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ของสัตว์ในวงศ์ตะกวดในภาคใต้ของประเทศไทย

นายคมศร เลาห์ประเสริฐ

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SPECIES DIVERSITY, DISTRIBUTION AND MORPHOLOGICAL DIFFERENCES OF MONITOR LIZARDS (FAMILY VARANIDAE) IN SOUTHERN THAILAND

Mr. Komsorn Lauprasert

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By	Mr. Komsorn Lauprasert
Department	Biology
Thesis Advisor	Assistant Professor Kumthorn Thirakhupt, Ph.D.

Accepted by the Faculty of Science, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master 's Degree

.... Dean of Faculty of Science
(Associate Professor Wanchai Phothiphichitr, Ph.D.)

THESIS COMMITTEE

.... Chairman
(Professor Siriwat Wongsiri, Ph.D.)

.... Thesis Advisor
(Assistant Professor Kumthorn Thirakhupt, Ph.D.)

.... Member
(Jarujin Nabhitabhata)

.... Member
(Art-ong Pradatsundarasar, Ph.D.)

คมศร เลาห์ประเสริฐ : ความหลากหลายของสัตว์ในวงศ์ตะกวด การแพร่กระจายและความแตกต่างทางสัณฐานวิทยาของสัตว์วงศ์ตะกวดในภาคใต้ของประเทศไทย. (SPECIES DIVERSITY, DISTRIBUTION AND MORPHOLOGICAL DIFFERENCES OF MONITOR LIZARDS (FAMILY VARANIDAE) IN SOUTHERN THAILAND) อาจารย์ที่ปรึกษา : ผศ. ดร. กำธร ธีรคุปต์, 129 หน้า. ISBN 974-334-566-3.

การศึกษาความหลากหลายของชนิดและการแพร่กระจายของสัตว์วงศ์ตะกวดในภาคใต้ของประเทศไทย ตั้งแต่เดือน มกราคม พ.ศ. 2540 ถึงเดือนธันวาคม พ.ศ. 2542 พบสัตว์ในวงศ์ตะกวด 4 ชนิดได้แก่ เหี้ย *Varanus salvator* (Laurenti, 1768) เห่าช้าง *Varanus rudicollis* (Gray, 1845) ตะกวด *Varanus bengalensis nebulosus* (Gray, 1831) และตุ๊ดตู่ *Varanus dumerilii* (Schlegel, 1839) สำหรับ แลนดอน *Varanus flavescens* (Hardwicke and Gray, 1827) และ เหี้ยดำ *Varanus salvator komaini* Nutphand, 1987 ไม่พบในการสำรวจครั้งนี้ เหี้ยและตะกวดมีการกระจายทั่วทุกพื้นที่ในภาคใต้ ทั้งพื้นที่ป่าและพื้นที่เกษตรกรรม เห่าช้างและตุ๊ดตู่ส่วนมากอยู่ตามบริเวณป่าชื้นที่รกทึบและมีความอุดมสมบูรณ์ สามชนิดแรกพบว่ามีการกระจายอยู่ทุกเทือกเขาทั่วทั้งภาคใต้คือ เทือกเขาภูเก็ต เทือกเขานครศรีธรรมราชและเทือกเขาสันกาลาคีรี สำหรับตุ๊ดตู่พบเฉพาะบริเวณเทือกเขานครศรีธรรมราชและสันกาลาคีรีเท่านั้น

การศึกษาความแตกต่างของลักษณะทางสัณฐานวิทยาในสัตว์วงศ์ตะกวดในภาคใต้ของประเทศไทย พบว่า เห่าช้างและตุ๊ดตู่สามารถแยกออกจากกันได้ด้วยลักษณะของเกล็ดคอ (nuchal scale) ในชนิดที่เหลือคือ เหี้ย(รวมทั้งเหี้ยดำ) และตะกวด เมื่อใช้สถิติ Analysis of Variance ในการวิเคราะห์ความแตกต่างพบว่า ระยะห่างระหว่างจมูกถึงปลายจงอยปาก ความยาวของจมูกและระยะห่างระหว่างจมูกด้านซ้ายและขวา สามารถใช้จำแนกชนิดได้ โดยมีค่าความแตกต่างอย่างมีนัยสำคัญที่ $p< 0.05$ ความแตกต่างระหว่างเพศใน เหี้ย ตะกวด และเห่าช้าง เมื่อวิเคราะห์ด้วยสถิติ Mann-Whitney U-test พบว่าในตัวผู้มีความยาวใหญ่มากกว่าตัวเมียทุกลักษณะ โดยมีค่าความแตกต่างอย่างมีนัยสำคัญที่ $p< 0.05$ นอกจากนี้ Discriminant Function analysis ยังถูกนำมาประยุกต์สร้างสมการทำนายชนิดและเพศของสัตว์ในวงศ์ตะกวดด้วย

การเปรียบเทียบความแตกต่างระหว่างเหี้ยและเหี้ยดำ พบว่าค่าสัดส่วนของลักษณะส่วนมากไม่มีความแตกต่างกันอย่างมีนัยสำคัญ เมื่อนำผลการศึกษา Canonical Discriminant Function มาพิจารณาสรุปได้ว่า เหี้ยดำไม่สามารถแยกออกเป็นชนิดใหม่หรือชนิดย่อยของเหี้ยได้

การศึกษาข้อมูลทางนิเวศวิทยาและชีววิทยาบางประการ พบว่าสัตว์วงศ์ตะกวดทุกชนิดอยู่ในภาวะถูกคุมคามจากข้อมูลการศึกษาทั้งหมดและอาศัยเกณฑ์การจัดสถานภาพของ IUCN สามารถประเมินได้ว่าเหี้ยและตะกวดควรถูกจัดอยู่ในภาวะสัตว์ที่มีแนวโน้มจะสูญพันธุ์ เห่าช้างและตุ๊ดตู่ควรจัดอยู่ในสภาวะเป็นสัตว์ใกล้สูญพันธุ์ ส่วนเหี้ยดำจัดเป็นสัตว์ที่ใกล้สูญพันธุ์อย่างยิ่ง ถึงแม้ว่าข้อมูลเกี่ยวกับแหล่งที่อยู่อาศัยของเหี้ยดำในสภาพธรรมชาติยังไม่เป็นที่ชัดเจน

ภาควิชา ชีววิทยา .... ลายมือชื่อนิสิต คมศร เลาห์ประเสริฐ ....
สาขาวิชา สัตววิทยา .... ลายมือชื่ออาจารย์ที่ปรึกษา กำธร ธีรคุปต์ ....
ปีการศึกษา 2542 .... ลายมือชื่ออาจารย์ที่ปรึกษาร่วม ....-........

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KEY WORD: MONITOR LIZARD/ VARANUS/ SPECIES DIVERSITY/ MORPHOLOGY/ SEXUAL DIFFERENCES/ SOUTHERN THAILAND

KOMSORN LAUPRASERT : SPECIES DIVERSITY, DISTRIBUTION AND MORPHOLOGICAL DIFFERENCES OF MONITOR LIZARDS (FAMILY VARANIDAE) IN SOUTHERN THAILAND. THESIS ADVISER : ASSIST. PROF. KUMTHORN THIRAKHUPT, Ph.D., 129 pp. ISBN 974-334-566-3

The studies of species diversity, distribution and sexual dimorphism of monitor lizards were carried out from January 1998 to December 1999. Four species were found in southern Thailand, comprising *Varanus salvator* (Laurenti, 1768), *V. rudicollis* (Gray, 1845), *V. bengalensis nebulosus* (Gray, 1831) and *V. dumerilii* (Schlegel, 1839). *V. flavescens* (Hardwicke and Gray, 1827) and the *Varanus salvator komaini* Nutphand, 1987 were not found during the field survey.

V. salvator and *V. b. nebulosus* distribute throughout southern Thailand in both forest and agricultural areas while *V. rudicollis* and *V. dumerilii* are usually found in undisturbed forests. The former three species distribute in three main mountain ranges (MR), i.e. Phuket MR, Nakhon Sri Thammarat MR and San Karakiri MR whereas the last is only found in Nakhon Sri Thammarat MR and San Karakiri MR.

Morphological differences among monitor lizards in southern Thailand were studied using the Analysis of Variance ($p < 0.05$). Some specific characters can be used to identify the species of monitors i.e. nuchal scale, snout-vent length, nostril length and nostril width. Sexual difference was studied in *V. salvator*, *V. rudicollis* and *V. b. nebulosus* using Mann Whitney U-test ($p < 0.05$). All traits of male monitors were found to be longer and larger than that of the female monitors in all three species. Moreover, the Discriminant Function Analysis was applied to create equations for the prediction of the species and sexes of monitor lizards in southern Thailand as well.

Morphological characters of *V. s. komaini* were compared to *V. salvator*. Both of them have similarity in most of their morphological characters. Considering the result from Canonical Discriminant Function, it could not be concluded that the *V. s. komaini* is a separate species or a subspecies of *V. salvator*.

Some ecological and biological information of monitor lizards were studied. All species are being threatened by human disturbance. Based on the IUCN's criteria for the categories of threat, *V. salvator* and *V. b. nebulosus* are suggested to classified under in vulnerable category while *V. rudicollis* and *V. dumerilii* should be in endangered status. The *V. s. komaini* is critically endangered and its natural habitat is still unknown.

ภาควิชา Biology	ลายมือชื่อนิสิต K. Lauprasert.
สาขาวิชา Zoology	ลายมือชื่ออาจารย์ที่ปรึกษา K. Thirakhupt
ปีการศึกษา 1999	ลายมือชื่ออาจารย์ที่ปรึกษาร่วม –

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Chapter 1

Introduction

Thailand is located in tropical and subtropical zones which exceeding abundance in biological diversity. There are approximately 313 species of reptiles from 3 orders and 23 families. Almost all of them are still little-known and available primary data are absent for advanced researches. In addition, human has threatened many species both by hunting and by destroying their habitats. Monitor lizards belong to Family Varanidae, Genus *Varanus*. They are diverse in sizes, but some species have high potential to be developed into economic animals. The conspicuous use is their skins for leather industries, including their meats and bones are derived to analeptic and aphrodisiac medicines. Each year, therefore, a lot of monitor lizards are hunted and killed for commercial trade. There is also some international trade in live specimens (Luxmoore and Groombridge, 1990).

Currently, more than 46 species of monitor lizards around the world were found in 3 continents as Africa, Australia and Asia (Bennett, 1998). There are 9 species in Asia. Five species (Taylor, 1963; Nutphand, 1987) and a new subspecies (Nutphand, 1987) of varanids have ever been reported to occur in Thailand. They are clouded monitor *Varanus bengalensis nebulosus* (Gray, 1831), water monitor *Varanus salvator* (Laurenti, 1768), rough-necked monitor *Varanus rudicollis* (Gray, 1845) dumeril's monitor *Varanus dumerilii* (Schlegel, 1839) and *Varanus flavescens* (Hardwicke and Gray, 1827). The new subspecies suggested by Nutphand (1987) is the black water monitor *Varanus salvator komaini*, which was reported to occur at Amphur Langu, Satun Province and the area near to Thailand-Malaysia border. Nevertheless, there are some disagreements of how many species and subspecies actually occurring in Thailand.

Previous data of monitor lizards were also confused by several local names. Moreover, their similar shapes of external morphology both within and between species are difficult to identify. The visible external morphology usually can not tell the differences in sexes. Therefore, the detailed morphometric study of each species should be conducted.

At present, monitor lizard skins of Thailand become excellent quality products and are demanded by international markets such as Japan, USA and France. The effect of hunting for skins results in the population of monitor lizards having rapidly declined. Luxmoore and Groombridge (1990) reported that hunting of *Varanus* has occurred throughout Thailand, but is most concentrated in southern parts. Viable populations are likely to persist only in areas received total protection. Therefore, conservation management is an important aspect for the protection of the animals from human disturbance. Ecological and biological data are most necessary at present in order to design proper management, such as preservation and enhancement, translocation of animals to more suitable habitats and captive breeding programs. All monitor lizards should be managed with high quality and sustainability.

Objectives

1. To study species diversity and distribution of monitor lizards in southern Thailand.
2. To study morphological differences and sexual dimorphism of monitor lizards in southern Thailand.
3. To study some ecological and biological data such as habitat types, status of monitor lizards in southern Thailand, clutch sizes and egg sizes.

Anticipated benefit

This study will provide basic knowledge on species diversity, distribution, morphological differences among species, sexual dimorphism, including some ecological and biological data of monitor lizards in southern Thailand. This could be used for the conservation management of monitor lizards in natural habitats and could be applied to advance captive-breeding programs in the future.

Chapter 2

Literature Review

2.1 Topography of southern Thailand

The southern part of Thailand, with a total area of 70,715.187 km^2 or 44,196,991.875 rais[1], is situated between latitudes 5° 37' and 11° 42' N and between longitudes 98° and 102° E. The region is bounded by Amphur Bang Saphan Noi, Prachuap Khirikhan Province in the north and by Malaysia in the south. The east coast is bounded by the Gulf of Thailand whereas the west coast faces the Andaman Sea. The total length of the region from north to south is about 700 kms.

There are three main mountain ranges in the southern peninsula of Thailand (Figure 2-1). The first range is Phuket Mountain range, which separates the west coast of Thailand from Myanma. It lies along the provinces of Chumphon, Ranong, Phang Nga and Phuket. The elevation ranges from sea level up to 1,050 meters of the Khao Plai Bang To peak, Phang Nga province. The second range is Nakhon Sri Thammarat Mountain range, which lies alongside with the east coast from Surat thani to Satun provinces. The elevation ranges from sea level up to 1,835 meters of the Khao Luang peak, Nakhon Sri Thammarat province. Between the both ranges is the flat terrain with scattered limestone mountains. The last one is Sankala Kiri Mountain range, which is partly the borderline between Thailand and Malaysia. However, most of the range situate in Malaysia. The elevation ranges from sea level in the part of Thailand up to 1,535 meters of the Khao Ulutiti Bazar peak, Yala province.

The topography of southern region is hilly and mountainous. It was formerly occupied by thick virgin forests and rich deposits of minerals. Due to the combination of high humidity and topography of the region, the areas had favoured the evolution and maintenance of heterogeneous forest types (Nalampoon, 1991). The main forest type in southern Thailand is tropical rain forest, which occupies most parts of the region. This type of forest forms layer with a dense continuous canopy. The topmost layer is about 20-25 meter above the ground and above which scattered emergent trees may be as high as 50-60 meters. The middle layer

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[1] 1 rai =0.16 ha

comprises smaller trees and the trees of the lower layer are even smaller, mainly woody saplings. The forest floor consists of herbs and seedlings. Dominant trees are of the family Dipterocarpaceae (Poonswad & Kemp, 1993).

Some other types of forest which occur in the southern part of Thailand are Mangrove forest, Beach forest, Freshwater swamp forest, Peat swamp forest and Limestone forest.

Mangrove forest is considered as a tropical evergreen forest with unique flora adapted to grow in brackish and saline water (Lauprasert, 1999). It's usually found along the estuaries of rivers and muddy coastlines where the soil is a deep alluvium with high saline concentration (Poonswad & Kemp, 1993). This type of forest is extensive on the west coast, from Ranong southward to Satun Provinces, and along the east coast, from Chumphon to Narathiwat Provinces, but in scattered areas (RFD, 1997).

Beach forest is scattered along the coastal area of the Thai Gulf, the Andaman Sea, and on many islands. This type of forest commonly exists on a narrow stretch along the beach. The soil is sandy, with few nutrients and much exposed to sunlight (Poonswad & Kemp, 1993). The areas are now much degraded by settlement and tourism developments (Lauprasert, 1999).

Freshwater swamp forest is usually found in lowland areas, along inland depressions where the soil is either muddy or sandy and without peat deposits e. g. Thale Noi in Phatthalung Province and Thale Ban in Satun Province. Freshwater swamp vegetation is found in small patches around these reservoirs (Poonswad & Kemp, 1993).

Peat swamp forest only occurs as a microhabitat in the peninsula, at Toa Daeng district, Narathiwat province, near the Malaysian border. It is limited to an area of approximately 25 km^2. The habitat is more or less at sea level. In rainy season, therefore, the areas are flooded or with high tide; producing a high water flow which drains to the surrounding areas. Peat swamp tree species are usually shallow rooted. To fix the soils, plants spread out strong adventitious roots horizontally and vertically, firmly anchoring them both under and above the ground (Poonswad and Kemp, 1993; Rajani, 1996).

Limestone forest contains several chalk-loving species confined to this habitat. In the southern peninsula of Thailand, limestone mountains occur both in mainland and offshore islands (Lauprasert, 1999). At high elevations on ranges and peaks, erosion is excessive. Plants are affected directly by several factors of high soil alkalinity, scarcity of water, eroded ground and slopes and the open exposed habitats (Poonswad and Kemp, 1993).

The southern region of Thailand is influenced by tropical climate, with characteristicly high rainfall and year round high temperature. There are two major monsoons i.e. the southwest monsoon from the Andaman Sea that brings the rainfall into the west coast and the east coast will be affected by the northeast monsoon from Mainland China. The seasons of southern Thailand are divided into dry season from January to April and wet season from May to December. The mean annual rainfall ranges from 1,600-4,300 mm./year and the temperature is between 26.4-28.2 $^{\circ}$C. The average of annual humidity ranges between 75.4-82.4 %.

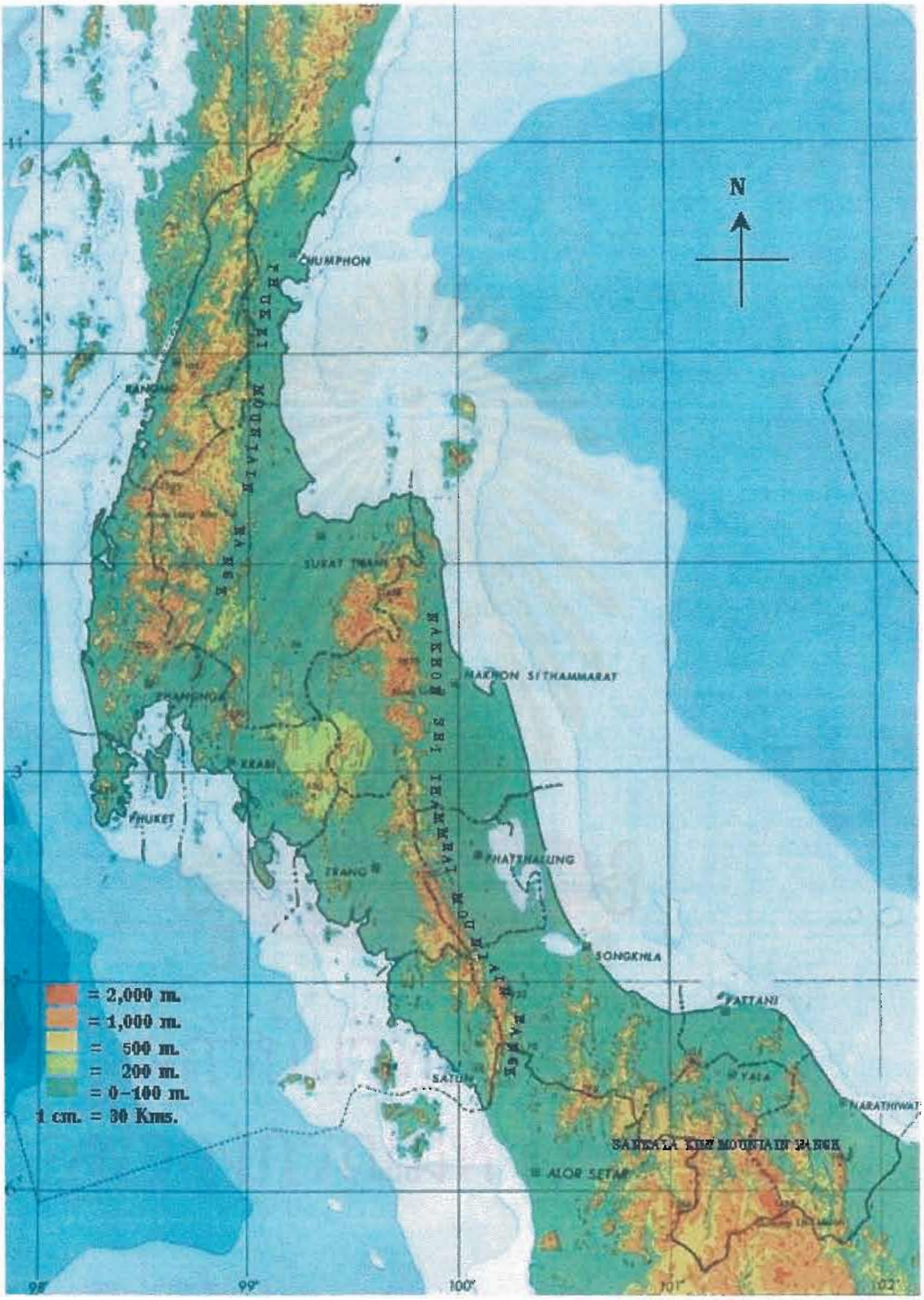


Figure 2-1 The picture illustrates three main mountain ranges in the southern peninsula of Thailand.

