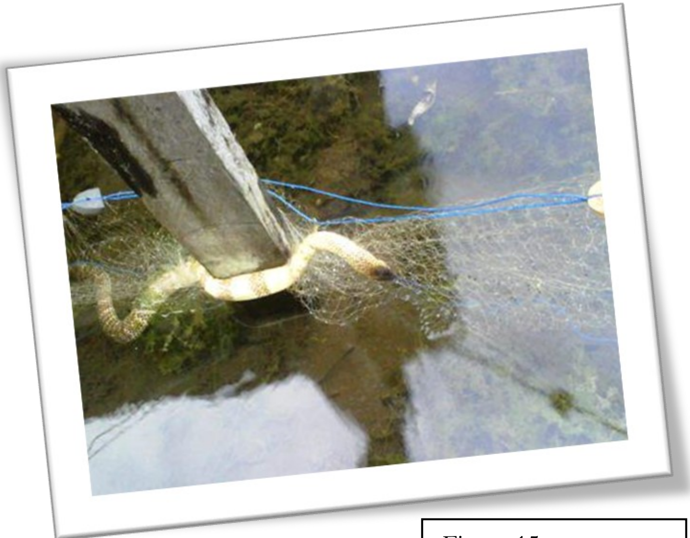

Figure 15.
A adult of *M. ikaheka*,
Kaimana

CHAPTER III

SKIN SCALES OF *M. IKAHEKA*

In microscope investigation the skin of the snake were covered by keratinocytes. There are two main types of intermediate filament proteins in vertebrate keratinocytes: alpha (*a*) and beta (*β*) keratins. The epidermal appendages of reptiles and birds are characterized by the presence of both alpha (*a*) and beta (*β*) type keratin proteins (Sawyer *et al.* 2000). *Micropechis ikaheka* have both *a* and *β*-keratins (Figure 16). These cells are thus being transformed into a hard protective layer called *oberhautchen* which constitutes the strongest outermost layer (Chang *et al.* 2009; Abdel-Aal *et al.* 2011).

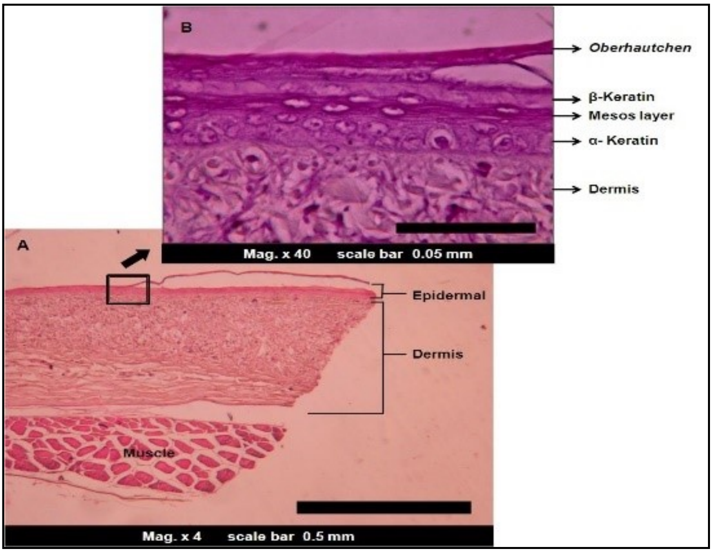

Figure 16. Photomicrographs of the dorsal midbody skin

Overlapping scales and production of β-keratins provide strong protection (Wu *et al.* 2004). β-keratins are specific proteins utilized to make hard structures including scales, scutes, and claws (beak and feathers in birds) (Toni *et al.* 2007). In this study, β-keratin observed at the underside scale is thinner than the top surface (Figure 17-B2 and Figure 18) even much thinner on the hinge region (h). The β-layer arrangements of *M. ikaheka* are similar to the American anole *Anolis carolinensis*. Maderson *et al.* (1998) found the β-layer of the *A. carolinensis* was the thinnest, close to the sense organ and in the inner scale surface and hinge regions. The hinged region (h) that exists between scales should be flexible to assist the snakes when they moved across substrate.

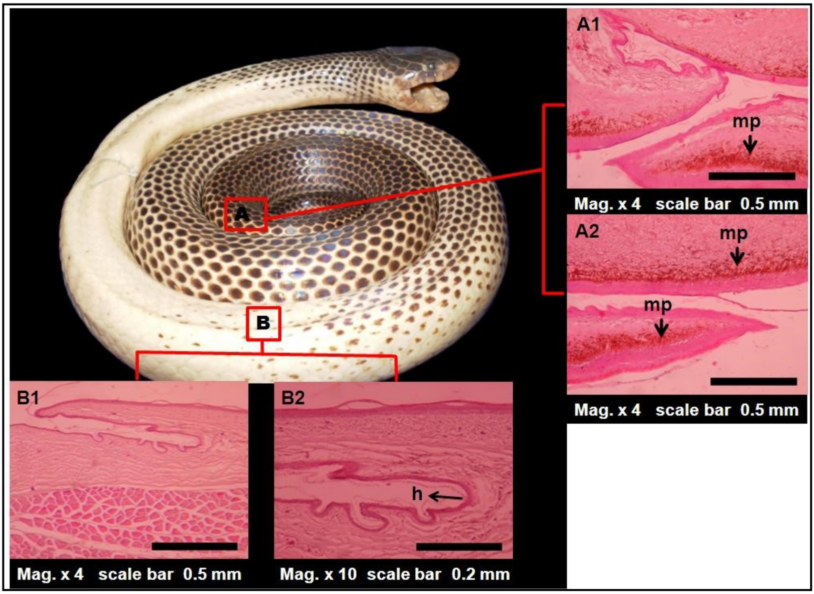

Figure 17. The arrangement and different color of *M. ikaheka* skin scales. A = skin samples from the dorsal caudal; B = skin samples from the dorsal midbody; mp = melanin pigment; h = hinge. Region.

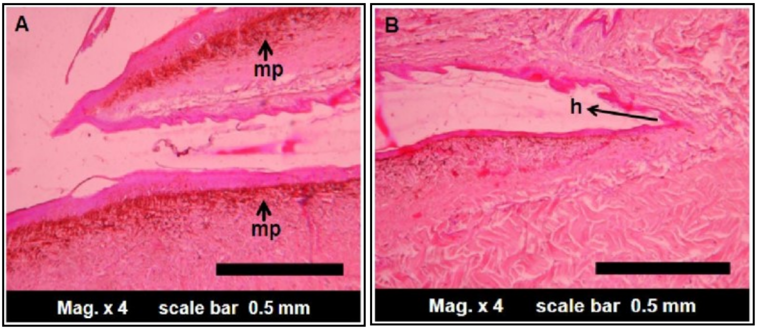

Figure 18. The scales overlapping and pigmentation pattern of the dorsal caudal region. mp = melanin pigment.

This snake skin histology study showed that the thin hinged region can be the entry point for ectoparasites mite or other pathogens invade the host. McKenzie and Green (1976) found early skin lesions occurred in three captive carpet snakes (*Morelia spilotes variegata*) at hinge regions between scales. Simonov and Zinchenko (2010) also found common snake mite (*Ophionyssus natricis*) on the soft tissues around the eyes, under scales and shields on the underside of snakes head and more often in loreal pits of Siberian pit-viper (*Gloydius halys halys*). In the slive snakes of *M. ikaheka* we found some of mite on the underside of an overlapping ventral scales. The mite possessed a tiny sharp claw tarsus to stab the snake skin, especially in the hinge region (Krey observations).

Melanin pigments were identified in dorsal body with dark color. These findings suggested that of skin color was due to melanin richness. The staining method needed to distinguish the color of the different types of melanin in *M. ikaheka* in the future studies. Although this study only used one sample of the yellow group, one can predicted that the entire surface of the dark skin of the snake contained abundant melanin pigment. Kikuchi and Pfenning (2012) found black tissue in the skin of non-venomous scarlet kingsnake *Lampropeltis elapsoides* contained only melanophores, which were mostly large and found within the dermis. Dark color might facilitate snakes to absorb heat during cooler weather (Tylor and O'Shea 2004).

The green python *Morelia viridis* is commonly yellow or red in juveniles but green in adult. The pythons are regionally variable in colour patterns found throughout the lowland rainforest of New Guinea and adjacent far northeastern Australia (Rawlings and Donnellan 2003). Gibson and Fals (1979) found that a melanic morph of a temperate zone snake maintained a higher body temperature when exposed to solar radiations than the lighter, striped morph snake. Therefore, one can conclude that colors are response with respect to age, seasons, and other environment factors. In this study, further ecology study of *M. ikaheka* is needed to explain the environmental factor drives color differentiation in *M. ikaheka* pattern.

Scales of various shapes and sizes cover the skin of *Micropechis ikaheka*. The number, arrangement, size and shape of the scales vary greatly from one species to the other, however they are genetically fixed for each species (Abdel-Aal *et al.* 2011). In this study, scales microtopography of all of *M. ikaheka* specimen was similar. However, corresponding with their geographic distribution, they differ in color scales sharply. Therefore, the scales and color patterns might provide simple and accessible recognition of characteristics to classify *M. i.ikaheka* and *M. i. fasciatus* in New Guinea.

Three individuals of *M. ikaheka* representing for the black, brown, and yellow groups were chosen for SEM observations. The SEM method was used to study the microtopography structure of the *oberthoutchen* layer surface between the three groups of *M. ikaheka*. Skin characters between dorsal and ventral sides of the snake body were observed were: surface texture of scales, microornamentation and microtopography variation (Figure 19).