2.2 Description and Taxonomy of Monitor lizard

Cladistic classification of Monitor lizards is:

Kingdom Animalia
Phylum Chordata
Subphylum Vertebrata
Class Reptilia
Subclass Lepidosauria
Order Squamata
Suborder Sauria
Family Varanidae
Subfamily Varaninae
Genus *Varanus*

Phyletic relationships of monitor lizards among the living families of squamates and among species of Indo-Asian are shown in figure 2-2 and 2-3.

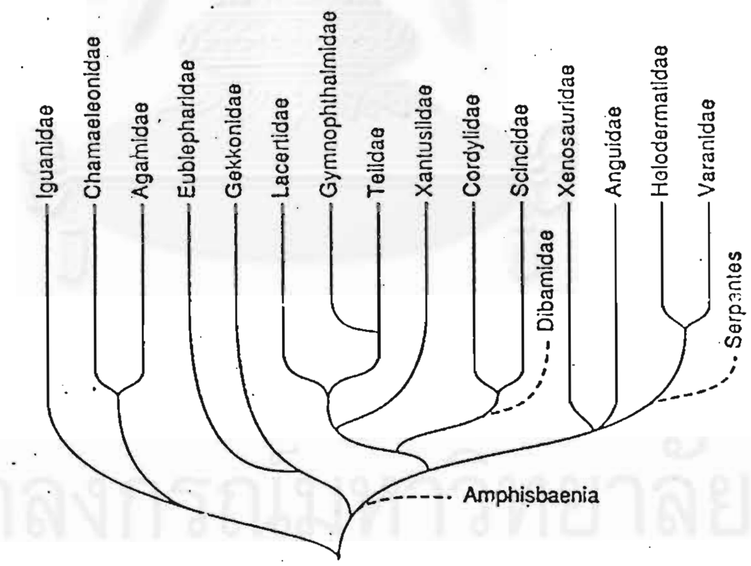


Figure 2–2 Dendrogram of presumed phyletic relationships among the living families of squamates, exclusive of snakes. (Zug, 1993)

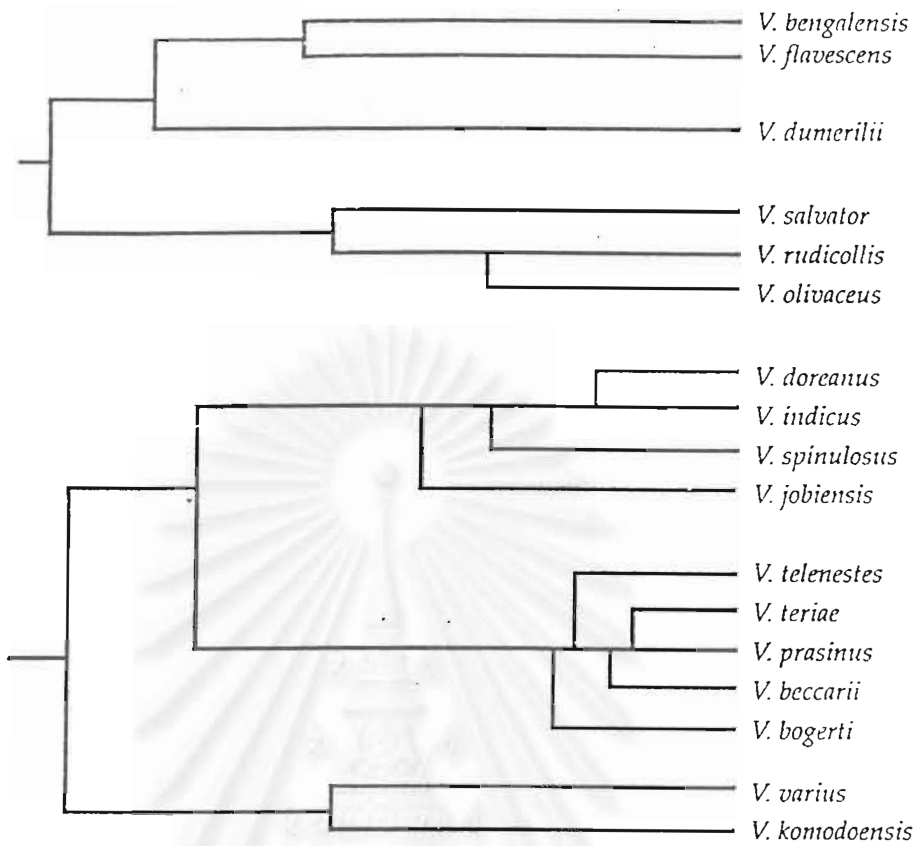


Figure 2-3 Phylogeny of Indo-Asian radiation of *Varanus* (De Lisle, 1996).

Figure 2-4 The distribution range (shaded color) of varanids (De Lisle, 1996).

The Reptilia consists of two ancient lineages, the anapsids and the diapsids. The living representatives of the former are turtles, and of the latter are crocodilians, tuataras, lizards and snakes. The autarchoglossan lizards contain nearly a dozen families of lizards including the family Varanidae, which have well-developed limbs (Zug, 1993).

The family Varanidae includes two subfamilies i.e. the Varaninae and the Lanthanotinae. The former includes one genus (*Varanus*) with more than 46 species while the latter contains only the earless monitor, *Lanthonotus borneensis* (Zug, 1993; Auffenberg, 1994). The varanids arose over 65-70 million years ago in Laurasia and subsequently dispersed to Africa and Australia. At present, the distribution of this family covers almost all of the continent of Africa, Asia, South of the Himalayas (including the Arabian Peninsula), the Indo-Australian Archipelago, the Philippines and Australia (Taylor, 1963; Zug, 1993; Bennett, 1995)(Figure 2-4).

Monitor lizards have diploid chromosome number of 40, consisting of 8 large and 12 small pairs. Female appears to be the heterogametic sex, but there are suggestions that environmental conditions during incubation may have some bearing on sex determination (King&King, 1975; King *et al*, 1982; Bennett, 1995). They can be distinguished from other lizards at a glance by their deeply forked tongues, which can be retracted into a basal sheath. Head is covered with small juxtaposed scales. The shape and size of the skull and teeth determine the nature of the prey that can be manipulated and swallowed (Rieppel, 1979). Teeth are replaced at regular interval throughout their lives. The eyes are situated on the sides of the head, but the eyeball can not rotate in the socket. Furthermore, the eyelids are very well developed and possess a thin protective membrane which is moved horizontally across the eye. The body and limbs are sturdy, and covered by even smaller scales. The feet and claws are powerful organs. There are small pits on ventral scales, arranging transversely. Tail is truly a multi-purpose organ, long and cylindrical or compressed (De Rooij, 1915; Smith, 1935)

Usually, foraging behaviour is much better documented from observations of wild and captive animals, from interpretation of footprints and other marks left in soft ground. However data on the precise foraging movement of monitor lizards are difficult to obtain in the wild. In general the diets of monitor lizards include a variety of animals of different sizes. They are often thought of as generalized feeders that will consume anything they are able to catch. Many monitor lizards will feed from carcasses of animals, including human corpses (Bennett, 1995; Taylor, 1963). All monitor lizards of Thailand are totally carnivorous (Auffenberg, 1988).

Smith (1935) reported that the living species of monitor lizards are confined to Old World, being found in the warm parts of southern Asia, Africa, the East Indies and the Australian Region. All of them are carnivorous, and they usually prepare to eat any kinds of animal that they can overcome.

Jankins and Broag (1994) reported that *Varanus* is the most important lizard genus in the skin trade. Over the period 1983-1989, an annual average of 2.3 million skins in trade was recorded.

The water monitor, *Varanus salvator* is the most heavily collected species, with trade in almost 2.5 million skins reported in 1990 alone. The major exporters of water monitor lizard skins are Indonesia, the Philippines and Thailand. Furthermore *Varanus* skins are frequently misidentified in official declarations. (Bennett, 1995).

In Thailand, *Varanus nebulosus, Varanus rudicollis and Varanus dumerilii* are indicated as threatened (Humphuy and Bain, 1990). All species are protected animal under the Wild Animal Protection Act of 1992.

CITES (1998) reported that *Varanus salvator, Varanus rudicollis* and *Varanus dumerilii* are listed in Appendix II while *Varanus bengalensis* or *Varanus nebulosus* are listed in Appendix I of the CITES Convention.

2.3 Species diversity and Distribution

Taylor (1963) reported that five species of monitor lizards were found in Thailand i.e. *Varanus rudicollis* (Gray, 1845), *Varanus dumerilii dumerilii* (Schlegel, 1839), *Varanus salvator* (Laurenti, 1768), *Varanus flavescens* (Hardwicke and Gray, 1827) and *Varanus bengalensis nebulosus* (Gray, 1831).

Lekagul (1969) reported that *Varanus dumerilii* and *Varanus rudicollis* occurred especially below Kra Isthmus, Ranong Province. Therefore, there are all species of monitor lizards in southern Thailand. However, the data of the distribution is still not absolutely studied.

Luxmoore and Groombridge (1990) investigated species diversity of monitor lizards in Thailand and reported that only 4 species of *Varanus* were known to occur in Thailand i.e. *Varanus rudicollis* (Gray, 1845), *Varanus dumerilii dumerilii* (Schlegel, 1839), *Varanus salvator* (Laurenti, 1768) and *Varanus bengalensis nebulosus* (Gray, 1831).

Nabhitabhata and Kongtong (1993) reported that four species of monitor lizards were found in Thailand i.e. *Varanus rudicollis* (Gray, 1845), *Varanus dumerilii* (Schlegel, 1839), *Varanus salvator* (Laurenti, 1788) and *Varanus nebulosus* (Gray, 1831).

Bennett (1995) also reported that there were four species of monitor lizards in Thailand i.e. *Varanus rudicollis* (Gray, 1845), *Varanus dumerilii* (Schlegel, 1839), *Varanus salvator* (Laurenti, 1788) and *Varanus bengalensis nebulosus* (Gray, 1831)

Nabhitabhata and Kongtong (1993) considered *Varanus nebulosus* (Gray, 1831) as a full species while Bennett (1995) recognized as a subspecies.

Nutphand (personal communication, July 2,1999) mentioned that there were five species and one type of monitor lizards occurred in Thailand i.e. *Varanus rudicollis* (Gray, 1845), *Varanus dumerilii* (Schlegel, 1839), *Varanus salvator* (Laurenti, 1788), *Varanus bengalensis nebulosus* (Gray, 1831), *Varanus flavescens* (Hardwicke and Gray, 1827) and *Varanus salvator komaini* Nutphand, 1987. The specimen of *Varanus flavescens* is now in his collection at Pata Zoo, Bangkok, while *Varanus salvator komaini* is still understudy on its taxonomy.

Steel (1996) stated that *Varanus bengalensis nebulosus* occurred from Bengal through Thailand, Burma, South Vietnam, Malaya and Java(but not Sumatra) *Varanus dumerilii* being the principal one, occurred from Thailand to the eastern end of the Indo-Australian archipelago except for northern and northwest Borneo. *Varanus rudicollis* occurred from Burma and Thailand down through peninsular Malaysia, Sumatra, the Riouw archipelago, Banka, Sarawak and Borneo, and *Varanus salvator* ranges eastwards from the Indian subcontinent through Assam, Burma, Thailand and Indo-China to Malaysia and Indonesia.

Photo: Tawit Poopradit

Figure 2-5 *Varanus salvator* or water monitor

Figure 2-6 *Varanus salvator komaini* Nutphand, 1987 or black water monitor.

2.4.1 *Varanus salvator* (Laurenti, 1768) Water monitor or asian water monitor

The water monitor is widespread. It is of greater economic importance than any other varanids and millions are killed each year for their meat and skins. This species occurs from the Indian subcontinent through Assam, Myanma, Thailand, Indo-China to Malaysia and Indonesia (Bennett, 1995; Steel, 1996). The water monitor is more aquatic in its habits than other Asiatic species. They are found principally in humid forests, mangrove forests, farmland, grassland forests, swamps, beaches, agricultural land, rice fields, coconut plantation and along riverbank, favouring marshy localities but sometimes occupying drier areas if adequate cover can be found. They are not exclusively aquatic animals, although they are never found very far from water, either fresh or saline. Much of their food are taken on land and they are often seem to live on the ground or on the trees (Luxmoore and Groombridge, 1990; Bennett, 1995; Steel, 1996)

This species is the second largest lizard species in the world and were reported to reach two and one-half meters in length (Taylor, 1963). Males mature at around 40 cm SVL. (= 1 m total, 1 kg.), and females at around 50 cm (Shine *et al.*, 1996). *Varanus salvator* is a long-necked reptile with an elongate snout (depressed towards the tip), its length is at least three times its height. Nostrils are round or oval, twice as far from orbit as from tip of snout. Supraoculars are enlarged, scales on crown of head larger than nuchal scales, with 4-10 large, transversely broad scales above each eye. Along the back, the scales are small, oval and keeled, while the similarly keeled abdominal scales comprise 80-95 transverse rows. The neck scales are smaller than those on the head but, along the top of the back, the scales are enlarged. The compressed, pointed teeth of the water monitor form a murderous battery of predatory weapons with which it secures its prey: birds and their eggs, small mammals, fish, lizards, frogs in large numbers, snakes, juvenile crocodiles, tortoises, crustaceans and molluscs, the eggs of turtles and crocodiles, and beetles. Digits are elongate and moderate. Tail is strongly compressed, with a low double-toothed crest above, about one time and one-fourth the length of head and body. Subcaudal scales are much larger than the lateral caudal (De Rooij, 1915; Smith, 1935; Taylor, 1963; Steel, 1996).

The young water monitor is dark brown or blackish above, with small yellow spots and larger rounded spots or ocelli arranged in transverse series. Snout lighter, with black transverse bars, most distinct on the lips and usually continued below on to the chin. A black temporal streak, commencing from the eye, with a more or less distinct yellow band below which usually extends on to the side of the neck. Lower parts are yellow, usually with narrow black vertical V-shaped marks extending on to the sides of the belly. Limbs are blackish above, with small whitish spots. Tail is alternately banded with black and whitish. The yellow markings are very conspicuous in young individuals but tend to fade with ages, old adults being a dark olive colour with only indistinct yellow patterning. This subspecies can be distinguished from their members of the species by its coloration. Adults lack enlarged dorsal ocelli but have ventral yellow markings, forming a series of confluent diamond shapes, with black bands at the tail tip that are no more than twice as long as the yellow ones. Juveniles, however, do have ocellate dorsal spots. The most brightly marked races are claimed to be from Thailand and Java (De Rooij, 1915; Smith, 1935; Steel, 1996).

The breeding season of *Varanus salvator* varies through different regions of its extensive range but generally coincides with the rainy season (Steel, 1996). In Southern Sumatra, all adult-size males had active gonad. But testes were larger in April than in October. All adult females in the August and April samples were reproductively active, but less activity was evident in October. The egg-laying season extends from April to October (Shine *et al.*, 1996).

There are 2 types of water monitor in southern Thailand i.e. water monitor (Figure 2-5) and black water monitor (Figure 2-6). The latter has whole body in black color, including its tongue. Nutphand (1981) first recorded black water monitor. After that, It was found at Amphur La Ngu, Satun Province. Head and snout are slenderness with small rostral scales. Nostrils are oval slit. Scales on the head are larger than temporal scales. There are small nuchal scales. Body scales are small and strongly keeled. Tail is strongly compressed, with a low double-toothed crest above. All body is black color. There are brownish eyes, with black round pupil (Nutphand, 1981). However, the name of this animal is still unclear.

Bennett (1995) cited that Thailand is also home to some huge water monitors. In most areas males reach a larger size than females and probably grow faster and are more active.

Figure 2-7 *Varanus rudicollis* or rough-necked monitor

2.3.2 *Varanus rudicollis* (Gray, 1845) Rough-necked monitor or harlequin monitor.

The rough-necked monitor is one of the most fascinating varanids. It is also among the most poorly studied of the Asia species. The name "rudicollis" is broken out from "rudi" that means rough and "colli" which refers to the neck. Most researches confirmed their distribution in Myanmar, Malaysia, Indonesia and Southern Thailand, especially below Kra Isthmus in evergreen forests. They are found only in primary and secondary rainforests and in mangrove swamps, which were recorded, from Kuala Selangor, the forest at several small reserves outside

Kuala Lumpur (Bennett, 1995; Bennett and Lim, 1995). This species is a rather small and with essentially arboreal habits (Losos & Greene, 1988; Steel, 1996)

This monitor was recorded to reach a maximum size of 146 cm. TL. (59 cm. SVL.) and weight just over 4 kg. (Harrison and Lim, 1957). According to Lekagul (1969), in Thailand they rarely exceed 100 cm. in length. Nostril oblique, distance between eye and nostril is half that between nostril and tip of snout. There are three to six transversely widened supraocular scales. Large prominent scales on nuchal region are strongly keeled and forming ten to twelve longitudinal series. Body covered with small, strongly keeled scales. Ventral scales are keeled, in 85 transverse series and there are yellow transverse bands or rows of ocelli on their body. Tail compressed and covered with keeled scales. Limbs are strong. The fourth digit of hindlimb is longest (De Rooij, 1915; Taylor, 1963; Bennett, 1995; Bennett and Lim, 1995). Top of the head is generally brownish or olive-brown and most scales have a darker center. A yellowish tinge on the neck and foreparts of the body, yellowish ocelli on the flanks and the rear part of the trunk, and yellowish spots on the limbs relieve the very dark coloration. There are irregular yellowish bars across shoulders followed by a black irregular bar with extension onto arms. At middle of the back is a double row of ocelli preceded and followed by indefinite dark bands. There is a faint yellowish band between hind legs and some yellow spots appear at arms and legs. Moreover, there is a distinct yellow spot at the base of each claw dorsally. Ventral is definite yellowish bars separated by a darker area. Tail generally appears with broad black and narrow yellow transverse bands. Subcaudal region is yellowish (De Rooij, 1915; Taylor, 1963).

Losos and Greene (1988) examined the diet of rough-necked monitor and found a large number of small preys; for example, frogs, a cluster of frog eggs, spiders, crabs and orthopterans. No prey type was predominant. In Sumatra, only insects were found in specimens (Werner, 1900). One specimen examined by Brandenberg (1983) had a stomach full of large cockroaches and grasshoppers.

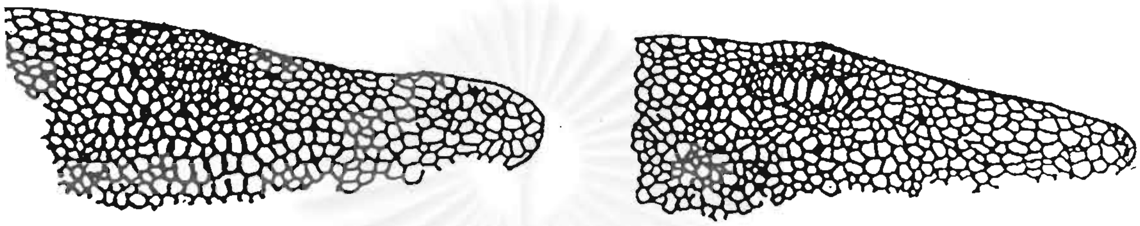
Figure 2-8 *Varanus bengalensis nebulosus* or clouded monitor

2.3.3 *Varanus bengalensis nebulosus* (Gray, 1831) Clouded monitor

This scientific name, *Varanus bengalensis*, is still not clearly status. Two subspecies are recognized, *Varanus bengalensis bengalensis* is found from India and another subspecies, *Varanus bengalensis nebulosus* is found in Thailand (Taylor, 1963).

The specific name, *nebulosus*, was assigned to those individuals in which "several" scales in the supraocular region were enlarged in comparison with their neighbors (Auffenberg, 1994)(Figure 2-9).

Nutphand (1996) gives maximum size in Thailand as about 125 cm in Total length. Clouded monitor is very widespread in Thailand, being known from Malaya north to Chiang Mai Province and east to Laos and Cambodia. Outside Thailand, they occurred in Bengal, Myanma, South Vietnam, Malaya and Java. This monitor was found in all types of habitat such as dry evergreen forest, coconut plantation, farmland and rice field, mangrove forest, moist evergreen forest and mixed deciduous forest. It is terrestrial and highly arboreal. It is common in suitable habitat types (Luxmoore and Groombridge, 1990; Nutphand, 1996; Steel, 1996). Taylor (1963) found all specimens in trees.



a) b)

Figure 2–9 Supraocular scales of *Varanus bengalensis bengalensis* (a) and *Varanus bengalensis nebulosus* (b) (Auffenberg, 1994)

Clouded monitor has an oblique high-snouted skull. Snout is pointedness and convex as long as the distance between the anterior conner of the eye and the posterior border of the ear. Nostrils are oblique slit, located nearer to the orbit than to the end of snout. Ears opening are oblique. The laterally compresses dentition includes 10-12 maxillary teeth, the crowns being blunt in large adults but pointed in immature individuals. Scales on the crown of the head are larger than the nuchal scales, which are smooth or feebly keeled. Scales on the back are more strongly keeled. Supraocular regions are 4-7 transversely enlarged (De Rooij, 1915; Smith, 1935; Taylor, 1963; Steel, 1996). Smith (1935) reported that abdominal scales of clouded monitor are smooth or feebly keeled with 70-90 transverse rows. Auffenberg (1994) studied and reported that there are the abdominal scales about 78.6 transverse rows in clouded monitors of Southern Thailand while Taylor (1963) reported that there are 70 transverse rows. Body is covered above with small, oval and keeled scales. But this scales on the anteriorly neck are larger, smooth and roundish. Digits are elongate and moderate. Limbs are strong. Tail is strongly compressed, with a low double-toothed crest above. Lateral caudal scales are keeled, about as large as the subcaudal scales (De Rooij, 1915; Smith, 1935; Taylor, 1963; Steel, 1996).