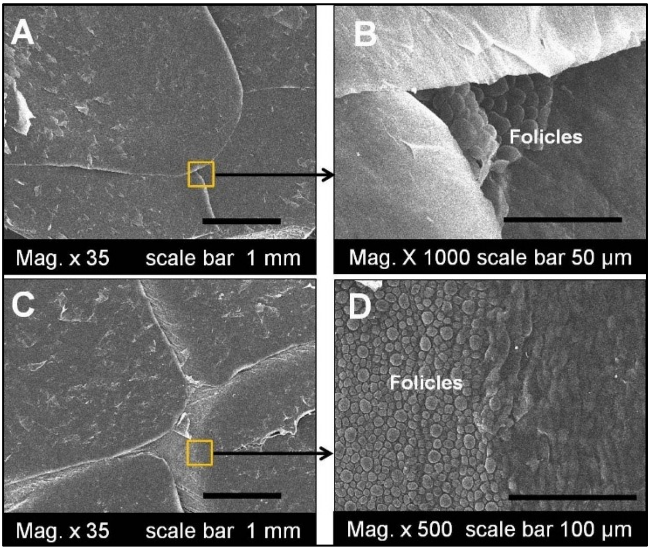

Figure 19. SEM images illustrating the microstructure of the *oberhautchen* on the dorsal outer scale surface of the mid-body (A,B) and caudal (C,D) scales

Similarity of the microtopography scale surface and there is no microornamentation in all specimen examined in this work, due to the snake occupy the same terrestrial habitat and use the same substrate as well (O'Shea 1996). However, Gower (2003) found six characters of microornamentation variation in 27 species of fossorial uropeltidae snake, such as cell shape, cell borders, pores/pits, cell length, denticulations and their length, denticulation length: cell length. Moreover, Klein and Gorb (2012) found difference in epidermis thickness, scale size and shape of the microstructure of the four snake species [*Lampropeltis getula californiae* (terrestrial), *Epicrates cenchria cenchria* (generalist), *Morelia viridis* (arboreal), and *Gongylophis colubrinus* (sand-burrowing)] correlated with a specific adaptation to factors such as habitat, substrate and locomotion.

Disparity between scales boundary and scales region (Figure 20) might be related to the scales contact intensity with substrate surface. Scales boundary might contain slightly thin keratin for relaxation maintenance when the snake moves. In addition to protecting the body, scales also aid in locomotion, assist retain moisture, and alter the surface characteristics (Abdel-Aal *et al.* 2011).

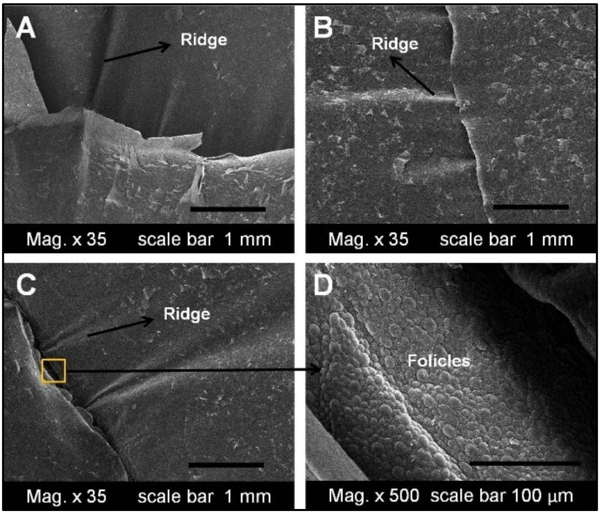

Figure 20. SEM images illustrating the microtopography of the *oberhautchen* on the ventral outer scale surface of the mid-body. Black group (A), brown group (B), yellow group (C), and ventral scales boundary (D).

The ridge found in ventral scales might assist *M. ikaheka* when they moved on the surface of the substrate or channel. Gower (2003) found regular ridges in some uropeltid snake and suggests that the ridges microornamentation might offer performance advantages for life in soil. However, the functional significance of *M. ikaheka* ridges is difficult to ascertain. There are no data on the relative locomotors mechanics among *M. ikaheka* as yet.

CHAPTER IV

THE HEMIPENIS OF *MICROPECHIS IKAHEKA*

The hemipenial morphology of 64 terrestrial Australian elapids was described by Keogh (1999). He describes little intraspecific variation within the species and specimens at his disposition. The first description of hemipenial variation (Figure 21 and 22) at intraspecific level in *Micropechis ikaheka,* a snake belonging to the Australian Elapid radiation investigated by Keogh (1999). Hemipenial characteristics of the four color morphs of *M. ikaheka* were examined (Figure 23), some corresponding to currently recognized subspecies, namely, Yellow (*M. i. ikaheka*), Brown-striped (*M. i. fasciatus*), Black, and Intermediate (Yellow-Brown).

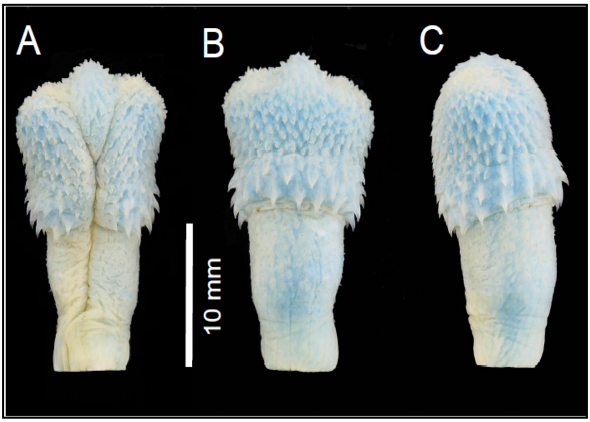

Figure 21. Sulcate (A), asulcate (B) and lateral (C) view morphology of left hemipenis of *M.i. ikaheka*. Injected with blue-stained petroleum jelly. Photo by Eric Smith.

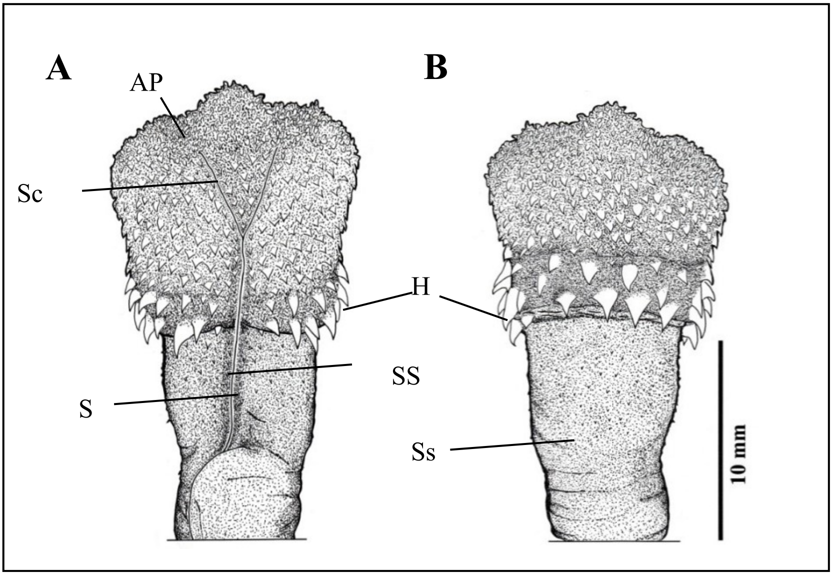

Figure 22. Sulcate (A) and asulcate (B) morphology illustrate of left hemipenis of *M.i. ikaheka* (LZU 28). The line drawing illustrate views with camera lucida, showing sulcus spermaticus (SS), hooks (H), spicules (Sc), spines (S), small spines (Ss), and apical lobe (AP). Illustrated by Keliopas Krey.

There are three traditionally shape character of snakes hemipenial i.e. single, bilobed, and divided, defined by Dowling and Savage (1960). The hemipenis of all seven specimens of *M. ikaheka* are bilobed and with the *sulcus spermaticus* bifurcating near the crotch continuing to the apical lobes like a ”Y”.

The ornamental structures of the hemipenis of *M. ikaheka* shown a great basic knowledge for defining taxonomic of the groups of *M. ikaheka* in Papua, Indonesia. There are many variation in hemipenial proportions (length of organ and position of *sulcus spermaticus*) and number of hooks around the organ and spines bordering the *sulcus spermaticus* (Table 1). Although the sample size is small and there is considerable variation in proportions it is difficult to associate these with any of the current subspecies or color morphs. The same is true for the hook and spine counts. Extremes in variation are almost invariable encompassed by those of the better-sampled color morphs. The color morphs left to right as they occur in Papua, west to east, and the ranges of variation do not even appear to show gradients in distribution, for example, black *M. ikaheka*, extreme west, contains the highest count of hooks around the organ, but also one of the lowest, just as the yellow morph (*M. i. ikaheka*) from the Vogelkop Peninsula (with both low an high counts). The intermediate and the brown (*M. i fasciatus*) morphs contain high and low counts, respectively, both within the ranges of the first two morphs.