Back is dark olive or brownish above, dot all over or marble with yellow. Chin and throat cross with transverse blackish bands or marble with blackish. Belly marble with dark brown and yellow. Top of the head and sometimes also the nape are mostly yellow. Young appears a dark temporal streak and sometimes also with yellow ocelli upon the back arranged in transverse series, limbs and base of tail (De Rooij, 1915; Smith, 1935).

In Thailand, young specimens are olive to black, and the chins are strongly barred in bluish and yellow-cream. There are irregular white chevron-shaped bars on their neck. On the breast and ventral, there are about 15 dark transverse bands with very irregular edges separate by rows of whitish spots more or less confluent. Head is blackish with a series of white spots on upper lip. Neck has a pair of dim dark lines from eyes and another chevron-shaped mark following it. Back appears numerous (16-17) transverse rows of tiny ocelli. There are rounded or rosette light spots under limbs. Arm and leg comprise with punctate spots much smaller than on underside. Two cream bands and two broader black bands are distally on tail (Taylor, 1963).

Mertens (1942) stated that the Bengal monitor is distinguished from the clouded monitor by having larger scales above the eyes and fewer scales around the body. Moreover, Taylor (1963) reported that both races of the Bengal monitor feed mainly on the ground, but clouded monitors in particular are excellent climbers.

These lizards get most of their nutrition from tiny prey and feed mainly on beetles, grubs, orthopterans, scorpions, snails, ants and other small invertebrates, which are consumed in enormous numbers. The lizards collect ants and similar sized prey by licking them up with the tongue. Vertebrate preys are comparatively rare, but include frogs molluscs, fish, lizards, snakes (including cobras) and small mammals. The clouded monitor often use their tongues to collect small insects and fine much of their food by rooting the ground, especially under cow pats and in leaf litter. They often forage in human rubbish dumps and occasionally take carrion (Losos and Greene, 1988; Auffenberg, 1994; Bennett, 1995, 1998).

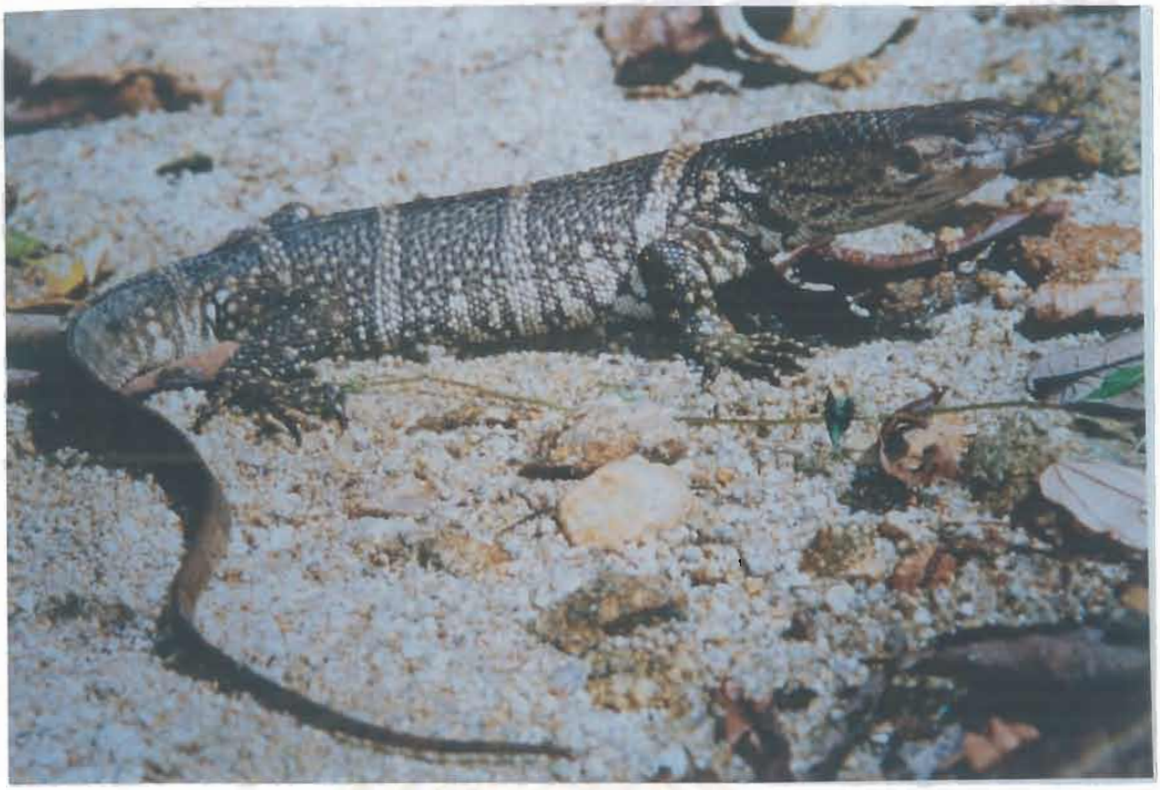


Photo: Peter Paul van Dijk

Figure 2-10 *Varanus dumerilii* or Dumeril's monitor

2.3.4 *Varanus dumerilii* (Schlegel, 1839) Dumeril's monitor

Dumeril's monitor is a tame animal, which appears to be the rarest or at least the most inconspicuous varanid in all the countries it inhabits. It was found in the southern part of Myanma, Thailand, Malaysia, Borneo, Sumatra and small neighboring island (Bennett, 1995). Steel (1996) referred that it distributed from Thailand to the eastern and of the Indo-Australian archipelago. It was the least active of monitor lizards found in Thailand, spending most of its time in rock crevices and tree hollows and using the same retreats consistently (Lekagul, 1969; Nutphand, 1987).

Steel (1996) described that this species spends quite a lot of time in the water and exhibits obvious aquatic specialization, such as valvular nostrils that can be sealed via an interior scale operated through a sphincter muscle. It is a good swimmer and will forage underwater for short periods, force fully expelling air from its lung as it dives to reduce its buoyancy, and pulling itself along stream beds by means of its claws. On the other hand, it is also entirely at home on land and will readily climb trees if alarmed.

Snout depressed at the tip, a little longer than the distance between the anterior border of the eye and the ear (De Rooij, 1915). Nostrils are oblique slit, twice as near orbit as to end of snout (Smith, 1935; Taylor, 1963). Nuchal scales are very large about two to three times size of scales on top of head, almost as long as broad, flat, only the posterior keeled. Scales on the crown of the head are smaller than nuchal scales and in the middle of the supraocular region slightly enlarged transversely. Teeth are acute and compressed. Body covered with large oval keeled scales. Abdominal scales are smooth or feebly keeled, in from 75 to 85 transverse rows. Tail is strongly compressed with a low double toothed crest above. Limbs are strong and digits are moderate. Lateral caudal scales keeled, irregular in size, much smaller than the subcaudal scales (De Rooij, 1915; Smith, 1935; Taylor, 1963; Steel, 1996).

There are two black dorsolateral head-bands join a black band, which usually confluent with U-shaped dark band mark upon the neck. Moderately distinct, dark vertical bars are present on the lips. Top of the head is all brown. Limbs are dark brown spotted with yellow. Body is blackish or dark brown with three narrow dotted or continuous cream bands and the belly is yellowish with dark transverse bands. The back bears very broad, dark transverse bars, which are broader than the interspaces between them. The very young are black above, with the dorsal bars and the whole of the head except the temporal streak bright yellow (said to be vermilion life). Tail is black with yellow transverse bands (De Rooij, 1915; Smith, 1935; Taylor, 1963; Steel, 1996).

Two subspecies are recognized, *Varanus dumerilii* being the principle one, occurring throughout the known range of the species except for northern and northwestern Borneo. There it is replaced by *Varanus dumerilii heteropholis*, which can be distinguished from the more common form by the possession of varying shaped scales, those on the neck being moderately keeled (Steel, 1996).

2.4 Specific names have been used for varanids that found in southern Thailand

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

1758 *Lacerta monitor* Linnaeus, (Opinion 540, ICZN: nomen rejectum), Syst. Nat, Ed. 10, 1: 201.

1768 *Stellio salvator* Laurenti, Synops. Rept.,: 56. - Type locality: America. - Type locality designata: Ceylon (Mertens, 1959).

1788 *Lacertus tupinambis* Lacépède, Hist. Nat. Qaudrup. Ovip., 1 Synops. Method.: 251.

1802 *Tupinambis elegans* Daudin, Hist. Nat. rept., 3: 36. - Type locality: Surinam.

1831 *Monitor exilis* Gray in Griffith, Anim. Kingd., 9 Synops.: 25. - Type locality: India.

1834 *Varanus vittatus* Lesson in Bélanger, Voyage Ind. Orient., Zool.,: 37.

1842 *Varanus binotatus* Bylth (ex errore), J. asiat. Soc. Bengal, Calcutta, 11: 867.

1844 *Monitor bivittatus* var. *celebensis* Schlegel, Abb. Amph.: X. - Type locality: Celebes.

1937 *Varanus salvator salvator* - Mertens, Senckenbergiana, Frankfurt a. M., 19: 178.

1942 *Varanus (Varanus) salvator salvator* - Mertens, Abh. Senckenb. Naturf. Ges., Frankfurt a. M., 465: 149. - 466: 245.

1944 *Varanus salvator macromaculatus* Deraniyagala, Spol. Zeylan., Colombo, 24: 60-62. - Type locality: Siam

1947 *Varanus salvator kabaragoya* Deraniyagala, Proc. 3. ann. Sess. Ceylon Ass. Sci., 2 Abstr.: 12. - Type locality: Ceylon.

1947 *Varanus salvator nicobariensis* Deraniyagala, Proc. 3. ann. Sess. Ceylon Ass. Sci., 2 Abstr.: 12. - Type locality: Nicobar Islands.

1959 *Varanus (Varanus) salvator salvator* - Mertens, Senckenb. Biol., Frankfurt a. M., 40: 234.

1963 *Varanus salvator salvator* - Taylor, The Lizards of Thailand.: 920-923.

1987 *Varanus salvator komaini* - Nutphand, Monitors of Thailand.: 16

1998 *Varanus salvator salvator* - Bennett, Monitor lizards.: 135.

In addition, the black color type of water monitor was first recognized and described by Nutphand (1987) in Journal of Thai Zoological Center, Vol. 2(15). It was treated as a subspecies, *Varanus salvator komaini*. However, the status, habitat type and description of the black water monitor are still unclear.

Bennett (1995) suggested that the name *V. salvator komaini* is used to describe many black water monitor that appear in the wildlife trade, but no such subspecies has been formally described and black animals attributed to many subspecies are known from many coastal regions.

Varanus rudicollis (Gray, 1845)

1845 *Uaranus rudicollis* Gray, Cat. Liz. Brit. Mus.: 10. - Type locality: Philippines

1885 *Varanus rudicollis* - Boulenger, Cat. Liz. Brit. Mus.: 2: 313

1896 *Varanus rudicollis* - Flower, Proc. Zool. Soc. London.: 873

1901 *Varanus rudicollis* - Hanitsch, Checklist of the reptiles and amphibians in Raffles Museum.: 2

1912 *Varanus rudicollis* - Boulenger, A Vertebrate fauna of the Malay Peninsula.: 78 (Trang, first report from Thailand)

1916 *Varanus rudicollis* - M. Smith, Journ. Nat. Hist. Soc. Siam, Vol. 2, No. 1: 55 (Trang, Thailand).

1932 *Varanus scutigerulus* Barbour, Proc. New. Engl. Zool. Club, Cambridge, Mass., 13: 1- Type locality: Kampong Ulu, Malam-River, Sarawak, N-Borneo.

1942 *Varanus (Varanus) salvator scutigerulus* - Mertens, Abh. Senckenb. Naturf. Ges., Frankfurt a. M., 466: 259.

1942 *Varanus (Dendrovaranus) rudicollis* - Mertens, Abh. Senckenb. Naturf. Ges., Frankfurt a. M., 466: 259. - 466: 360.

1963 *Varanus rudicollis* - Taylor, The Lizards of Thailand. : 915-918.

1998 *Varanus rudicollis* - Bennett, Monitor lizards.: 222.

Varanus bengalensis nebulosus (Gray, 1831)

1831 *Monitor nebulosus* Gray in Griffith, Anim. Kingd., 9 Synops. : 27. - Type locality: Java

1836 *Varanus nebulosus* -Dumeril & Bibron, Erpeétol. Gén., 3: 483.

1839 *Monitor nebulatus* - Schlegel (ex errore), Abb. Amphib.: 75.

1915 *Varanus nebulosus* - De Rooij, The Reptiles of the Indo-Australian
Archipelago.: 145-146.

1935 *Varanus nebulosus* - Smith, The Monitor lizards of Burma.: 403-404.

1942 *Varanus (Indovaranus) bengalensis nebulosus* - Mertens, Abh. Senckenb. Naturf. Ges., Frankfurt a. M., 465: 184 - 466: 332.

1958 *Varanus bengalensis nebulosus* - Taylor and Elbel, Univ. Kansas Sci. Bull., Vol. 38, Pt. 2: 1042, 1101-1102.

1963 *Varanus bengalensis nebulosus* - Taylor, The Lizards of Thailand.: 925-928.

1994 *Varanus vietnamensis* Yang Datong & Liu Wanchao, Zoo. Res., Vol. 15(1): 11-15.

1995 *Varanus bengalensis nebulosus* - Bobrov, Checklist and Bibliography of the lizards of Vietnam. Smithsonian Herp. Inf. Service., 105:

1997 *Varanus bengalensis nebulosus* - Böhme & Ziegler, Amphibia-Reptilia, Leiden.: 207-211.

1998 *Varanus bengalensis nebulosus* - Bennett, Monitor lizards. : 135.

Varanus bengalensis nebulosus is still confused in scientific name. However, Bohme and Ziegler (personal communication, October 28,1999) gave reasons that *bengalensis* and *nebulosus* being full species, but they refrained from doing this step (some authors like Yang and Liu already elevated nebulosus to specific status, but without reasoning). Because currently the exact distribution is still unclear and feature variation of both forms along their bordering occurrences still has to be checked.

Varanus dumerilii **(Schlegel, 1839)**

1839 *Monitor dumerilii* Schlegel, Abb. Amphib.: 78. Type locality: Benjermasin, South- East Borneo.

1858 *Varanus dumerilii* - Bleeker, Nat. Tijdschr. Nederl. Ind., Batavia u. Den Haag, 16: 188.

1881 *Varanus macrolepis* Blanford, J. asiat. Soc. Bengal, Calcutta, 59 (2): 239. - Type locality: Tenasserim, probably the vicinity of Tavoy (fide Mertems 1963)

1885 *Varanus dumerilii* - Boulenger, Catalogue of the lizards on the British Museum, Vol. 2: 312.

1892 *Varanus heteropholis* Boulenger, Proc. Zool. Soc. London: 506. - Type locality: Mt. Dulit, upper Baram River, Sarawak, North- West Borneo.

1912 *Varanus heteropholis* - Barbour(ex errore), Mem. Mus. Comp. Zool., Cambridge(Mass.), 44: 183.

1916 *Varanus dumerilii* - M. Smith, Journ. Nat. Hist. Soc. Siam, Vol. 2, No. 1: 54.

1942 *Varanus (Tectovaranus) dumerilii heteropholis* - Mertens, Abh. Senckenb. Naturf. Ges. Frankfurt a. M., 466: 366.

1942 *Varanus (Tectovaranus) dumerilii dumerilii* - Mertens, Abh. Senckenb. Naturf. Ges. Frankfurt a. M., 465: 179-466: 364.

1963 *Varanus dumerilii dumerilii* - Taylor, The Lizards of Thailand.: 918-920.

1998 *Varanus dumerilii* - Bennett, Monitor lizards.: 147.

The subspecies *Varanus dumerilii heteropholis* was described by Boulenger in 1892 from animals collected in Northern Borneo (Bennett, 1998). In case of Thailand, Taylor (1963) reported that the typical form only was known from peninsular Thailand i.e. *Varanus dumerilii dumerilii*.

In this study, the following scientific names of monitor lizards in southern Thailand will be used i.e. *Varanus salvator*, *Varanus rudicollis*, *Varanus bengalensis nebulosus* and *Varanus dumerilii*. In addition, the black water monitor will be treated as *Varanus salvator komaini*.

2.5 Morphological differences

2.5.1 Morphological measurement

Rohlf (1990) defined that morphometrics are the quantitative description, analysis, and interpretation of shape and shape variation in biology. It is a fundamental area of research. The measurement of many variables naturally leads to the use of multivariate analysis. If one has adequate sample sizes, multivariate analysis allow make overall tests as well as proper a posterior tests of set of variable that look interesting.

Bedford and Christian (1996) reported that although varanid lizards are similar in general body form, recent studied suggest a wild range of ecological (Shine, 1986) and physiological (Christian and Conley, 1994) diversity. Despite similar body forms, there are some morphological features that vary among species, and these are presumably adaptations to the habitats and life histories of the animals (King, 1991)

Christian and Garland (1996) studied scaling of limb proportion in monitor lizards (Squamata: Varanidae). The lengths and diameters of the limb segments of 105 monitor lizards from 22 species were measured on preserved museum specimens in order to determine whether limb proportions vary in relation to snout-vent length (used as an indicator of overall body size). The results are larger species of monitors tend to have larger limbs relative to their snout-vent length. Foot length, however, decreases relative to total hindlimb length in larger species. The empirical results on limb shape are consistent with prediction derived from biomechanical models.

The results from morphological measurement can evaluate the usefulness of alternative suites of variable without handling the original specimens again. With more comprehensive data more powerful morphometric analyses are possible (Rohlf, 1990).

2.5.2 Sexual differences

Three major hypotheses have been proposed to explain sexual differences in organisms:

1) The female fecundity hypothesis: females are larger because larger body size is associated with increased number or size of eggs.

2) The competition avoidance hypothesis: differences in head and mouth size and differences in microhabitat usage result in decreased intersexual competition for resources.

3) The sexual selection hypothesis: males are larger because large male size is favored in male-male disputes over breeding territories (Darwin, 1889; Slatkins, 1984; Shine, 1989, 1990; Kitana, 1997)

Sexual dimorphism is a condition in which the males and females in a species are different in morphological traits such as coloration, size or other features. Presumably the dimorphism in some species reflects factors important in social interactions, survival, or reproduction (Bury, 1979).

Dellinger and Hegel (1990) mentioned that sex identification in lizards is in most cases simple because of the existence of external sexual dimorphism, e.g., the presence or absences of femeral pores, coloration dimorphism, differences in scale counts, etc.

Auliya and Erdelen (1999) reported that all of the method of sexing monitors and the secondary sexual morphological characters used in field study refer to subadult and adult specimens. Auffenberg (1991) mentioned that sexing of juvenile specimens continues to be a major problem in monitor study.

Probing is not a reliable method to determine the sex of a given specimens (Auliya and Erdelen, 1999). Ziegler and Böhme (1996) also stress the unreliability of the probing method due to muscle contractions. Another critical aspect is the elasticity of the genital organs, which may lead to varying depth measurements of the genital pockets.

Sexual differences in average body size have been reported for *V. acanthurus*, *V. komodoensis* and *V. panoptes* (Fitch, 1981). Auffenberg (1994) mentioned that large individuals are always males. Nevertheless, Sprackland (1992) stated that for most of the varanid species no color morphs, color patterns or scalation differences can be used to identify males and females. It was believed that the color of the lace monitor was linked to sex, the males being banded and the females having spots. These "sex-criteria" lost their relevance after banded females were observed.

Chapter 3
Materials and Methods

3.1 Study area

This research has been carried out in twenty-two protected areas and seventeen villages in the southern part of Thailand. There are National Parks, Marine National Parks, Wildlife Sanctuaries, Non-hunting areas, Wildlife Conservation Development and Extension Centers, Wildlife Research Station, Nature and Wildlife Study Center, Botanical Gardens and homestead plantations which consist of farmlands, shrimp farms, rubber plantations, coconut plantations and orchard plantations. The study sites and their habitats are shown in Table 3-1 and a map of study sites is shown in Figure 3-1.

The climatic data in the study areas from January 1998 to December 1999 were collected from the records of Meteorological Department

In 1998, mean temperature ranged from 25.2 ^{0}C at Phang Nga and Surat Thani Provinces to 31.2 ^{0}C at Phuket Province. Mean relative humidity varied from 66 % at Ranong Province to 92 % at Phang Nga Province. Mean daily rainfall ranged from 0 mm. to 868.1 mm. at Ranong Province.

In 1999, mean temperature ranged from 23.9 ^{0}C at Chumphon Provinces to 28.9 ^{0}C at Phuket Province. Mean relative humidity varied from 70 % at Phuket Province to 90 % at Phang Nga and Krabi Provinces. Mean daily rainfall ranged from 0 mm. at Phang Nga Province to 1,159.3 mm. at Narathiwat Province. The monthly climatic data in 1998 and 1999 of southern Thailand are charted in Appendix VI.

Table 3-1 Study areas in southern Thailand.