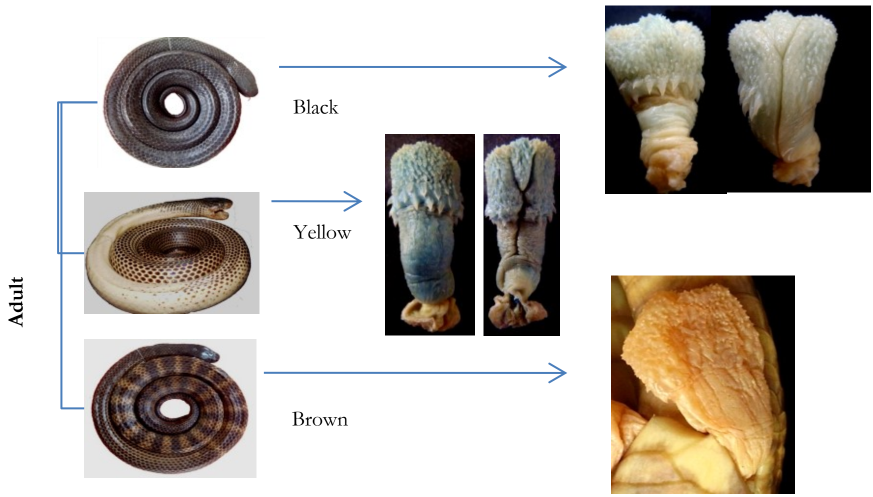

Figure 23. The same hemipenial type of the four color morphs of *M. ikaheka*

Table 1 Selected character variation in *M. ikaheka*

	M. ikaheka Black (n=3)	*M. i. ikaheka* (n=2)	*M. ikaheka* Intermediate (n=1)	*M.i.fasciatus* (n=1)
Hemipenis length/tail length, %	9.09–14.42	12.89–14.21	11.78	15.87
Length to *sulcus spermaticus* division from base as percentage of tail length	7.24–10.24	9.36–9.80	9.47	13.21
Length to *sulcus spermaticus* division from lobe apex as percentage of tail length	3.29–4.01	3.56–3.76	2.92	5.56
Number of hooks around organ	31–37	30–35	37	30
Spines on anterior border of *sulcus spermaticus*	14–24	21	15	23
Spines on posterior border of *sulcus spermaticus*	15–23	22–23	15	21
Spines on anterior and medial border of *sulcus spermaticus* after sulcal division	5–6	6–7	6	6
Spines on posterior and medial border of *sulcus spermaticus* after sulcal division	5	5–6	5	6

Color variation has been described by previous authors (O'Shea 1996; Rooij 1917; Krey and Farajallah 2013) in the context of zoogeographical distribution in mainland New Guinea some of its smaller satellite islands. Although there were striking difference in color variations on skin scales and zoogeographical (Krey and Farajallah 2013), *Micropechis ikaheka* has shown no differentiation on hemipenial structure between group. Therefore, the hemipenial characteristic cannot provide a significant differentiation to distinctive specific or subspecific limits on *Micropechis* in Papua.

Geographic variation in color is evident but we find little overlap in the distribution of the different color groups (Figure 24). *Micropechis i. fasciatus* is found widespread across the mainland to the eastern part of the island, in New Guinea, and including Yapen island in the north (Krey and Farajallah 2013) and Aru island in the south (Slater 1968). *Micropechis i. ikaheka* is limited to the Vogelkop peninsula, while *M. i.* Black is found only on Waigeo and Batanta islands (Krey and Farajallah 2013). Evolutionary processes act on *M. ikaheka* and color variants have arisen in different populations, from the east to west in New Guinea. This color variation might be related to environmental factors. Further and coming investigation, including molecular sequencing of different populations, will try to elucidate the nature of variation in these fascinating snakes.

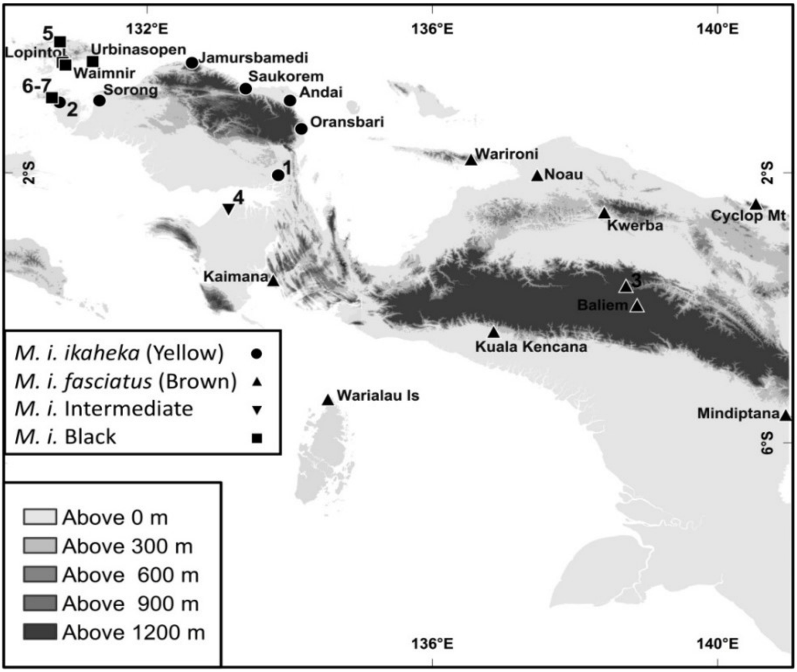

Figure 24. Distribution of geographic variants of *M. ikaheka* in Papua

CHAPTER V

DIET AND CANNIBALISM OF *MICROPECHIS IKAHEKA*

Diet preference of *M. ikaheka* appears to be a generalist vertebrate predator, predating amphibians, fish, reptiles, and mammals (Figure 25). Prey primarily comprises reptiles (61.5% of all prey items), followed by mammals and fish (both 15.4%), and amphibians (7.7%). Three reptilian families: lizards (Scincidae) were the dominant prey items (75% of all reptile prey items), with snakes (Elapidae: *M. ikaheka* and Colubridae: *Dendrelaphis* sp.) accounting for the remaining 25%. The presence of hair and both of hindlimb and forelimb bones permitted identifications of mammals and frogs.

	Prey Type
Reptiles 61.5%	*M. ikaheka*
	Dendrelaphis sp.
	Scincidae
	Sphenomorphus simus
	S. muelleri
	Scincidae
	Eugongylus rufescens
Mammals 15.4%	Mammals
	Mammals
Fish	Cyprinidae
Amphibians 7.7%	Frogs

Figure 25. M. ikaheka appears to be a general vertebrate predator

An adult *M. ikaheka* was found consuming an eel, (in Indonesian, *sidat*) by two MZB researchers, at Waina Creek (GPS coordinates: 05^{0}22.493' S; 134^0 32.333' E), on 6th December 2013, on Warialau Island, North Aru Archipelago, Maluku Province, Indonesia. The eel was captured by the snake at 15.58 local time, and the snake was sighted approximately 1.0 m from the water edge. The eel was identified as *Anguilla* sp. (Figure 26-A, B, C, D) based on the general morphology (Wowor D 30 December 2013, personal communication, one of the observers).

Figure 26. *M. ikaheka* (*fasciatus* form) found ingesting an eel, *Anguilla* sp., at Warialau Island, North Aru. Rainforest habitat of the eel and *M. ikaheka* (A). The eel was captured in the water and pulled out to the creek bank (B). The direction of ingestion is head first (C). Most of the eel's body has been swallowed (D). All photos by D. Wowor

The New Guinea small-eyed snake, *M. ikaheka,*was reported to exhibit cannibalism in captivity (O'Shea 1994b). The first case of cannibalism in a wild *M. ikaheka*, based on a juvenile *M. ikaheka* found found in the gastrointestinal tract of an adult female (Figure 27). Approximately 120 mm length of the body of the smaller specimen (SVL: 320 mm; TL: 59 mm) had been ingested head first by a larger specimen (SVL: 630 mm; TL:130 mm). The incident took place in the afternoon on November 2010, at Manokwari, West Papua Province (GPS coordinates: $00^0$52.599'S; $134^0$05.192' E).

Figure 27. The cannibalism of *M. ikaheka* at Manokwari

Figure 28. The direction of ingestion of *M. ikaheka* is head first

CHAPTER VI

GEOGRAPHIC VARIATION AND TAXONOMY SIGNIFICANT

The coloration of *M. ikaheka* indicats a variable locally (O'Shea 1996; Krey and Farajallah 2013). In the eastern region of New Guinea, in PNG, the population in the north is different from the southern population in their skin color (O'Shea 1996).

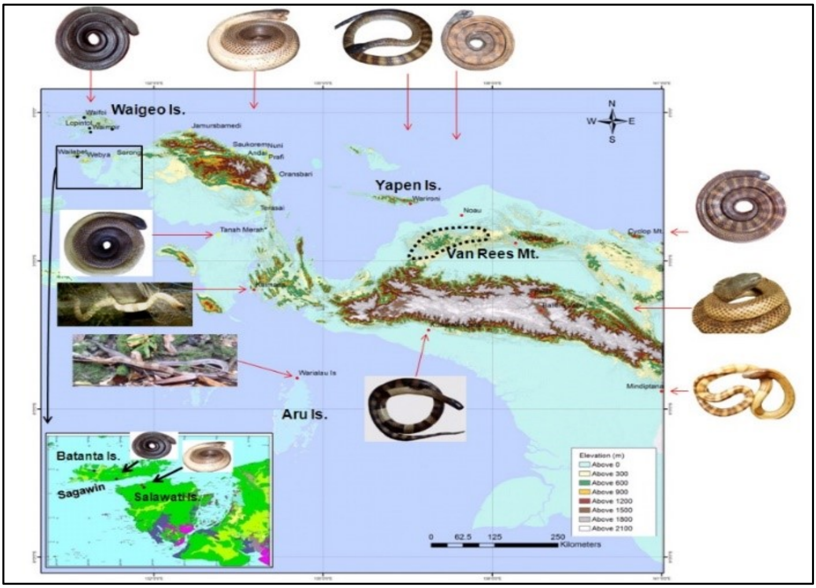

Figure 29. Geographical variation of *M. ikaheka* in Papua. All data were based on specimens and also photographed by both D. Wowor and Zet Parinding from Warialau Island and Kaimana, respectively.