<table>
<tr><th>Provinces</th><th>Protected Areas</th><th>Habitats</th><th>Agricultural areas</th><th>Habitats</th></tr>
<tr><td>Chumphon</td><td>(1)Prince Chumphon Park (South Section) WS.</td><td>Tropical rain forest</td><td>(a)Amphur Pa thiu</td><td>Shrimp farm and Mangrove forest</td></tr>
<tr><td rowspan="2">Ranong</td><td>(2)Lumnum Kraburi NP.</td><td>Tropical rain forest
Mangrove forest</td><td rowspan="2">(b)Amphur Suksamran</td><td rowspan="2">Farmland</td></tr>
<tr><td>(3)Mu Ko Payam MNP.</td><td>Mangrove forest</td></tr>
<tr><td rowspan="3">Phang Nga</td><td>(4)Sri Phang Nga NP.</td><td>Tropical rain forest</td><td rowspan="3">(c)Amphur Takua Pa
(d)Amphur Muang</td><td rowspan="3">Rubber plantation within tropical rain forest</td></tr>
<tr><td>(5)Khao Lak-Lum Ru MNP.</td><td>Tropical rain forest
Mangrove forest</td></tr>
<tr><td>(6) Ao Phang Nga MNP.</td><td>Mangrove forest</td></tr>
<tr><td>Phuket</td><td>(7)Khao Pra Taew WC.</td><td>Tropical rain forest</td><td>-</td><td>-</td></tr>
<tr><td rowspan="3">Surat Thani</td><td rowspan="3">(8)Khao Sok NP.</td><td rowspan="3">Tropical rain forest</td><td>(e)Amphur Khanchanadich</td><td>Rubber plantation</td></tr>
<tr><td>(f)Klong Bang Bai Mai Amphur Muang</td><td>Orchard plantation</td></tr>
<tr><td>(g)Khao Krung Sator Mt. Amphur Khanchanadich</td><td>Coffee plantation within tropical rain forest</td></tr>
<tr><td rowspan="2">Nakhon Sri Thammarat</td><td rowspan="2">-</td><td rowspan="2">-</td><td>(h)Amphur Chawang</td><td>Rubber plantation</td></tr>
<tr><td>(i)Amphur Tongsong</td><td>Rubber plantation</td></tr>
</table>

Table 3-1 (cont.) Study areas in southern Thailand.

Provinces	Protected Areas	Habitats	Agricultural areas	Habitats
Krabi	(9)Khao Pra-Bang Kram WS.	Tropical rain forest	(j)Amphur Khao Phanom	Rubber plantation
	(10)Mu Ko Lunta MNP.	Tropical rain forest Mangrove forest		
Phatthalung	(11)Khao Pu Khao Ya NP.	Tropical rain forest		-
	(12)Thale Noi NA	Freshwater swamp		
	(13)Ban Tha Mot WPU.	Tropical rain forest		
Trang	(14)Khaochong WC.	Tropical rain forest	-	-
	(15)Had Chao Mai MNP.	Tropical rain forest Mangrove forest		
Satun	(16)Nong Prag Praya NA.	Freshwater swamp	(k)Amphur La-Ngu	Mangrove forest
	(17)Thaleban NP.	Tropical rain forest Mangrove forest Freshwater swamp	-	-
	(18)Mo Ko Phetra NP.	Tropical rain forest Mangrove forest	-	-
Songkhla	(19)Ton Nga Chang WRS.	Tropical rain forest	(m)Amphur Rattaphum	Coconut plantation
	(20)Hat Yai NWSC.	Tropical rain forest		

Table 3-1 (cont.) Study areas in southern Thailand.

Provinces	Protected Areas	Habitats	Agricultural areas	Habitats
Pattani	-	-	(n)Amphur Saiburi	Coconut plantation
Yala	-	-	(p)Amphur Muang	Rubber plantation
			(u)Amphur Betong	Rubber plantation
Narathiwat	(21)Hala-Bala WS.	Tropical rain forest	(s)Amphur Sungi-Kolok	Rubber plantation Orchard plantation
	(22)Sirindhorn Peat Swamp Forest RNC.	Peat swamp forest	(t)Amphur Rue Soe	Rubber plantation

Note: MNP. = Marine National Park.
NA. = Non-hunting Area.
NP. = National Park.
NWSC. = Nature and Wildlife Study Center.
RNC. = Research and Nature Study Center.
WC. = Wildlife Conservation Development and Extension Center.
WPU. = Wildlife Protection Unit.
WRS. = Wildlife Research Station.
WS. = Wildlife Sanctuary.
Arabic numbers are for protected areas and letters are for villages. Map of study sites is shown in Figure 3-1.

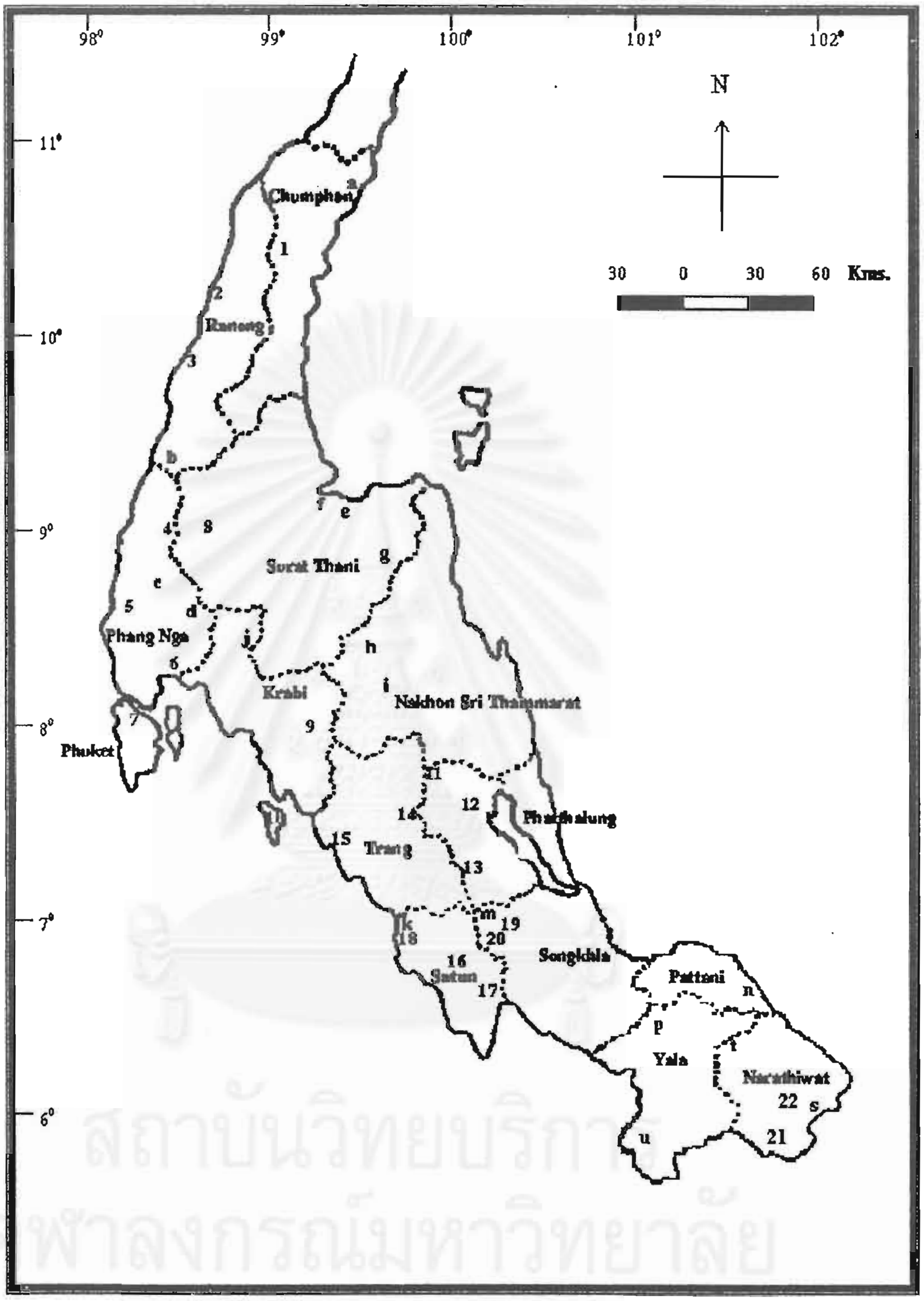


Figure 3-1 Map of study sites consists of protected areas and villages, Arabic numbers are for protected areas and letters are for villages.

3.2 Materials

3.2.1 Vernier caliper (30 cm.)
3.2.2 Probe (for checking sex)
3.2.3 Camera and films
3.2.4 GPS (Global Positioning System)
3.2.5 Altimeter
3.2.6 Thermometer
3.2.7 Spring balance (1 kg, 4 kg and 20 kg)
3.2.8 Flexible measuring tapes (200 cm.)
3.2.9 Glove
3.2.10 Nooses and Cages
3.2.11 Alcohol 70 % and Formaldehyde 40 %

3.3 Study Methods

3.3.1 Field study

Field surveys were carried out for species diversity and distribution of monitor lizards in twenty-two protected areas and seventeen villages of southern Thailand. Survey sites were shown in Table 3-1. Species diversity and distribution of monitor lizards were directly explored in each site, by sight, traps and interview. In case of interview, the relevant forest officers and villagers were communicated. The pictures of monitor lizards were shown to them that names, characteristics and habitats were questioned. The data were specially selected from available persons who could correctly identify monitor lizards. Moreover, wildlife checklists recorded by National Parks, Wildlife Sanctuaries and other government agencies in the areas were also reviewed.

During two years of field study, ecological and biological data of monitor lizards such as egg size, clutch size and habitat types were collected as well.

3.2.2 Trapping techniques

Most of varanids stay or bask in places where there are difficult to reach such as in the canopy of tall trees or in burrows. In this study, two methods used for capturing monitor lizards were as followed;

1. Using cage: The cage is 30 x 30 x 120 cm. by size (Figure 3-2; a), built from wire net which was about 0.5 mm. in diameters and used fresh meat or dead fish as bait.

2. Using noose: The noose consists of a long pole, with a loop of string at the tip, which can be tightened around the neck, trunk or leg of a monitor lizard and pulling tight in order to capture the animal (Figure 3-2; b).

Eight study sites from six provinces were set traps for the capture of monitor lizards i.e. Lumnam Kraburi NP in Ranong, Khao Krung Sator and Amphur Khanchanadich in Surat Thani, Thale Noi NA. and Khao Pu Khao Ya NP. in Phatthalung, Amphur La Ngu in Satun, Amphur Betong in Yala and Amphur Rue Soe in Narathiwat Province. The places selected for trapping were lowland near to watercourses (i.e. in mangrove forests and freshwater swamps), both in the human settlements and in the wild.

a)

b)

Figure 3-2 Trapping methods.

a) The cage; placed at Lumnum Kraburi NP.

b) The noose; placed at Amphur La Ngu

3.3.3 Morphological study

In this study, collected specimens were divided into two groups for study morphological differences among species and between sexes. The first group is specimen with known habitats i.e. caught by traps and measured at survey sites. Another group is specimen with unknown habitats i.e. specimens from zoos and museums. The following morphometric characters of each specimen were measured only on the right side of the body (Figure 3-3):

1. Total length (TTL): maximum length from the tip of snout to the tail tip.
2. Snout-vent length (SVL): length from the tip of snout to the vent.
3. Tail length (TL): maximum length from the tail base to the tail tip.
4. Head length (HL): length of head.
5. Snout tip - nostril length (SNL): length from the tip of snout to the nostril.
6. Snout tip - eye length (SEL): length from the tip of snout to eye.
7. Snout tip - ear opening length (SEaL): length from the tip of snout to the anterior of the ear opening.
8. Snout tip - mouth length (SML): length from the tip of snout to the mouth angle.
9. Snout tip - posterior head length (SPL): length from the tip of snout to the posterior head.
10. Nostril - eye length (NEL): length from the nostril to the eye.
11. Nostril - ear opening length (NEaL): length from the nostril to the anterior of the ear opening.
12. Nostril length (NL): maximum length of nostril.
13. Eye - ear opening length (EEaL): length from the posterior of the eye to the anterior of the ear opening.
14. Eye length (EL): maximum length of eye.
15. Nostril width (NW): width from right nostril to left nostril.
16. Eye width (EW): width from right eye to left eye.
17. Collar - vent length (CVL): length from the collar to the vent.
18. Snout - collar length (SCL): length from the snout to the collar
19. Upper arm length (UAL): length from the shoulder joint to the elbow joint.

20. Forearm length (FAL): length from the elbow joint to the center of the carpus.
21. Hand length (HaL): length from the center of the carpus to the tip of the longest toe (claw included).
22. Forelimb length (FLL): the sum of UAL+FAL+HaL.
23. Upper leg length (ULL): length from the hip joint to the knee joint.
24. Lower leg length (LLL): length from the knee joint to the center of the tarsus
25. Foot length (FL): length from the center of the tarsus to the tip of the longest toe (claw included).
26. Hindlimb length (HLL): the sum of ULL+LLL+FL.
27. Total weight (TW): weight of body mass.
28. Axilla circumference length (ACL): circumference length of axilla.
29. Lumbar circumference length (LCL): circumference length of lumbar.
30. Base of tail circumference length (TCL): circumference length of tail base.
31. Maximum of body circumference length (MCL): circumference length of maximum body.
32. Genital pocket length (GPL): length of genital pocket was checked by probe (Figure 3-4; a).

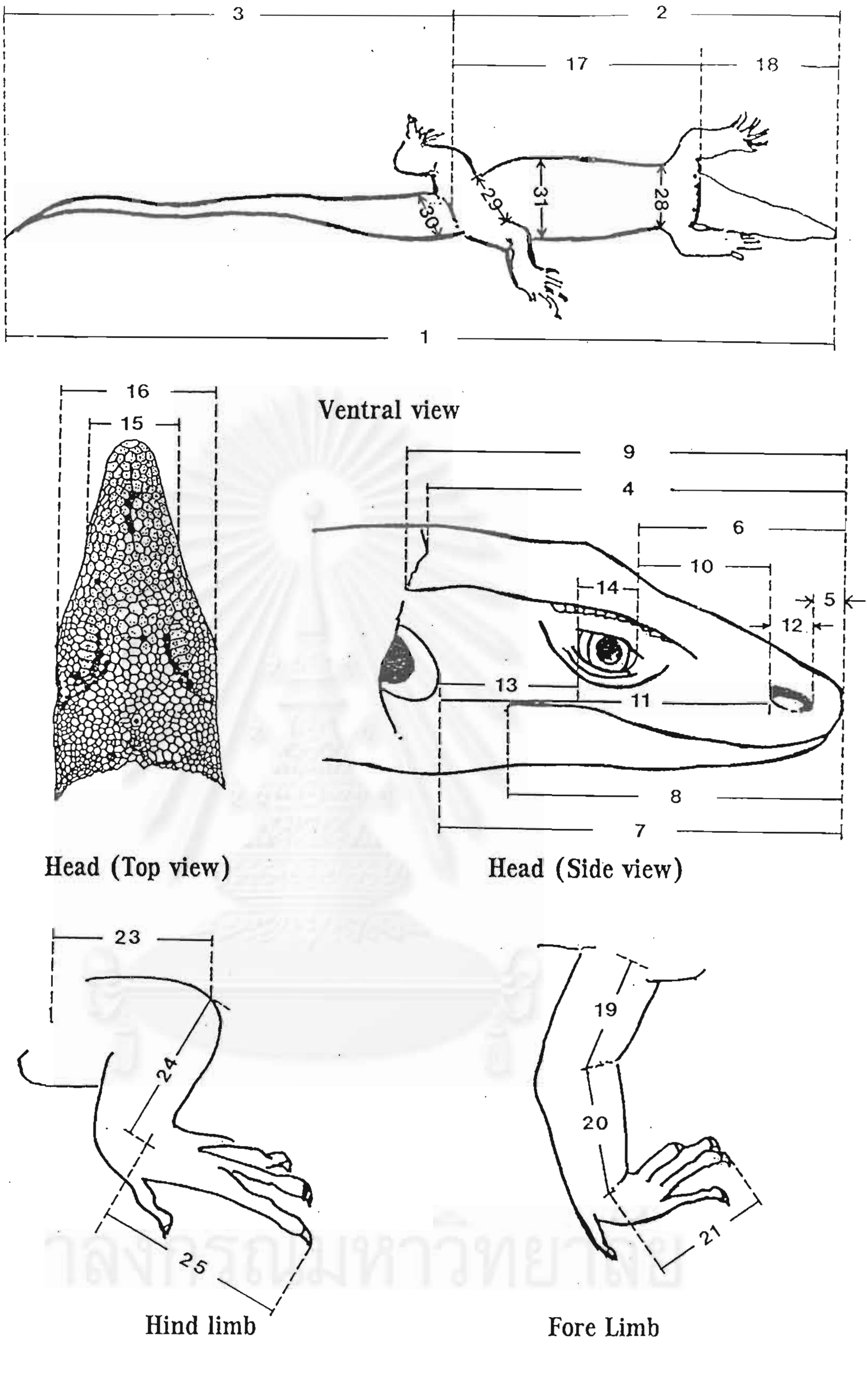


Figure 3–3 Morphological characteristics that were measured for the study of species identification and the sexual dimorphism.

a)

b)

Figure 3-4 a) Probing method for checking the sexes of monitor lizard.
b) Hemipenes of monitor lizard (*Varanus salvator*)

3.3.4 Data analysis

1. Morphological comparison

Sixteen specimens of *Varanus salvator*, ten specimens of *V. rudicollis*, nineteen specimens of *V. bengalensis nebulosus*, twelve specimens of *V. dumerilii* and three specimens of *V. s. komaini* were measured for thirty-two morphological characters. In order to minimize size bias, the thirty-one recorded of morphological characters were transformed into relative quantity to snout-vent length (SVL). The mean relative parameters were then compared between species using Analysis of Variance (ANOVA). Equations for predicting species of monitor lizards were created using Discriminant Function Analysis.

2. Sexual dimorphism

In each species, *Varanus salvator*, *V. rudicollis*, *V. bengalensis nebulosus* and *V. dumerilii*, the data of morphological characters between sexes were compared using Nonparametric Test (Mann-Whitney U-test). Equation for the prediction of sex was created using Discriminant Function Analysis.

In each comparison, probability of $p \leq 0.05$ were considered to be significantly different. General calculations were performed a computer using Microsoft Excel for Window 97 version 8.0. Statistical analyses were performed by a computer using SPSS for Window release 7.5 and 10.0.

Table 3-2 Number of monitor lizards under study.

Species	Known sex		Unknown sex	Total
	male	female		
Varanus salvator	5	3	8	16
V. rudicollis	3	5	2; (J = 1)	10
V. bengalensis nebulosus	7	4	8; (J = 1)	19
V. dumerilii	5	1	6; (J = 2)	12
V. s. komaini	2	-	1	3

Note: J = Juvenile

Chapter 4

Results and Discussions

4.1 Species diversity and distribution of varanids in southern Thailand.

4.1.1 Species diversity of monitor lizards in southern Thailand.

From January 1998 to December 1999, fifty-five individuals of four species of monitor lizards were found in field surveys (Table 4-1). There were thirty-five individuals of *Varanus salvator*, three individuals of *Varanus rudicollis*, thirteen individuals of *Varanus bengalensis nebulosus* and four individuals of *Varanus dumerilii*.

Nutphand (1981) reported that Siam & Zoological Company and Bangkok Wildlife Company collected twenty-nine specimens of black water monitor during 1975-1981. All specimens were caught from Amphur Thung Wa and Amphur La Ngu, Satun Province. In 1987, he published and described the black water monitor as a new subspecies, *Varanus salvator komaini*, in Journal of Thai Zoological Center, Vol. 2(15). In this study, three specimens from unknown habitats were examined. Two specimens, one live specimen and one preserved specimen, were studied at Pata Zoo, Bangkok and another one is a live specimen received from a wildlife dealer. From this study, the taxonomic status, distribution and habitat type of *V. s. komaini* are still unclear.

Varanus flavescens, which was reported by Taylor (1963) that occurred in southern Thailand, was not found in this study. In 1990, Luxmoore and Groombridge investigated the distribution of this species and found that Taylor (1963) had cited a single old record of *Varanus flavescens* from Trang Province, reported at the turn of the century by Boulenger. Moreover, Luxmoore and Groombridge mentioned that Mertens (1942) had earlier questioned this record, and other nineteenth century records of *Varanus flavescens* in Myanmar and the Malay Peninsula, and suggested the confusion with *Varanus dumerilii*. From Taylor (1963) until present, there has been no evidence of *V. flavescens* found in Thailand. Therefore it seems to be certain that *Varanus flavescens* does not occur outside the plains of the Indus-Ganges-Brohmaputra System (Smedley, 1932).

Wildlife checklists of National Parks, Wildlife Sanctuaries and other government agencies that were taken into consideration in order to support the distribution of monitor lizards observed in the field suggested the occurrence of four species in southern Thailand i.e. *Varanus salvator*, *V. rudicollis*, *V. bengalensis nebulosus* and *V. dumerilii*. None of the above checklists reported the occurrence of *V. salvator komaini* and *V. flavescens*. Details are shown in Table 4-2.

Table 4-1 Monitor lizards found in this study.

Species	No.	Date	Sex	SVL. (cm.)	TT. (cm.)	Elevation (m.)	Habitat	Locality	Province	Note
V. salvator	1.	11 Aug 98	M	61.0	155.0	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	2.	11 Aug 98	F	41.6	101.6	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	3.	30 Oct 98	F	43.5	102.0	175	F/PW	Khao Krung Sator Mt.	Surat Thani	measured
V. salvator	4.	8 Feb 99	UN	68.5	134.5	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	5.	8 Feb 99	UN	47.5	120.5	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	6.	8 Feb 99	UN	46.5	118.0	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	7.	8 Feb 99	UN	58.0	134.0	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	8.	8 Feb 99	F	52.0	127.5	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	9.	8 Feb 99	UN	53.5	124.6	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	10.	10 July 99	J	16.8	43.0	15	A/F-R	Amphur Suksamran	Ranong	measured
V. salvator	11.	27 July 99	J	24.6	66.4	0	F/FwS	Thale Noi NhA.	Phatthalung	measured
V. salvator	12.	8 Nov 99	M	75.0	179.0	0	F/MF	Amphur La-Ngu	Satun	measured
V. salvator	13.	10 Nov 99	M	58.0	144.5	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	14.	10 Nov 99	M	54.0	126.0	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	15.	10 Nov 99	M	46.0	118.0	0	F/MF	Lumnum Kraburi NP.	Ranong	measured
V. salvator	16.	10 Nov 99	UN	50.0	99.5	0	F/MF	Lumnum Kraburi NP.	Ranong	measured

Table 4-1 (Cont.) Monitor lizards found in this study.

Species	No.	Date	Sex	SVL. (cm.)	TT. (cm.)	Elevation (m.)	Habitat	Locality	Province	Note
V. salvator	17.	29 Jan 99	-	-	~110.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	18.	29 Jan 99	-	-	~120.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	19	29 Jan 99	-	-	~140.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	20.	29 Jan 99	-	-	~100.0	0	A/ShF-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	21.	29 Jan 99	-	-	~110.0	0	A/ShF-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	22.	29 Jan 99	-	-	~160.0	0	A/ShF-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	23.	29 Jan 99	-	-	~90.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	24.	29 Jan 99	-	-	~125.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	25.	29 Jan 99	-	-	~80.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	26.	29 Jan 99	-	-	~100.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	27.	29 Jan 99	-	-	~150.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	28.	29 Jan 99	-	-	~80.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	29.	29 Jan 99	-	-	~140.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	30.	5 Sep 99	-	-	~130.0	15	A/ShF	Amphur Pa Thiu	Chumphon	observed
V. salvator	31.	7 Sep 99	-	-	~160.0	110	F/TEF	Hala-Bala WS.	Narathiwat	observed
V. salvator	32.	4 Oct 99	-	-	~150.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed

Table 4-1 (Cont.) Monitor lizards found in this study.

Species	No.	Date	Sex	SVL. (cm.)	TT. (cm.)	Elevation (m.)	Habitat	Locality	Province	Note
V. salvator	33.	4 Oct 99	-	-	~90.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	34.	4 Oct 99	-	-	~100.0	0	A/OP-Wc	Klong Phun Phin	Surat Thani	observed
V. salvator	35.	8 Nov 99	-	-	~120.0	0	F/MF	Amphur La-Ngu	Satun	observed
V. rudicollis	36.	7 Feb 99	M	55.5	116.0	175	F/PW-Wc	Khao Krung Sator Mt.	Surat Thani	measured
V. rudicollis	37.	24 March 99	M	40.8	95.0	175	F/PW-Wc	Khao Krung Sator Mt.	Surat Thani	measured
V. rudicollis	38.	24 March 99	F	48.0	110.0	175	F/PW-Wc	Khao Krung Sator Mt.	Surat Thani	measured
V. b. nebulosus	39.	15 Jan 98	UN	36.5	73.5	50	F/TEF	Khao Pu Khao Ya NP.	Phatthalung	measured
V. b. nebulosus	40.	30 Jan 99	UN			25	A/RP	Amphur Khanchanadich	Surat Thani	measured
V. b. nebulosus	41.	29 Oct 98	F	42.0	99.0	25	A/OP	Amphur Betong	Yala	measured
V. b. nebulosus	42.	30 Oct 98	M	43.5	99.0	25	A/F-R	Amphur Rue Soe	Narathiwat	measured
V. b. nebulosus	43.	30 Oct 98	F	42.5	116.0	25	A/F-R	Amphur Rue Soe	Narathiwat	measured
V. b. nebulosus	44.	7 Nov 99	J	14.05	35.55	200	F/TEF	Hat Yai NWSC.	Songkhla	measured
V. b. nebulosus	45.	15 Jan 98	J	-	~25.0	50	F/TEF	Khao Pu Khao Ya NP.	Phatthalung	observed
V. b. nebulosus	46.	11 Jan 98	J	-	~30.0	25	F/TEF	Peninsular Khaochong Botanic Gardens	Trang	observed
V. b. nebulosus	47.	12 Aug 98	J	26.0	51.6	0	A/RP	Amphur Chawang	Nakhon Sri.	observed
V. b. nebulosus	48.	14 Aug 98	-	-	~110.0	110	F/TEF	Hala-Bala WS.	Narathiwat	observed

Table 4-1 (Cont.) Monitor lizards found in this study.

Species	No.	Date	Sex	SVL. (cm.)	TT. (cm.)	Elevation (m.)	Habitat	Locality	Province	Note
V. b. nebulosus	49.	5 Nov 99	-	-	~80.0	50	A/CoP	Amphur Rattaphum	Songkhla	observed
V. b. nebulosus	50.	8 Nov 99	-	-	~90.0	75	F/TEF	Thale Ban MNP.	Satun	observed
V. b. nebulosus	51.	8 Nov 99	-	-	~100.0	75	F/TEF	Thale Ban MNP.	Satun	observed
V. dumerilii	52.	2 Nov 98	M	40.0	102.0	175	F/PW-Wc	Khao Krung Sator Mt.	Surat Thani	measured
V. dumerilii	53.	30 Dec 98	J	12.4	26.5	75	A/RP	Khao Pu Khao Ya NP.	Phatthalung	measured
V. dumerilii (P)	54.	2 June 99	-	-	~100.0	150	F/TEF-We	Khao Pu Khao Ya NP.	Phatthalung	observed
V. dumerilii	55.	7 Nov 99	J	10.0	24.3	200	F/TEF-Wc	Hat Yai NWSC.	Songkhla	measured

Note M = Male; F= Female; UN = Unknown sex; J = Juvenile.
SVL = Snout-vent length; TT. = Total length.
F = Forest area; TEF = Tropical evergreen forest; MF = Mangrove swamp forest; FwS = Freshwater swamp (Adapted from Ruangpanit, 1998).
A = Agricultural area; FR = Farmland; OP = Orchard plantation; ShF = Shrimp Farm; RP = Rubber plantation; CoP = Coconut plantation;
PW = Private woodland; Wc = watercourse (Adapted from Luxmoore & Groombridge, 1990)
Mt. = Mountain; ~ = Estimated by size; Nakhon Sri. = Nakhon Sri Thammarat.
(P) = Photographed by Peter Paul van Dijk

Table 4–2 Species diversity of monitor lizards in the checklists of Royal Forest Department.

Locality	Province	*Varanus salvator*	*Varanus rudicollis*	*Varanus. b. nebulosus*	*Varanus dumerilii*
Mu Ko Payam MNP.	Ranong	🦎		🦎	
Ao Phang Nga MNP.	Phang Nga	🦎		🦎	
Sri Phang Nga NP.	Phang Nga	🦎	🦎	🦎	
Khao Lak-Lum Ru MNP.	Phang Nga	🦎	🦎	🦎	
Khao Pra Taew WC.	Phuket	🦎		🦎	
Khao Sok NP.	Surat Thani	🦎	🦎	🦎	
Khao Pu Khao Ya NP.	Phatthalung	🦎	🦎	🦎	🦎
Thale Noi NA.	Phatthalung	🦎		🦎	
Mu Ko Lunta MNP.	Krabi	🦎		🦎	
Khao Pra-Bang Kram WS.	Krabi	🦎	🦎	🦎	🦎
Had Chao Mai MNP.	Trang	🦎		🦎	
Khao Chong WC.	Trang	🦎	🦎	🦎	
Mu Ko Phetra MNP.	Satun	🦎		🦎	
Mu Ko Tarutao MNP.	Satun	🦎		🦎	
Thale Ban MNP.	Satun	🦎	🦎	🦎	
Nong Prag Praya NA.	Satun	🦎		🦎	
Ton Nga Chang WRS.	Songkhla	🦎	🦎	🦎	🦎
Sirindhorn RNC.	Narathiwat	🦎			🦎
Hala-Bala WS.	Narathiwat	🦎		🦎	

Note:
NP. = National Park.
MNP. = Marine National Park.
WC. = Wildlife Conservation Development and Extension Center.
WS. = Wildlife Sanctuary.
WRS. = Wildlife Research Station.
NA. = Non-hunting Area.
NWSC. = Nature and Wildlife Study Center.
RNC = Research and Nature study Center.
Varanus b. nebulosus = *Varanus bengalensis nebulosus*

During the field survey, several local names of monitor lizard in this study were noted for avoiding misidentification. In case of Hao Chang Kao, Bennett (1996; 1998) reported that it was *Varanus dumerilii*. Other names were collected by relevant villager interviews. Local names were in Table 4-3.

Table 4-3 Local names of monitor lizards in southern Thailand

Species	Local names
V. salvator	Hiea (เหี้ย), Tua-Nguen-Tua-Tong (ตัวเงินตัวทอง), Laan-Dok-Mai (แลนดอกไม้)
V. rudicollis	Ngu-Hao Chang (งูเห่าช้าง), Thao-Ra-Toei (เฒ่าราเตย หรือ เฒ่าระเตย), Kor-Lung (คอลั้ง), Hao Dong (เห่าดง), Hao Chang (เห่าช้าง)
V. b. nebulosus	Ta-kuat (ตะกวด), Laan (แลน), Kuat-Prow (กวดพร้าว)
V. dumerilii	Tut-too (ตุ๊ดตู่), Hao Chang Kao (เห่าช้างขาว)
V. s. komaini	Hiea-Dam (เหี้ยดำ), Mongkorn-Dam (มังกรดำ), Laan-Kiam (แลนเคี้ยม)

4.1.2 Distribution of monitor lizards in southern Thailand

The distributions of monitor lizards are shown in Figure 4-1 to 4-4. *Varanus salvator* is the most widespread species in southern Thailand. Thirty-five individuals of *Varanus salvator* were found in six provinces, i.e. Chumphon, Ranong, Surat Thani, Phatthalung, Satun and Narathiwat. Most of them were found near or in watercourses. Among thirty-five individuals of *V. salvator*, sixteen (Nos. 1-16) were captured and measured for morphometric details and the rest (Nos. 17-35) were observed by sight.

Thirteen individuals of *V. bengalensis nebulosus* were found in eight provinces, i.e. Surat Thani, Nakhon Sri Thammarat, Phatthalung, Trang, Satun, Songkhla, Yala and Narathiwat. Numbers 39-44 were measured for morphometric details and Numbers 45-50 were observed by sight. In addition, a specimen (No. 47) was found only its skin and skull.

Figure 4-1 and 4-2 demonstrate that *Varanus salvator* and *Varanus bengalensis nebulosus* distribute in three main mountain ranges i.e. Phuket Mountain Range, Nakhon Sri Thammarat Mountain Range and Sankala Kiri Mountain Range. That means both species commonly occur throughout southern Thailand.

Three individuals of *V. rudicollis* (Nos. 36-38) were found near a stream in private woodland of Surat Thani Province. Figure 4-2 displays that *V. rudicollis* occurs in Surat Thani, Phang Nga, Phuket, Krabi, Nakhon Sri Thammarat, Trang, Phatthalung, Satun and Songkhla Provinces. The area covers two mountain ranges i.e. Phuket Mountain Range and Nakhon Sri Thammarat Mountain Range. Moreover, data from the interview mentioned that *V. rudicollis* occurred in Sankala Kiri Mountain Range as well.

Four individuals of *Varanus dumerilii* were found in three provinces; Surat Thani, Phatthalung and Songkhla in two main habitats as of *V. salvator*. Figure 4-4 shows that *Varanus dumerilii* occurs in two main mountain ranges i.e. Nakhon Sri Thammarat Mountain Range and Sankala Kiri Mountain Range. This species distributes from east side of Surat Thani Province, only at the forest in Amphur Khanchanadich that connected to Nakhon Sri Thammarat Province, through Narathiwat Province.

Data from the interview and from wildlife checklists of the Royal Forest Department suggested that *V. dumerilii* probably does not occur in Phuket Mountain Range.

The elevations of the above-observed habitat range from mean sea level of mangrove forest to 200 meters of mountainous area, as shown in Table 4-1. Latitude and longitude of the study sites are presented in Appendix I.

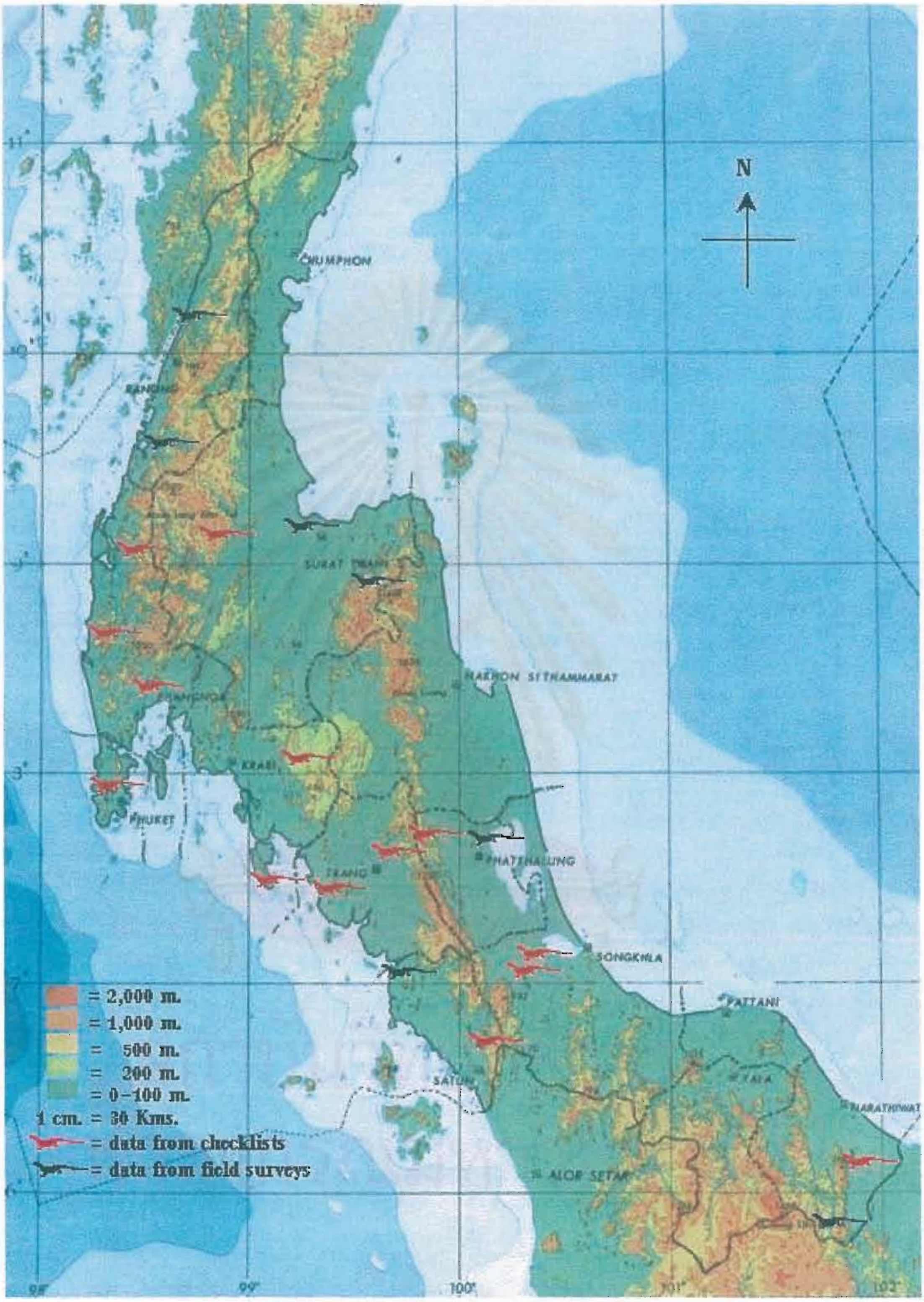


Figure 4-1 The distribution of *Varanus salvator* in southern Thailand.

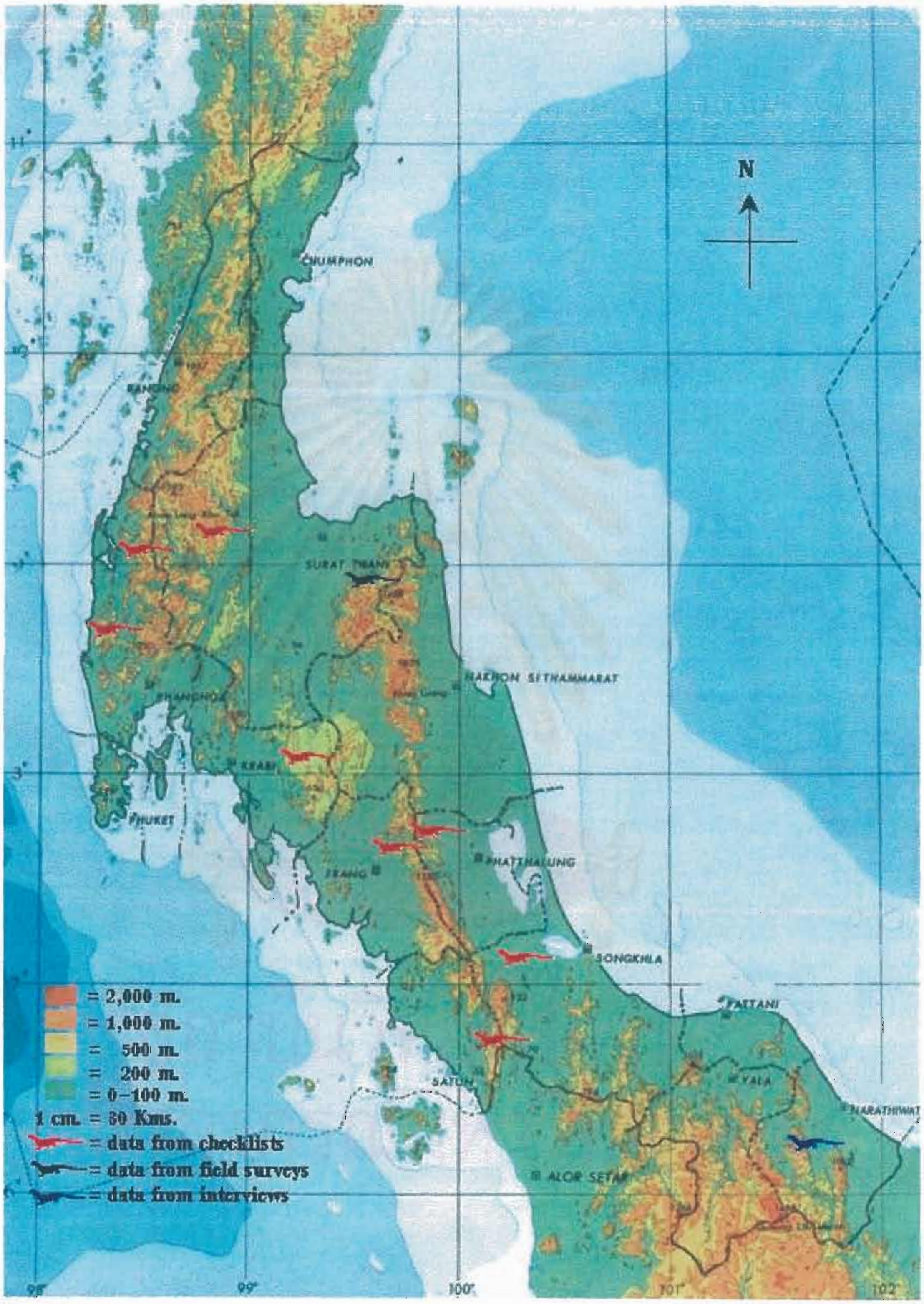


Figure 4–2 The distribution of *Varanus rudicollis* in southern Thailand.