Partially, *fasciatus* group was found widespread across the mainland to the eastern part of the island of New Guinea, including Aru island in the south (Slater 1968) and Yapen Island in the north, while *ikaheka* group is limited to Vogelkop Region; and the black group is spread from Waigeo and Batanta Islands (Krey 2009; Krey and Farajallah 2013). Surprisingly, there is no overlapping distribution among populations or groups of all of *M. ikaheka* in Papua (Figure 29).

Papua's bird regions can be further classified into 13 biogeographic subunits (Beehler 2007); and the freshwater endemism as defined into six region (Allen 2007). The distribution of *M. ikaheka* fall into four biogeographic subunits (Figure 30). The *fasciatus* group can be divided further into two groups or phases i.e. full-banded *fasciatus* phase and half-banded *fasciatus* phase (O'Shea, per.sonal com.). The Vogelkop includes a core of original Australian craton that separated from the main plate, and the adjacent Raja Ampat Islands include northern unit and southern unit, separated biogeographically by Sagawin Strait (Beehler 2007). Aru Islands are land-bridge islands which lie close to the southern lowlands. It has been shown that their biota is merely an isolated segregate of that present in the Arafura coastal lowlands (Allen 2007).

Microtopography of scales and hemipenial characteristics has provided some insights of the intra species relationships of *M. ikaheka* in Papua. Although the skin colors and zoogeography are clearly different (Krey 2009; Krey and Farajallah 2013), but there is no evidence that they are as a distinct species or sub species. Lesson (1830) and Ficher (1884) based their assessment on traditional systematic characters (morphology) of scales count and color to determine species status. *Micropechis ikaheka fasiciatus* that recognised by Ficher (1884) based on the single specimen from the Aru Islands. The skin color of the sub species is completely different with *Micropechis ikaheka ikaheka,* although the number and form of head scales, the number of ventral and sub caudal scales or, habits, is fully in conformity.

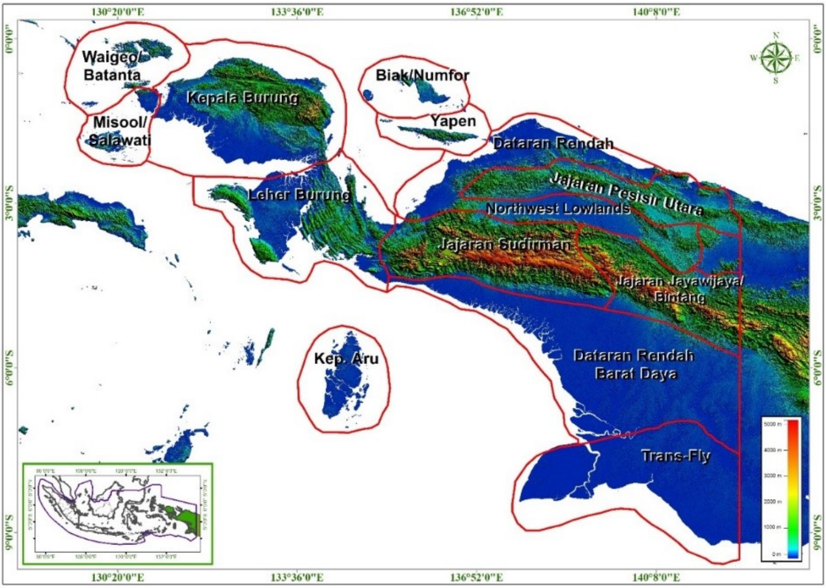

Figure 30. 13 biogeographic subunits and distribution of *M. ikaheka* fall into four biogeographic subunits

CHAPTER VII

GENERALE DISSCCUSION AND COMMENT ON CONSERVATION

Skin Melanin and Sex Dimorphism of *M. ikaheka*

Some species of snakes are known to change their skin colors as a physiology or morphology response with respect to age, seasons, or other environment factors. For example, the green python *Morelia viridis* is commonly yellow or red in juveniles, but they turn green in adulthood (Rawlings and Donnellan 2003). Many of harmless or mildly toxic species of American snakes are regarded as highly venomous coral snake mimics to reducing predation (Savage and Slowinzki 1992). This study concluded that *M. ikaheka* do not show mimicry behavior, since there is no pressure from other predators on this venomous species. Gibson and Fals (1979) found that a melanic morph of a temperate zone snakes was a mechanism to maintain body temperature when exposed to solar radiations than the lighter, striped morph snake.

Micropechis ikaheka has spectacular colors and patterns. Existing skin scales color of all individuals of *M. ikaheka* have melanin of basic brown and yellow, followed by black color. Melanin is responsible for the dark color in vertebrate skin which is in principle black and brown or red, but sometimes yellow (Hildebrand and Goslow 2001; Vevers 1982).

The color of skin appears through melanin pigment (melanophores) and that color may respond to morphological or physiological color changes, with respect to age or seasons (Hildebrand and Goslow 2001). Is the color variation on *M. ikaheka* a sexual dimorphism? The color variation in *M. ikaheka* is not determined by sex (Krey 2009). Based on the sex identification of 20 adult individuals, seven (approximately 35%) individuals were male and 13 (approximately 65%) were female. Observations of presence or absence of hemipenes conducted on all of adult specimens of *M. ikaheka* show that each color group has both male and female.