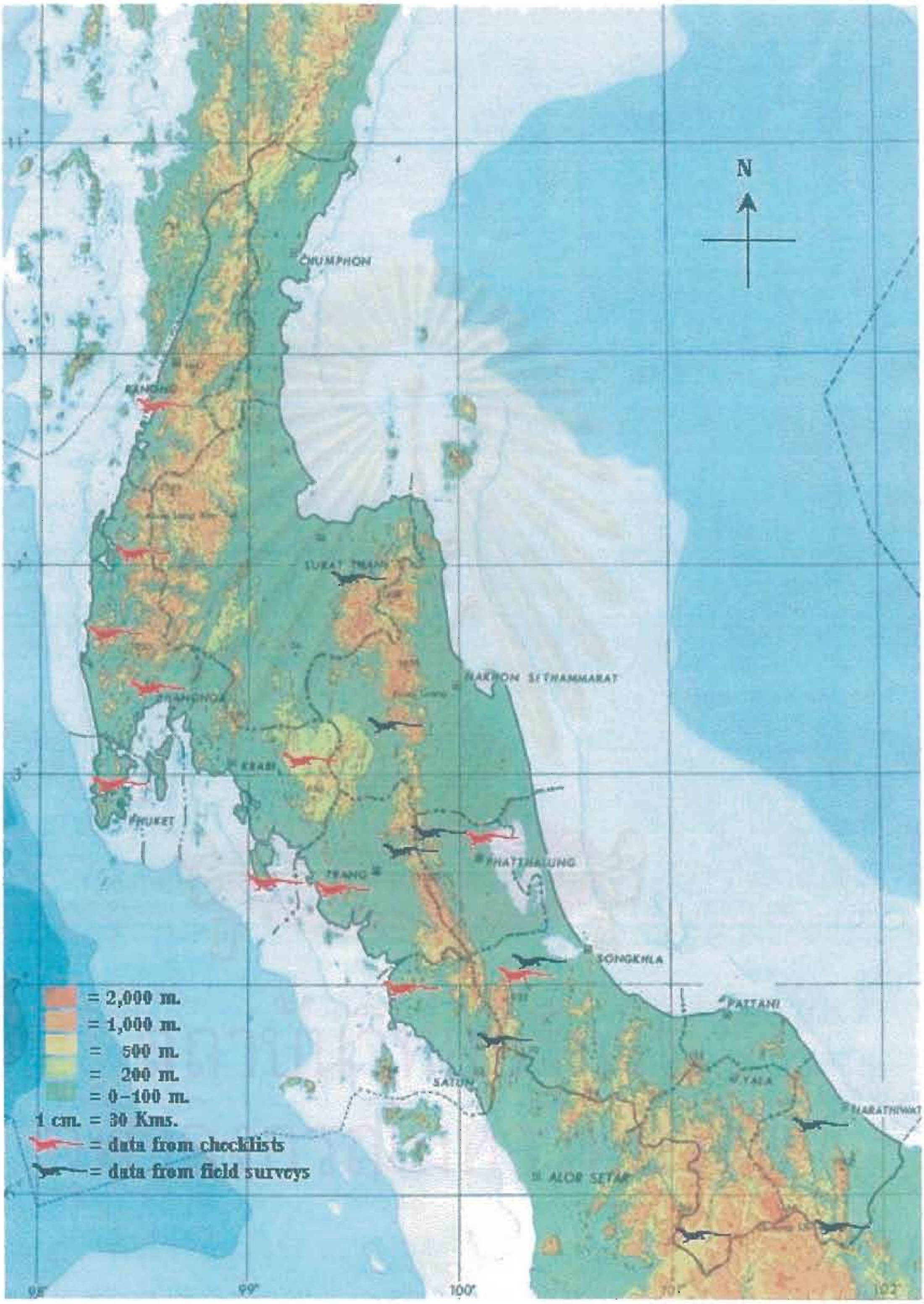


Figure 4-3 The distribution of *Varanus bengalensis nebulosus* in southern Thailand.

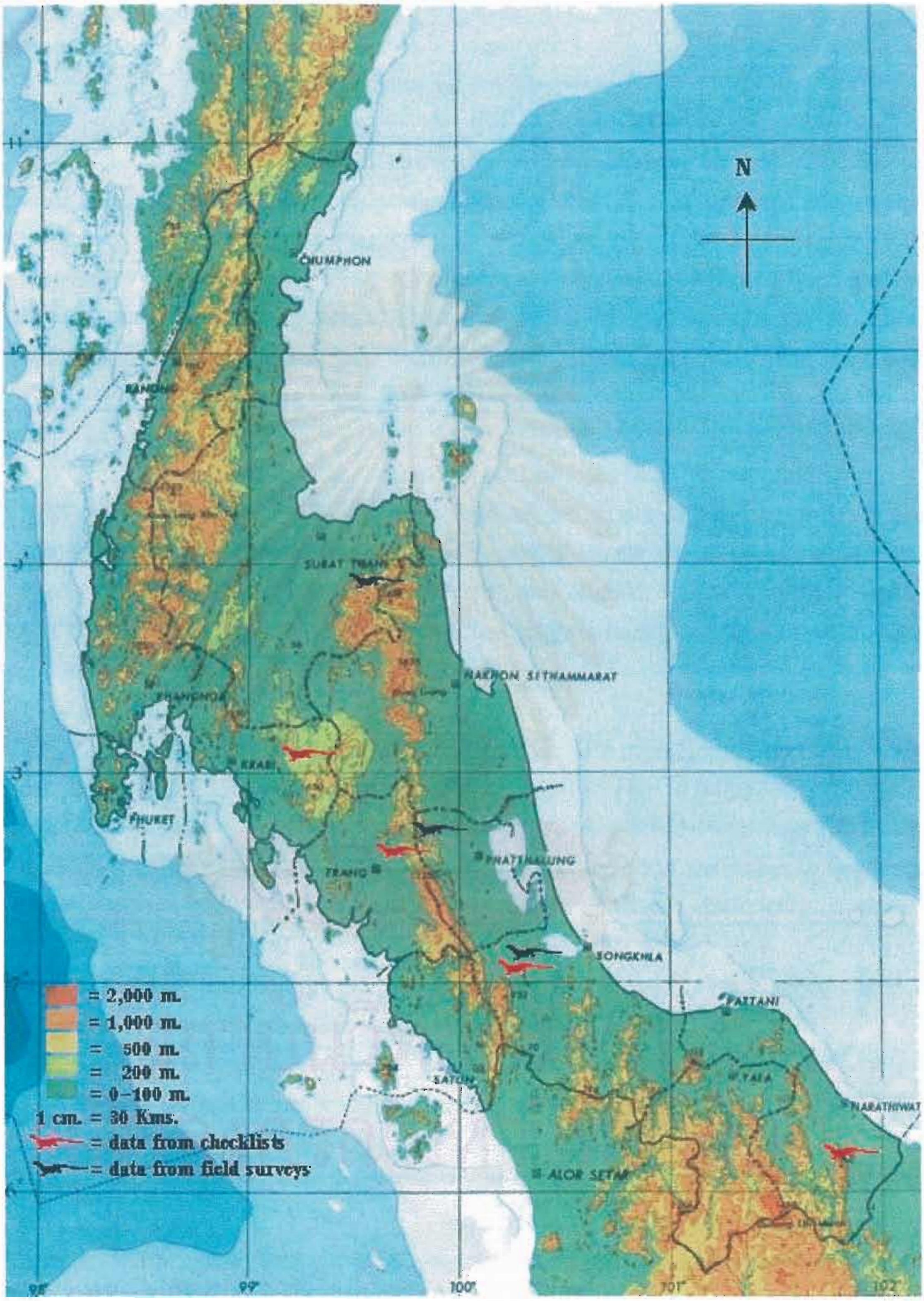


Figure 4–4 The distribution of *Varanus dumerilii* in southern Thailand.

4.2 Morphological analysis

4.2.1 Morphological differences among species

All morphological characters in the parameter column of Table 4-5, were transformed by using snout tip-vent length (SVL) as divisor. The average lengths of each transformed character (parameter) of all species including the *V. s. komaini* were compared using Homogeneous Subsets of Post Hoc Multiple Comparisons in SPSS program. There are seven parameters with no significant differences among species ($p < 0.05$) including HL/SVL, SML/SVL, SPL/SVL, EL/SVL, EW/SVL, FL/SVL and MCL/SVL.

Varanus salvator has no significant character to separate its species from other monitor lizards in southern Thailand whereas two parameters of *Varanus rudicollis* present the mean with significant difference when compared to other species i.e. SEL/SVL= 0.1182 ± 0.0078 cm., and NL/SVL= 0.0287 ± 0.0074 cm. It can be interpreted that *V. rudicollis* has the longest nostril length and snout tip to eye length when compared to other species.

Varanus bengalensis nebulosus has four significant parameters which can separate them from other species, i.e. SNL/SVL= 0.0483 ± 0.0057 cm.; NL/SVL= 0.0221 ± 0.0031 cm,; ULL/SVL= 0.1816 ± 0.0158 cm., and LLL/SVL= 0.1552 ± 0.0133 cm. This means that *V. b. nebulosus* has the snout tip to nostril length longer than *V. salvator* and *V. s. komaini* but shorter than *V. rudicollis* and *V. dumerilii*. Its nostril length is only significantly shorter than *V. rudicollis*. Moreover, the upper leg length and the lower leg length of this species are the longest characters among other varanids in southern Thailand.

Varanus dumerilii shows four parameters with significant difference from other varanids, i.e. NW/SVL= 0.0524 ± 0.0084 cm.; FAL/SVL= 0.1076 ± 0.0085 cm.; ULL/SVL= 0.1471 ± 0.0119 cm. and LLL/SVL= 0.1193 ± 0.0119 cm., which mean that *V. dumerilii* has the longest distance between right and left nostrils. Furthermore, forearm length, upper arm length and lower leg length of this species are the shortest parameters compared to other species.

Varanus salvator komaini shows two morphological characters with significant difference compared to other species including *V. salvator*, i.e. TTL/SVL= 2.6658 ± 0.3520 cm., and TL/SVL= 1.6658 ± 0.3520 cm. From these two parameters, it can be said that the *V. s. komaini* has relatively longer body than other species.

For the comparison between species, *V. rudicollis* and *V. salvator* show nine parameters with significant difference. *V. rudicollis* has longer snout tip-nostril length, snout tip-eye length, nostril length, nostril width, hand length and forelimb length than those of *V. salvator* while nostril-eye length, nostril-ear opening length and eye- ear opening length are shorter than those of *V. salvator*.

For *V. rudicollis* and *V. s. komaini*, there are thirteen parameters with significant difference. *V. rudicollis* has five out of thirteen parameters longer than those of *V. s. komaini*, i.e. snout tip-nostril length, snout tip-eye length, nostril length, nostril width and snout tip-collar length. Other parameters, i.e. total length, tail length, nostril-eye length, nostril-ear opening length, eye-ear opening length, collar-vent length and base of tail circumference length are shorter, and total weight is heavier, than those of *V. s. komaini*.

Between *V. rudicollis* and *V. b. nebulosus*, there are ten parameters with significant difference. *V. rudicollis* has five out of ten parameters longer than those of *V. b. nebulosus*, i.e. snout tip-nostril length, snout tip-eye length, snout tip-ear opening length, nostril length and snout tip-collar length. Other parameters, i.e. collar-vent length, upper leg length, lower leg length, lumbar circumference length and base of tail circumference length are shorter than those of *V. b. nebulosus*.

V. rudicollis and *V. dumerilii*, have ten parameters with significant difference. *V. rudicollis* has eight out of ten parameters longer than those of *V. dumerilii*, i.e. snout tip-eye length, nostril length, snout tip-collar length, forearm length, forelimb length, upper leg length, lower leg length and hindlimb length. The other shorter characters are nostril width and collar-vent length.

V. b. nebulosus and *V. salvator* show eleven parameters with significant difference. *V. b. nebulosus* has eight out of eleven parameters longer than those of *V. salvator* i.e. snout tip-nostril length, nostril length, nostril width, upper leg length, lower leg length, hindlimb length, lumbar circumference length and base of tail circumference length. Three out of eleven parameters are shorter than those of *V. salvator* i.e. nostril-eye length, nostril-ear opening length and eye-ear opening length.

V. b. nebulosus and *V. s. komaini* exhibit ten parameters with significant difference. *V. b. nebulosus* has five out of ten parameters longer than those of *V. s. komaini*, i.e. snout tip-nostril length, nostril length, nostril width, upper leg length and lower leg length. The other shorter characters are total length, tail length, nostril-eye length, nostril-ear opening length and eye-ear opening length.

Between *V. b. nebulosus* and *V. dumerilii*, the results display eleven parameters with significant difference. *V. b. nebulosus* has nine out of eleven parameters longer than those of *V. dumerilii*, i.e. nostril length, upper arm length, forearm length, forelimb length, upper leg length, lower leg length, hindlimb length, lumbar circumference length and base of tail circumference length. Other parameters, i.e. snout tip-nostril length and nostril width are shorter than those of *V. dumerilii*.

V. dumerilii and *V. salvator* show eleven parameters with significant difference. *V. dumerilii* has three parameters longer than those of *V. salvator*, i.e. snout tip-nostril length, nostril width and axilla circumference length. Other parameters, i.e. nostril-eye length, nostril-ear opening length, eye-ear opening length, forearm length, upper leg length, lower leg length and base of tail circumference length are shorter than those of *V. salvator*. Total weight of *V. dumerilii* is lighter than those of *V. salvator*.

For *V. dumerilii* and *V. s. komaini*, the results display seventeen parameters with significant difference. *V. dumerilii* has three parameters longer than those of *V. s. komaini*, i.e. snout tip-nostril length, nostril width and snout tip-collar length. The other shorter characters are total length, tail length, nostril-eye length, nostril-ear opening length, eye-ear opening length, collar-vent length, upper arm length, forearm length, forelimb length, upper leg length, lower leg length, hindlimb length and base of tail circumference length. Total weight of *V. dumerilii* is lighter than those of *V. s. komaini*.

The last pair of species comparison is between *V. salvator* and *V. s. komaini*. The results show seven parameters with significant difference. *V. salvator* has only one out of seven parameters longer than that of *V. s. komaini*, i.e. snout tip-collar length. The other shorter characters are total length, tail length, collar-vent length, forearm length, forelimb length and axilla circumference length.

Table 4–4 Analysis of Variance of the samples' morphological characters (Significant differences ($p<0.05$) among each species are indicated by differences in superscript letter) .

Parameter	Mean ± S.D.				
	V. salvator (n=16)	*V. rudicollis* (n=10)	*V. b. nebulosus* (n=19)	*V. dumerilii* (n=12)	*V. s. komaini* (n=3)
TTL/SVL.	2.4052^{a} ± 0.1986	2.2785^{a} ± 0.1016	2.4442^{a} ± 0.1653	2.3876^{a} ± 0.1379	2.6658^{b} ± 0.3520
TL/SVL	1.4052^{a} ± 0.1986	1.2766^{a} ± 0.0979	1.4479^{a} ± 0.1648	1.3830^{a} ± 0.1382	1.6658^{b} ± 0.3520
HL/SVL	0.1700^{a} ± 0.0207	0.1847^{a} ± 0.0180	0.1660^{a} ± 0.0206	0.1730^{a} ± 0.0272	0.1666^{a} ± 0.0124
SNL/SVL	0.0258^{a} ± 0.0038	0.0580^{c} ± 0.0082	0.0483^{b} ± 0.0057	0.0576^{c} ± 0.0076	0.0272^{a} ± 0.0064
SEL/SVL	0.1016^{a} ± 0.0069	0.1182^{b} ± 0.0078	0.1010^{a} ± 0.0104	0.1017^{a} ± 0.0135	0.0959^{a} ± 0.0098
SEaL/SVL	0.1729^{ab} ± 0.0179	0.1841^{b} ± 0.0126	0.1622^{a} ± 0.0149	0.1722^{ab} ± 0.0259	0.1721^{ab} ± 0.0107
SML/SVL	0.1453^{a} ± 0.0371	0.1716^{a} ± 0.0133	0.1491^{a} ± 0.0160	0.1564^{a} ± 0.0217	0.1506^{a} ± 0.0146
SPL/SVL	0.1846^{a} ± 0.0201	0.1993^{a} ± 0.0171	0.1797^{a} ± 0.0196	0.1916^{a} ± 0.0277	0.1861^{a} ± 0.0099
NEL/SVL	0.0660^{a} ± 0.0051	0.0328^{b} ± 0.0042	0.0339^{b} ± 0.0073	0.0297^{b} ± 0.0047	0.0611^{a} ± 0.0106
NEaL/SVL	0.1386^{a} ± 0.0163	0.1006^{b} ± 0.0095	0.0993^{b} ± 0.0133	0.1039^{b} ± 0.0173	0.1370^{a} ± 0.0062
NL/SVL	0.0108^{a} ± 0.0021	0.0287^{b} ± 0.0074	0.0221^{c} ± 0.0031	0.0141^{a} ± 0.0021	0.0117^{a} ± 0.0026
EEaL/SVL	0.0563^{a} ± 0.0075	0.0478^{b} ± 0.0018	0.0460^{b} ± 0.0064	0.0489^{b} ± 0.0085	0.0603^{a} ± 0.0072
EL/SVL	0.0211^{a} ± 0.0073	0.0234^{a} ± 0.0054	0.0232^{a} ± 0.0046	0.0251^{a} ± 0.0089	0.0221^{a} ± 0.0072
NW/SVL	0.0302^{a} ± 0.0059	0.0446^{b} ± 0.0029	0.0425^{b} ± 0.0050	0.0524^{c} ± 0.0084	0.0343^{a} ± 0.0014
EW/SVL	0.0686^{a} ± 0.0066	0.0749^{a} ± 0.0078	0.0741^{a} ± 0.0098	0.0769^{a} ± 0.0112	0.0717^{a} ± 0.0065
CVL/SVL	0.6296^{ab} ± 0.0339	0.6103^{a} ± 0.0288	0.6537^{bc} ± 0.0224	0.6476^{b} ± 0.0352	0.6837^{c} ± 0.0371
SCL/SVL	0.3704^{ab} ± 0.0339	0.3897^{b} ± 0.0288	0.3463^{ac} ± 0.0224	0.3524^{a} ± 0.0352	0.3163^{c} ± 0.0371

Table 4-4(cont.) Analysis of Variance of the samples' morphological characters (Significant differences ($p<0.05$) among each species are indicated by differences in superscript letter)

Parameter	Mean ± S.D.				
	V. salvator (n=16)	*V. rudicollis* (n=10)	*V. b. nebulosus* (n=19)	*V. dumerilii* (n=12)	*V. s. komaini* (n=3)
UAL/SVL	0.1312^{ab} ± 0.0068	0.1339^{ab} ± 0.0163	0.1377^{b} ± 0.0082	0.1236^{a} ± 0.0114	0.1423^{b} ± 0.0184
FAL/SVL	0.1189^{a} ± 0.0071	0.1272^{ab} ± 0.0123	0.1260^{ab} ± 0.0076	0.1076^{c} ± 0.0085	0.1304^{b} ± 0.0154
HaL/SVL	0.1353^{a} ± 0.0108	0.1517^{b} ± 0.0085	0.1399^{ab} ± 0.0148	0.1388^{ab} ± 0.0146	0.1502^{ab} ± 0.0321
FLL/SVL	0.3853^{ac} ± 0.0218	0.4165^{b} ± 0.0312	0.4037^{bc} ± 0.0246	0.3699^{a} ± 0.0272	0.4229^{b} ± 0.0649
ULL/SVL	0.1623^{a} ± 0.0136	0.1660^{a} ± 0.0120	0.1816^{b} ± 0.0158	0.1471^{c} ± 0.0119	0.1642^{a} ± 0.0055
LLL/SVL	0.1335^{a} ± 0.0101	0.1398^{a} ± 0.0075	0.1552^{b} ± 0.0133	0.1193^{c} ± 0.0119	0.1372^{a} ± 0.0163
FL/SVL	0.1681^{a} ± 0.0138	0.1821^{a} ± 0.0111	0.1714^{a} ± 0.0150	0.1668^{a} ± 0.0094	0.1796^{a} ± 0.0429
HLL/SVL	0.4639^{ab} ± 0.0272	0.4880^{bc} ± 0.0212	0.5082^{c} ± 0.0348	0.4332^{a} ± 0.0274	0.4810^{bc} ± 0.0638
TW/SVL	0.0418^{ac} ± 0.0224	0.0316^{ab} ± 0.0235	0.0368^{abc} ± 0.0126	0.0189^{b} ± 0.0073	0.0514^{c} ± 0.0254
ACL/SVL	0.4168^{a} ± 0.0333	0.4555^{ab} ± 0.0643	0.4707^{ab} ± 0.0570	0.4830^{b} ± 0.0724	0.4896^{b} ± 0.0965
LCL/SVL	0.3882^{a} ± 0.0322	0.3864^{a} ± 0.0330	0.4566^{b} ± 0.0710	0.3764^{a} ± 0.0501	0.4254^{ab} ± 0.0454
TCL/SVL	0.3089^{ad} ± 0.0247	0.2756^{ab} ± 0.0340	0.3566^{c} ± 0.0336	0.2581^{b} ± 0.0453	0.3278^{cd} ± 0.0573
MCL/SVL	0.5228^{a} ± 0.0641	0.5949^{a} ± 0.0863	0.5680^{a} ± 0.0847	0.5418^{a} ± 0.0828	0.6033^{a} ± 0.0780
GPL/SVL*	0.0795^{a} ± 0.0271	0.0758^{a} ± 0.0134	0.0368^{a} ± 0.0126	0.0649^{a} ± 0.0210	0.2534^{a} ± 0.0284

Note: GPL/SVL* = Numbers of samples = 47: *V. salvator* (n=14), *V. rudicollis* (n=5), *V. b. nebulosus* (n=19), *V. dumerilii* (n=7) and *V. salvator komaini* (n=2); GPL = Genital pocket length

SVL = snout tip-vent length; TTL = total length; TL = Tail length; HL = head length; SNL = snout tip - nostril length; SEL = snout tip - eye length; SEaL = snout tip - ear opening length; SML = snout tip - mouth length; SPL = snout tip - posterior head length; NEL = nostril - eye length; NEaL = nostril - ear opening length; NL = nostril length; EEaL = eye - ear opening length; EL = eye length; NW = nostril width; EW = eye width; CVL = collar - vent length; SCL = snout tip- collar length; UAL = upper arm length; FAL = forearm length; HaL = hand length; FLL = forelimb length; ULL = upper leg length; LLL = lower leg length; FL = foot length; HLL = hindlimb length; TW = total weight; ACL = axilla circumference length; LCL = lumbar circumference length; TCL = base of tail circumference length; MCL = maximum of body circumference length;

Normally, the character of nuchal or neck scales can be used to identify two species of monitor lizards in southern Thailand (Figure 4-5). *Varanus dumerilii* has enlarged nuchal scales with round and flat shape whereas *Varanus rudicollis* has enlarged and strongly keeled nuchal scales. Nevertheless, the other two species including *V. s. komaini* have similar character at nuchal scales (Figure 4-6). Therefore, the study on other morphological differences to identify all species is necessary.

From the comparison of thirty-one parameters in this study, there is no single parameter that can clearly separate species of monitor lizards. However, it was found that the snout tip-nostril length, nostril length and nostril width is the best parameters to be used for the identification in field observation.

The results from Table 4-5 show that *Varanus rudicollis* has the longest distance between snout and nostril and the longest nostril length. Its nostril width length is shorter than that of *V. dumerilii*, but longer than *V. salvator* and *V. salvator komaini*.

Varanus bengalensis nebulosus shows the shorter distance between snout and nostril than that of *V. rudicollis* and *V. dumerilii*, but longer than the *V. salvator* and *V. salvator komaini*. Its nostril length is shorter than *V. rudicollis*, but longer than *V. salvator*, *V. dumerilii* and *V. salvator komaini*. Moreover, *V. b. nebulosus* has an oblique nostril. The nostril width length is shorter than *V. dumerilii*, but longer than *V. salvator* and *V. salvator komaini*.

Varanus dumerilii has the longest distance between snout and nostril. It nostril is the shortest and round. It has the widest distance between right and left nostril.

Varanus salvator and *V. salvator komaini* has the shortest distance between nostril and snout. Moreover, They have the shortest distance between right and left nostril. Both species have the shortest nostril length and round nostril opening.

Furthermore, *V. salvator komaini* can be separated from *V. salvator* by different coloration and size of tail and body. The morphological characters of snout tip-nostril length and nostril length are shown in Figure 4-7.

In addition, the size and position of the nostril openings reflect the range of habitats and feeding techniques of the monitor lizards. The nostrils of species that spend a lot of time in water are often equipped with flaps of skin that prevent water entering while the animals are submerged (Mertens, 1942). In species such as the water monitor the nares are situated towards the front of the snout, allowing the lizards to be able to keep almost all of the head below the water and still be able to breath. In this study, this character was found in *V. salvator* of which it is more aquatic than other species.

In other ground dwelling species, such as Bengal monitor, the round openings are replaced with slits and situated closer to the eye than the tip of the snout. This species use their remarkable sense of smell to detect prey and uncover it by pushing their snouts into the earth. The narrow slit-like opening prevents the entry of most of the debris that would otherwise congest the nostrils (Bennett, 1998). This is consistent to the characters of *V. b. nebulosus* and *V. rudicollis* from this study. Both species usually spend their activity on land more than in water. *V. dumerilii* has nearly round nostril but close to the eye than the tip of the snout. Previous reports had been stated that it was found in mangrove forest. Therefore, it should spend a lot of time in water. In this explored and interviewed, however, it seems that mangrove forests in southern Thailand are not its habitat. But it was found at Peat swamp forests and other watercourse in primary forests.

a)

b)

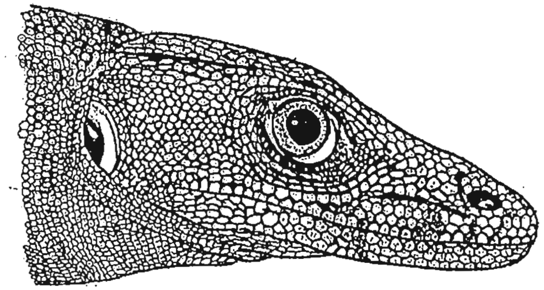
Figure 4-5 The different characters of nuchal scales between *V. rudicollis* (a) and *V. dumerilii* (b).

Varanus bengalensis nebulosus

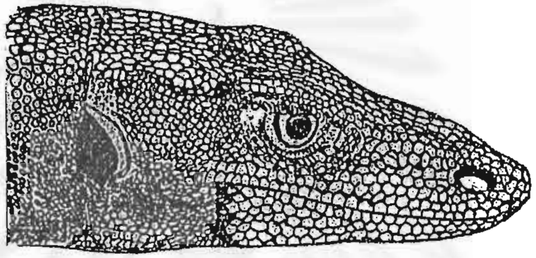
Varanus salvator komaini

Varanus salvator

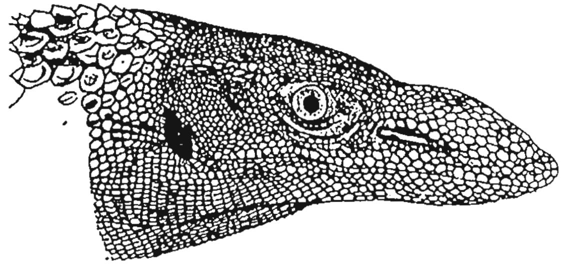
Figure 4-6 The nuchal scales of monitor lizards



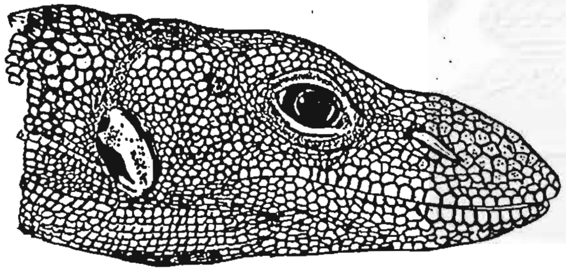
a) *V. salvator* ⊢—⊣ = 1 cm.



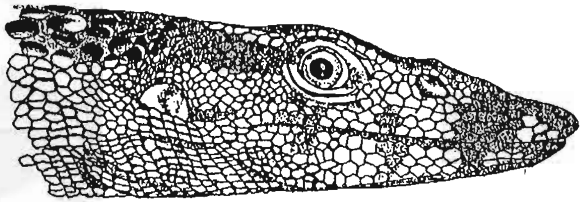
b) *V. s. komaini* ⊢⊣ = 1 cm.



c) *V. rudicollis* ⊢⊣ = 1 cm.



d) *V. b. nebulosus* ⊢⊣ = 1 cm.



e) *V. dumerilii* ⊢⊣ = 1 cm.

Figure 4–7 Morphological characters of snout tip-nostril length and nostril length of monitor lizards in this study.

Canonical Discriminant Analysis was computed using twenty-two parameters with significant difference. In order to minimize bias, a varying parameter such as the total weight was excluded. Results demonstrated that Canonical Discriminant Functions can separate the varanids in southern Thailand into four groups i.e. *V. salvator* (including *V. s. komaini*), *V. rudicollis*, *V. b. nebulosus* and *V. dumerilii* (Figure 4-9). In case of *V. salvator* and *V. s. komaini*, most of their morphological characters are alike except the size of body and tail. Thus Canonical Discriminant Functions of *V. s. komaini* present overlap with the values of *V. salvator*. One reason of this similarity is probably due to the small sample size of *V. s. komaini* since only three specimens were examined in this study.

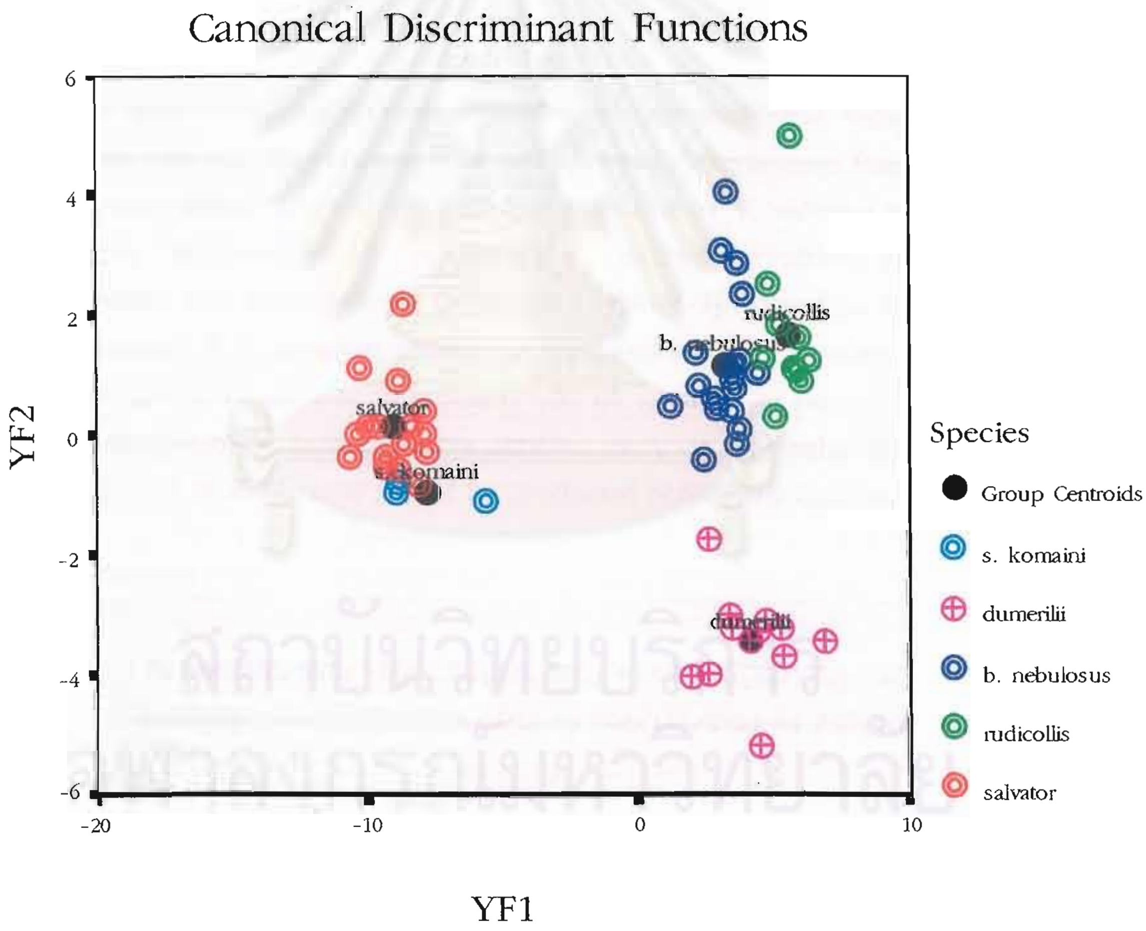


Figure 4-8 Morphological differences among varanids in Southern Thailand. Analysis using Canonical Discriminant Functions.

The equation for species prediction was employed using Discriminant Function Analysis. The length of eight transformed morphological characters i.e. snout tip-vent length, nostril-eye length, nostril length, nostril width, collar-vent length, forelimb length, lower leg length and base of tail circumference length were chosen and multiplied by unstandardized coefficients. Two equations for the prediction of each species of monitor lizards including *V. s. komaini* were created and shown in Equation 4-1, Equation 4-2 and Territorial map (Figure 4-9). The values of Y_{F1} and Y_{F2} were then plotted in the map. An intersection, caused by Y_{F1} and Y_{F2} values, in each area of the map represents the types of monitor lizard concerned. A group centroid point in the map indicates the accuracy of species identification. If the intersection of Y_{F1} and Y_{F2} falls closer to the point, higher accuracy is the value. The accuracy of Equation 4-1 and Equation 4-2 in this case is correctly classified as 98.33%.

In the territorial map, *V. salvator komaini* displays its group centroid in the area of *V. salvator* even though its morphological value was input as a separate species. This is consistent to Canonical Discriminant Functions value of *V. s. komaini* which is almost coincided to the value of *V. salvator* and the Analysis of Variance of transformed morphological characters which shows twenty-four parameters with no significant difference (Table 4-3). Therefore, based on the above information, *V. s. komaini* should not be classified as a separate species or even a subspecies of *V. salvator*. It probably can be assumed at present that *V. s. komaini* is a variation of *V. salvator*. More detailed study on molecular biology, ecology and behavior of *V. s. komaini* should be conducted before any conclusion can be made.

<u>Equation 4-1</u>

$$Y_{F1} = 177.960(\mathrm{SNL/SVL}) - 186.362(\mathrm{NEL/SVL}) + 149.968(\mathrm{NL/SVL}) + 20.214(\mathrm{NW/SVL}) - 0.028(\mathrm{CVL/SVL}) - 8.137(\mathrm{FLL/SVL}) + 9.508(\mathrm{LLL/SVL}) + 4.763(\mathrm{TCL/SVL}) - 3.080$$

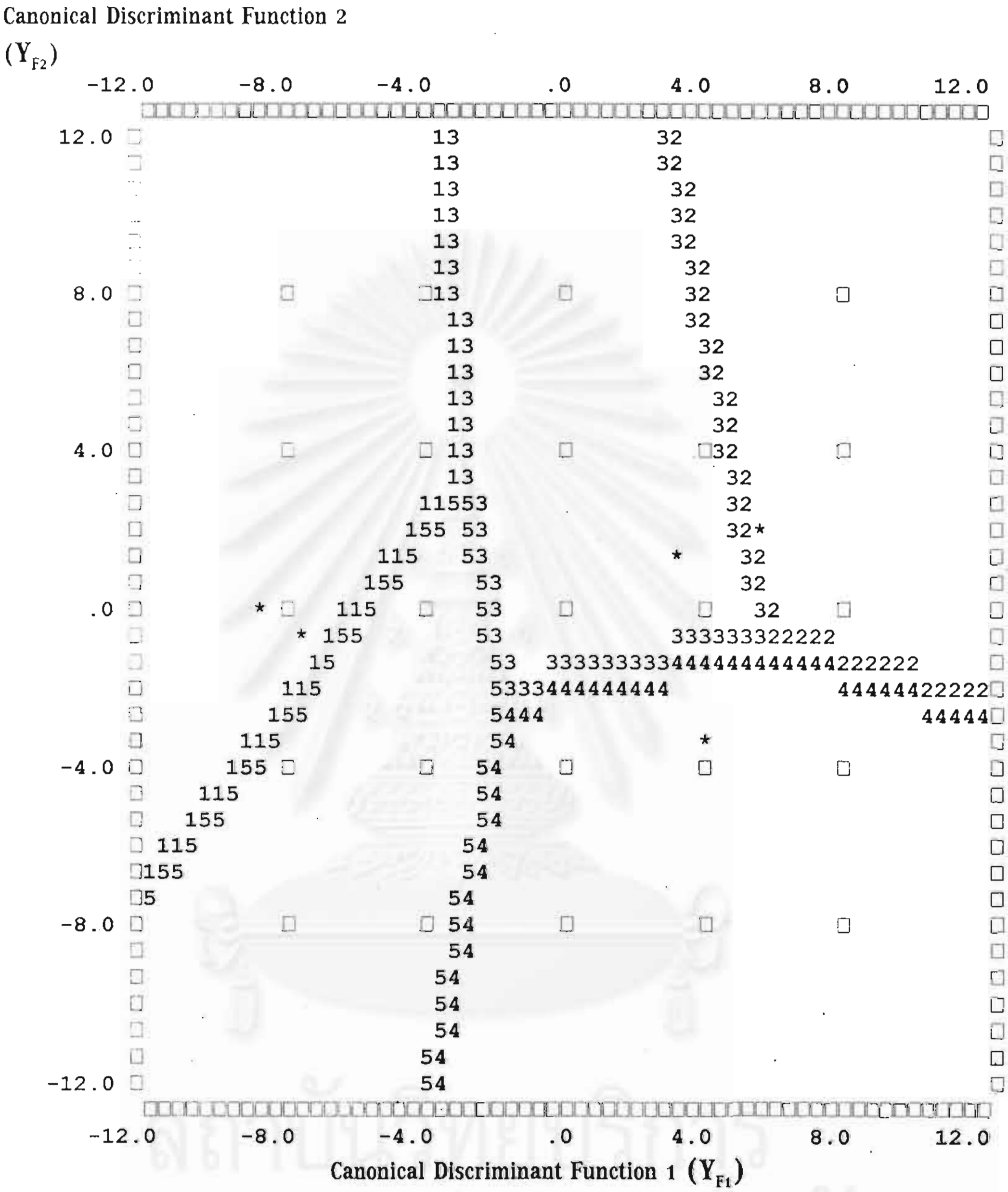
<u>Equation 4-2</u>

$$Y_{F2} = 36.906(\mathrm{SNL/SVL}) + 19.691(\mathrm{NEL/SVL}) + 146.374(\mathrm{NL/SVL}) - 145.560(\mathrm{NW/SVL}) - 16.278(\mathrm{CVL/SVL}) + 0.412(\mathrm{FLL/SVL}) + 52.322(\mathrm{LLL/SVL}) + 4.876(\mathrm{TCL/SVL}) + 2.344$$

<u>Note</u>: SVL = snout tip-vent length; SNL = snout tip - nostril length; NEL = nostril - eye length; NW = nostril width; NL = nostril length; CVL = collar-vent length; FLL = forelimb length; LLL = lower leg length; TCL = base of tail circumference length

Territorial Map

(Assuming all functions but the first two are zero)



Symbols used in territorial map

Symbol	Group	Label
1	1	*V. salvator*
2	2	*V. rudicollis*
3	3	*V. b. nebulosus*
4	4	*V. dumerilii*
5	5	*V. s. komaini*
*		Indicates a group centroid

Figure 4–9 Territorial Map

4.2.2 Sexual differences

From Table 3-2, samples of three species were checked about their sexual differences, i.e. *Varanus salvator*, *V. rudicollis* and *V. bengalensis nebulosus*, using Mann-Whitney U-test. *Varanus dumerilii* was not included since it has a small sample size. Results are shown in Table 4-5.

Table 4-5 Sexual differences of varanids in southern Thailand.

Species	Parameter	Mean ± S.D.		Significant
		Male	Female	
V. salvator	TCL/SVL	$0.3268^{a} \pm 0.0261$	$0.2790^{b} \pm 0.0075$	P < 0.05
	GPL/SVL	$0.0956^{a} \pm 0.0370$	$0.0531^{b} \pm 0.0004$	P < 0.05
V. rudicollis	ULL/SVL	$0.1789^{a} \pm 0.0089$	$0.1593^{b} \pm 0.0086$	P < 0.05
	TCL/SVL	$0.3138^{a} \pm 0.0189$	$0.2643^{b} \pm 0.0217$	P < 0.05
V. b. nebulosus	HLL/SVL	$0.5386^{a} \pm 0.0149$	$0.4929^{b} \pm 0.0299$	P < 0.05
	ULL/SVL	$0.1980^{a} \pm 0.0079$	$0.1732^{b} \pm 0.0135$	P < 0.05
	GPL/SVL	$0.1276^{a} \pm 0.0114$	$0.0742^{b} \pm 0.0131$	P < 0.05

Note: ULL = upper leg length; TCL = base of tail circumference length; HLL = hindlimb length; SVL = snout tip-vent length; GPL = genital pocket length

V. salvator shows two morphological characters with significant differences (p<0.05) between male and female i.e. base of tail circumference length and genital pocket length which are longer in male than in female. The range of the probing length measured for genital pocket in this study was 3.50-5.60 cm. in male (n=5) and 2.20-2.80 cm. in female (n=3). This is consistent to the study of Gaulke (1989a) who reported that probing length below 2.50 cm. may indicate females, specimens with more than 3.50 cm. may be male water monitors. Moreover, Auliya and Erdelen (1999) reported that a dead male and female of water monitor, each with a snout-vent length of 60 cm., were examined in a skinnery. The female had a maximum probing length of 3.30 cm., the male of 5.30 cm.

However, there are many disagreements with probing method for the determination of the sex in a given specimen. Andrews and Gaulke (1990) described the probing method as a potentially erroneous method. Repeatedly measured probing length, especially shown in mark-recapture studies, varied considerably in the same specimen. Moreover, Ziegler and Böhme (1996) also stress the unreliability of the probing method due to muscle contractions and the elasticity of the genital organs, which may lead to varying depth measurements of the genital pockets.

Hemiclitoris, which is discovered by Böhme (1998), may be a reason for supporting the unreliability of the probing method. Hemiclitoris is the ubiquitous presence of paired evertible and erectile structures in the ventral portion of the tail root, which are miniaturized mirror images of the hemipenes of the males. These organs contain all the structural elements (including a forked retractor muscle, supporting ossifications, epidermal flounces etc.) that are also characteristics for the hemipenes of the respective conspecific males (Böhme, 1998).

Varanus rudicollis displays two morphological characters with significant differences ($p<0.05$) in sexes. The first parameter is upper leg length, 0.1789 ± 0.0089 cm. in males and 0.1593 ± 0.0086 cm. in female. The others is base of tail circumference length 0.3138 ± 0.0189 cm. in male and 0.2643 ± 0.0217 cm. in female. That means male has upper leg longer and base of tail circumference larger than female. In addition, the sample of genital pocket lengths of *V. rudicollis* is not enough for computation (numbers of female = 2; male = 3).