Diet and Cannibalism Phenomena with a Comment on Conservation

All snakes are carnivorous, unlike other reptiles that feed on nectar, fruit, and leaves (Donoghue 2006). Moreover, *M. ikaheka* has been reported as a cannibal (O'Shea 1994), as well as to prey on other snakes such as *Dendrelaphis* sp (Table 4). All items in the diet of *ikaheka* snakes that examined in this study consist of whole body or body parts of amphibians, fish, reptiles, and mammals. The stomach contents analyzed conclude that scincid lizards are the primarily prey, which may reflect the ability of *M. ikaheka* to capture the scincid rather than active selection (Houston and Shine 1993). It is probably that *M. ikaheka* preys primarily on scincid lizards because of their great abundance and preference for semi-fossorial and terrestrial habitats, similar to habitat inhabited by *M. ikaheka*.

Although the study recorded a single incident of cannibalism, it is believed that only females are cannibalistic. Unfortunate, data cannot explain whether or not the adult female was a cannibal of her own offspring. However, it is suggested that maternal cannibalism may be more ubiquitous among free-living *M. ikaheka*. Maternal cannibalism in rattlesnakes is more on to recover than for the parental care (Mocino-Deloya *et al.* 2009). Cannibalism in *M.ikaheka* could be due to two factors: 1) intraspecific competition; and 2) a mechanism in regulating population. Molecular analysis may help explain both these hypothesis in future studies.

The findings of "eel prey" by *M. ikaheka* is also interesting. The name “ikaheka” is originated from an Papuan dialect, which means “land eel” (O’Shea 1996), or *Anguille de terre* in Lesson (1830). Since long time ago, people in Papua have believed that the snake often enters the river to copulate with eel. Of course, these findings have rejected this anecdotes. The *M. ikaheka* goes into river or stream for food rather than mating.

The Contributions of Snakes For Conservation and the Local Wisdom

Snakes are feared by humans, and many find them uninteresting. This is one of the reasons only few studies have done on snakes in many places in the world, including Papua. As we know of all reptiles, snakes are definitely the reptiles that always evoke positive and negative responses. Snakes have been the primary subject of folklore, mythology, religion, and medicine in the past, and now in the pet trade (Funk 2006). Many people have excessive fear (phobia) even when they only see snakes in pictures, movies or just hear about the tales of snakes.

The comparatively sophisticated people have been known to refer to the snake as the "epitome of evil" (Ramona and Morris 1965), even until now. Long before Christianity came to Papua in 1855, snakes had been present in Papuan folklore, mythology, and medicine. Even many types of snakes had names in the local languages of Papua as well as the scientific names. For example, the specific name “*ikaheka*” was from the local name. Religion had shaped the perception of the Papuans that traditionally snakes had always been associated with evil and sin, perhaps the worst reputation ever given by humans to animals on Earth. Consequently, most Papuans are still afraid of all snakes or any thing appearing like a snake which makes them disinterested in snake preservation. Spontaneous reactions usually occur when they see a snake, and without thinking whether it is venomous or not, people will kill it. Based on the interviews with local Papuans, snakes have always been at the top of their list of the most feared animals in Papua until now. The local community and even parents often remind one another not to enter and destroy the forest because there are "big and dangerous" snakes. This may be one of the local wisdom that is good for forest conservation in Papua.

Although feared, there is some interesting information about the traditional utilization of snakes by the Papuans. In Papua New Guinea, snakes are used for food, entertainment, traditional medicine, and financial gain (O'Shea 1999). Some of the indigenous people in Papua eat *Leiophyton albertisii* and *Morelia viridis*, and used the body parts of snakes for traditional medicine. Indiginous people from Arfak Manokwari extract *Micropechis ikaheka* to get the oil and use it as a liniment to treat a swelling muscle (Krey personal observation).

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THE *Micropechis* SPECIES:

SKIN, diet, cannibalism

This book provides a comprehensive scientific exploration of Micropechis ikaheka, an endemic venomous snake found in Papua and Papua New Guinea, commonly known as the "white snake" or "New Guinea small-eyed snake". The book delves into various aspects of this species, including skin morphology, color variation, hemipenial structure, skin histology, and zoogeographical distribution in Papua.

Through extensive research, the author identifies three distinct color morphs—brown, yellow, and black—each with unique distribution patterns across Papua and its satellite islands. Additionally, the book investigates the cannibalistic behavior observed in this species and its dietary habits, which include reptiles, small mammals, and even eels.

Supported by historical data, recent studies, and field observations, this book serves as a valuable reference for biologists, herpetology researchers, students, and anyone interested in reptilian ecology and anatomy. Dr. Keliopas Krey's detailed analysis not only enhances our understanding of M. ikaheka, but also contributes significantly to the conservation of Papua's biodiversity.

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