Males and females of *Varanus bengalensis nebulosus* displays significantly different ($p<0.05$) in hindlimb length, upper leg length and genital pocket length. Hindlimb length is 0.5386 ± 0.0149 cm. in male and 0.4930 ± 0.0299 cm. in female while upper leg length is 0.1980 ± 0.0079 cm. in male and 0.1732 ± 0.0135 cm. in female. Both hindlimb length and upper leg length of male are larger than female. Another parameter is genital pocket length which is 0.1276 ± 0.0114 cm. in male and 0.0742 ± 0.0131 cm. in female, which means that male has genital pocket deeper than female. The range of the probing length measured for genital pocket was 4.68-6.58 cm. in male (n=7) and 2.3-3.5 cm. in female (n=4).

In case of *Varanus dumerilii*, its sexual difference is little known and has never been examined without using probing method. However, David and Phillips (1991) disagreed and believed that probing method is unreliable.

Equations for sex prediction in three species, i.e. *Varanus salvator*, *V. rudicollis* and *V. bengalensis nebulosus* were employed using Discriminant Function Analysis. In order to minimize bias, the total weight and seven parameters with no significant difference between species were excluded. The length of transformed morphological characters were chosen and multiplied by unstandardized coefficients that computed by Discriminant Function Analysis. The results are in Equation 4-3, 4-4 and 4-5 (See details in Appendix II). Steps for using the equation to predict sexes are similar to the method of species prediction.

Equation 4-3 the equation for predicts sex of *Varanus salvator*.

$$Y_{V.\ salvator} = -269.9882068(ACL/SVL)-5.6020481(FAL/SVL)+821.6613275(NEL/SVL)+2533.5578533(SNL/SVL)+1211.5296941(TCL/SVL)-44.8127540$$

$Y_{V.\ salvator} >$ -5.557085; *Varanus salvator* is male.

$Y_{V.\ salvator} <$ -5.557085; *Varanus salvator* is female.

Equation 4-4 the equation for predicts sex of *Varanus rudicollis*.

$$Y_{V.\ rudicollis} = -2311.5935352(NEaL/SVL)+2047.7835940(SEaL/SVL)-249.7990875(SNL/SVL)+215.3168304(UAL/SVL)+264.0185231(TCL/SVL)-232.8118218$$

$Y_{V.\ rudicollis} >$ 4.410585; *Varanus rudicollis* is male.

$Y_{V.\ rudicollis} <$ 4.410585; *Varanus rudicollis* is female.

Equation 4-5 the equation for predicts sex of *Varanus bengalensis nebulosus*

$$Y_{V.\ b.\ nebulosus} = -358.6464404(NL/SVL)+272.7897036(ULL/SVL) +364.0441772(EEaL)-312.5829651(FAL/SVL)-19.1460140$$

$Y_{V.\ b.\ nebulosus} > 0.911535$; *Varanus bengalensis nebulosus* is male.

$Y_{V.\ b.\ nebulosus} < 0.911535$; *Varanus bengalensis nebulosus* is female.

Note: SVL = snout tip-vent length; SNL = snout tip - nostril length; SEaL = snout tip - ear opening length; EEaL = eye - ear opening length; NEaL = nostril - ear opening length; NL = nostril length; NEL = nostril - eye length; UAL = upper arm length; FAL = forearm length; ULL = upper leg length; ACL = axilla circumference length; TCL = base of tail circumference length.

The accuracy of Equation 4-3, 4-4 and 4-5 in this case is correctly classified as 100.00%.

4.3 Ecological and biological data of monitor lizards.

4.3.1 Habitat types

The habitat of monitor lizards in southern Thailand can be divided into two major types i.e. forested areas which are tropical rain forest, mangrove forest, peat swamp forest and freshwater swamp area (Figure 4-10 and 4-11), and agricultural areas which are farmland, orchard plantation, rubber plantation, coconut plantation, shrimp farm, coffee and rubber plantation within tropical rain forest areas (Figure 4-12 to 4-13). Most of the forested areas are protected by the Royal Forest Department in forms of Wildlife Sanctuary, National Park, National Forest Reserve, Non-hunting Area, etc.

Table 4-6 The number of monitor lizards found in each habitat.

Habitat types	Species			
	V. salvator	*V. rudicollis*	*V. b. nebulosus*	*V. dumerilii*
Forested areas				
Tropical rain forest	2	-	7	2
Mangrove forest	14	-	-	-
Peat swamp forest	-	-	-	-
Freshwater swamp area	1	-	-	-
Agricultural areas				
Farmland	1	-	2	-
Orchard plantation	13	-	1	-
Rubber plantation	-	-	2	1
Coconut plantation	-	-	1	-
Shrimp farm	4	-	-	-
Coffee and rubber plantation within tropical rain forest area	-	3	-	1
Total	**35**	**3**	**13**	**4**

Table 4-7 Physical data of monitor lizards in the study areas.

Physical data	Species			
	V. salvator	*V. rudicollis*	*V. b. nebulosus*	*V. dumerilii*
Elevation Ranges (m at MSL)	0-175	130-175	25-200	130-200
Humidity Ranges (%)	66-89	69-89	69-89	69-89
Temperature Ranges (C^{o})	23.9-30.6	24.2-30.5	24.2-30.5	24.2-30.5
Rainfall Ranges (mm.)	0-1159.3	0-375.6	0-1159.3	0-526.7

Notes: MSL = Mean Sea Level

V. salvator, is commonly found in most habitat types (Table 4-6), including the highland of main mountain ridges. They were found in two main habitats; forest areas and agricultural areas. One of them was found in tropical rain forest, fourteen were found in mangrove forest and one was found in freshwater swamp area. In agricultural areas, thirteen individuals were found in orchard plantations, one was killed on the road across farmlands in Amphur Suksamran, four were found in shrimp farms and one was found in coffee plantation, which look like tropical rain forest. Most of them were seen near or in watercourses, both brackish and fresh water, during the day. They were sometimes found swimming across the rivers or along the riverbanks or basking on timber logs or tall trees' branches as well. However, for Peat-swamp forest habitat, *Varanus salvator* was recorded in the checklists of Papru To Dang NSC. in Narathiwat Province and Papru tuae, Khao Pra-Bang Kram WS. in Krabi Province, but no other details are reported.

Thirty-five samples of *V. salvator* were found at the elevation from 0-175 m. MSL. Ranges of the humidity, temperature and rainfall were from 66-89 %, 23.9^{o}-30.6^{o}C and 0-1159.3 mm, respectively (Table 4-7).

Varanus rudicollis is rarely found. Only three specimens were seen and recorded in coffee plantation, surrounded by dense evergreen forest, of Khao Krung Sator in Surat Thani and Nakhon Sri Thammarat Provinces, at 175 m. MSL. height. The specimens were found in dry season, near watercourses, at the humidity ranged from 69-89 %, temperature ranged from 24.2^{o}-30.5^{o} C and rainfall ranged from 0-375.6 mm. From interviewing the local people, the species lives in dense evergreen forest at the top of the mountain. This is consistent to de Rooij (1915)

Varanus bengalensis nebulosus was found in two main habitats that as of *V. salvator*. Seven of them were found in tropical rain forest areas, two were found in rubber plantation and two were found in farmland near village. The rest two individuals were found in orchard plantation and coconut plantation respectively. The individuals in forest habitat were mostly found on the trees and far away from watercourses. They were all found basking on tall trees' branches in the morning (9:00-11:00 a.m.) and in the afternoon (2:00-4:00 p.m.). The species lived in tree hollows both bottom and top of the trees at elevation ranged from 25-175 m. MSL., humidity ranged from 69-89 %, temperature ranged from 24.2°-30.5° C and rainfall ranged from 0-1159.3 mm.

Varanus dumerilii is also rarely found like *V. rudicollis*. Only four samples were seen near the watercourse in tropical rain forest, rubber plantation and coffee plantation within tropical rain forest area. One male specimen was caught by trap in coffee plantation, which look like tropical rain forest at elevation of 175 m. MSL., inside Khao Krung Sator (Ban Khao Nang), Surat Thani Province, the same area where a *Varanus rudicollis* was recorded. The second one was a juvenile, found as roadkill in rubber plantation, at elevation of 90 m. MSL., near Khao Pu Khao Ya National Park, Pattalung Province. The third one is a juvenile preserved specimen collected from tropical rain forest nature trail in Hat Yai Nature and Wildlife Study Center, Songkhla Province. The last specimen was photographed by Peter Paul van Dijk in 1999 in tropical rain forest area of Khao Pu Khao Ya National Park, Pattalung Province (No. 54 in Table 4-1). However, for Peat-swamp forest habitat, *Varanus dumerilii* were recorded in the checklists of Sirindhorn Peat-swamp forest RNC. in Narathiwat Province and Papru tuae, Khao Pra-Bang Kram WS. in Krabi Province, but no other details are known. .

All specimens of *Varanus dumerilii* were found and recorded at elevation ranged from 130-200 m. MSL., humidity ranged from 69-89%, temperature ranged from 24.2°-30.5°C and rainfall ranged from 0-526.7 mm.

a1) Phang Nga Province.

a2) Hala-Bala WS.
Narathiwat Province

b1) Amphur Pa thiu
Chumphon Province

b2) Lumnum Kraburi NP
Ranong Province

Figure 4–10 Habitat types of forested areas:
a) Tropical rain forest
b) Mangrove forest

a1) Khao Pra-Bang Kram WS.
Krabi Province

a2) Siridhorn Peat swamp forest RNC.
Narathiwat Province

b1) Khao Pu Khao Ya NP.
Phatthalung Province

b2) Thaleban NP.
Satun Province

Figure 4-11 Habitat types of forested areas:

a) Peat swamp forest
b) Freshwater swamp area

a) Coffee plantation within tropical rain forest
at Khao Krung Sator Mt, Surat Thani Province

b) *V. salvator* in orchard plantation at Klong Bang Bai Mai
Surat Thani Province

c) Rubber plantation at Amphur Khanchanadich
Surat Thani Province

Figure 4-12 Habitat types of agricultural areas:
a) Coffee plantation within tropical rain forest; b) Orchard plantation;
c) Rubber plantation

a1)

a2)

a) Coconut plantation at Amphur Rattaphum (a1) and a hollow habitat of *V. b. nebulosus* (a2), Songkhla Province

b) Farmland at Amphur Suksamran Ranong Province

c) Shrimp farm at Amphur Pa thiu Chumphon Province

Figure 4–13 Habitat types of agricultural areas:
a) Coconut plantation; b) Farmland; c) Shrimp farm

4.3.2 Egg size and Clutch size

During the two years study, twenty-seven eggs of three species of monitor lizards i.e. *Varanus rudicollis*, *Varanus bengalensis nebulosus* and *Varanus salvator* were collected.

The eggs of *Varanus bengalensis nebulosus* are from Amphur Betong, Yala Province and are the only sample with known locality. Its clutch was composed of nine eggs. Four out of nine were collected and were incubated in the laboratory of the Department of Biology, Chulalongkorn University. The means ± SD of egg length, egg width and egg weight are 53.93 ± 0.1217 mm., 35.29 ± 0.0850 mm. and 36.37 ± 1.5392 g. respectively (n = 4).

In January 28-29, 1998, *Varanus rudicollis* laid fifteen eggs in the laboratory, Chulalongkorn University. The means ± SD of egg length, egg width and egg weight are 51.58 ± 0.2268 mm., 29.34 ± 0.0610 mm. and 24.98 ± 1.1815 g. respectively (n = 15).

The Queen Saovabha Memorial Institute of the Thai Red Cross Society collected eight eggs of *Varanus salvator*, at Samutprakan Province in June 15, 1999. The total number of eggs was not known. The means ± SD of egg length, egg width and egg weight are 75.55 ± 0.1654 mm., 47.65 ± 0.3529 mm. and 89.21 ± 8.9676 g. respectively. All eggs were hatched in February 23-March 6, 2000. Taylor (1963) reported that clutches from large females typically consist of about fifteen eggs, and up to forty may be laid over a year. The data of egg sizes from references and this study were shown in Table 4-8.

De Lisle (1996) reported that clutch size is generally related to body size, with large species having larger clutches, and larger females of a species having larger numbers of eggs.

The above-mentioned data shows that *V. salvator*, the biggest varanid in Thailand, has the largest egg size while *V. rudicollis* has the second largest egg size and *V. b. nebulosus* has the smallest egg size.

V. salvator and *V. b. nebulosus* eggs from this study are heavier than the eggs of the same species studied by other authors. This is probably due to several factors such as the eggs' weight was not recorded at the same time, the conditions during incubation were different and the size of the female was unknown. No detailed information and references about the egg of *V. dumerilii* are available at the time of study.

Table 4-8 Summary of data on eggs of monitor lizards, which occur in southern Thailand

Species	Clutch size	Weight (g)	Egg dimensions (mm.)	Incubation period (days)	References
V. salvator	6-30	50.0	75.0x38.0	85-250	De Lisle, 1996
	4	-	-	232-241	Graham, 1994
	5	56.0	-	194-198	Herrmann,
	6	50.0	-	176-200	1999
	> 8	89.2	75.6x47.6	253-266	In this study
V. rudicollis.	4-16	32.0	58.0x32.0	180-184	De Lisle, 1996
	11	-	-	152-154	McGinnity, 1993
	15	25.0	51.6x29.3	Dead	In this study
V. bengalensis	6-30	11.4	40.9x23.8	240-270[a] 168-254[b]	Auffenberg, 1994; Deraniyagala, 1958
	19-30	11.0	40.0x24.0	172-254	De Lisle, 1996
	11	-	-	252	Gorman, 1993
	9 (4)	36.4	53.9x35.3	Dead	In this study
V. dumerilii	6-14	-	-	215-222	De Lisle, 1996
	4	-	-	214	Conners, 1994
	23	-	-	194-195	Frost, 1995

Note a = Nature; b = Laboratory
(-) = Number of eggs collected into Laboratory

Table 4-8 shows that *V. salvator* has the longest period of incubation i.e. 85-266 days, while *V. rudicollis* is only 152-184 days. The incubation periods of *V. bengalensis nebulosus* and *V. dumerilii* are 168-270 days and 194-222 days, respectively. Length of incubation shows great variation and may be determined genetically as well as being influenced by temperature (Bennett, 1996; 1998).

De Lisle (1996) stated that laboratory incubation, under constant conditions of warmth and humidity, indicates that the incubation period is partially related to body size, with longer periods for larger species. Laboratory incubation is usually shorter than that seen in the wild, probably because of low or fluctuating temperatures experienced in natural situation.

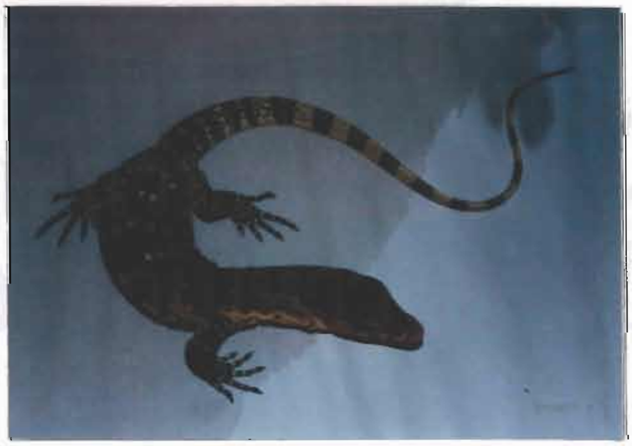
In general more humid conditions result in larger neonates and warmer conditions result in a decrease in incubation time. Most monitor lizard eggs can be incubated safely at 27-29 °C with 90-100% humidity. Higher temperatures tend to give slightly less successful results. It is wise to split large clutches and incubate eggs at a range of slightly different temperatures (Bennett, 1998).

Eggs of monitor lizards have soft, smooth, leathery or parchment-like shell. It is extremely rich in lipids (13-14 percent), which provide the main energy source for the embryo during the often-long incubation period (De Lisle, 1996).

De Lisle (1996) reported that the embryo lizards grow a special structure called the egg tooth (Figure 4-14; b), with which they can cut their way out of the eggshell. Slit eggshells usually indicate that the hatchlings make several attempts to open the eggs before succeeding. Figure 4-14; a and c displayed the slits on eggshell of *V. salvator* until hatchling (March 3, 2000).

a)

b)



c)

Figure 4-14 a) and b) illustrate the slits on eggshell and egg tooth of *V. salvator*; c) illustrates a hatchling of *V. salvator*.

a)

b)

c)

Figure 4–15 Illustrates eggs of varanids in this study
a) *V. salvator*; b) *V. rudicollis*; c) *V. b. nebulosus.*

4.3.3 The proposed status of monitor lizards in southern Thailand

For the current legal status, *Varanus salvator*, *Varanus rudicollis* and *Varanus dumerilii* are listed in Appendix II of the CITES Convention, which means trading in wild population is allowed. *Varanus bengalensis nebulosus* is in Appendix I, which means that no trade in wild population of this species is allowed. All of them are listed as protected species by the Wild Animal Reservation and Protection Act (B. E. 2535) of Thailand except *V. salvator komaini* (Table 4-9).

Following the above status and the information from this study, only *V. salvator* is agreed to continuously stay in the Appendix II due to its common in the wild and it has high potential for international trade. Other varanids are recommended to classify in Appendix I, which means no trade in the wild population of this species is allowed.

The relative abundance of *V. salvator* and *V. b. nebulosus* based on this study is consistent to the survey of Luxmoore and Groombridge (1990) who suggested that wild populations of *V. salvator* and *V. b. nebulosus* in southern Thailand are common and uncommon, respectively. For other species, *V. rudicollis* and *V. dumerilii*, the information from this survey in natural habitats, local hunters and wildlife traders, indicates that they should be classified as rare while *V. salvator komaini* is very rare (Table 4-9).

According to Humphrey and Bain (1990), they classified *V. b. nebulosus*, *V. rudicollis* and *V. dumerilii* as threatened by their criteria. In this observation, based on the criteria of IUCN, *V. salvator* and *V. b. nebulosus* should be classified as vulnerable. *V. rudicollis* and *V. dumerilii* should be listed as endangered and *V. salvator komaini*, in case it is considered as a separate group of *V. salvator*, as critically endangered, because the wild populations of these varanids especially *V. salvator komaini* are small and rarely found.

In spite of the intensive habitat survey of *V. salvator komaini*, this monitor was not found and the occurrence in southern Thailand is still uncertain. However, *V. salvator komaini* is always mentioned by wildlife traders as a new species of varanids found in southern Thailand and it is not under the protection by the Wild Animal Reservation and Protection Act (B. E. 2535) which means trading and hunting in Thailand is possible. Since the result of this study cannot indicate *V. salvator komaini* as a separate taxonomic status from *Varanus salvator*. It should be considered as *V. salvator*, therefore, which is protected by the Wild Animal Reservation and Protection Act (B. E. 2535) and also be controlled by the CITES Convention.

Generally, monitor lizards have been widely used by villagers. The mainly uses of monitor lizard in Thailand are for their meat and skin. Figure 4-16 shows the local food in Yala Province made from the meat of monitor lizards.

Figure 4-16 Meat of clouded monitor was cooked as food.

Table 4–9 Status of monitor lizards in southern Thailand suggested by this study.

Criteria based on	*V. salvator*	*V. rudicollis*	*V. b. nebulosus*	*V. dumerilii*	*V. s. komaini*
RFD (B.E. 2535)	Protected	Protected	Protected	Protected	-
This study	Protected	Protected	Protected	Protected	Protected
CITES (1998)	App. II	App. II	App. I	App. II	App. II
This study	App. II	App. I	App. I	App. I	App. I
Luxmoore and Groombridge (1990) Relative abundance	Common	-	Uncommon	-	-
This study	Common	Rare	Uncommon	Rare	Very rare
Humphrey and Bain (1990)	-	Threatened (-)	Threatened (-)	Threatened (-)	-
This study	Threatened (V)	Threatened (E)	Threatened (V)	Threatened (E)	Threatened (CE)

Note: CE = Critically Endangered
E = Endangered
V = Vulnerable
App. I = Appendix I
App. II= Appendix II
RFD = Royal Forest Department

Chapter 5

Conclusions and Recommendations

5.1 Conclusion

5.1.1 Species diversity and Distribution

In this study, four species of monitor lizard are found in southern Thailand, comprising water monitor or *Varanus salvator* (Laurenti, 1768), clouded monitor or *Varanus bengalensis nebulosus* (Gray, 1831), rough-necked monitor or *Varanus rudicollis* (Gray, 1845) and dumeril's monitor or *Varanus dumerilii* (Schlegel, 1839). Due to insufficient information on *Varanus salvator komaini* Nutphand, 1987 or black water monitor, it can not be decided that the black water monitor is a separate species or a subspecies. Further detailed studies are recommended to confirm its taxonomic status.

Varanus salvator and *Varanus bengalensis nebulosus* are the most common and are widespread in natural, semi-natural and agricultural areas of southern Thailand whilst *Varanus rudicollis* and *Varanus dumerilii* are relatively rare and were found only in dense and moist forests. The first three species was found inhabits in all main mountain ranges whereas *Varanus dumerilii* was found only in Nakhon Sri Thammarat and Sankala Kiri Mountain ranges of Surat Thani to Narathiwat Provinces. The distribution and habitats of *Varanus salvator komaini* are still unknown.

5.1.2 Morphological difference.

The Nuchal scale is the best character to identify *V. rudicollis* and *V. dumerilii*. Snout-nostril length and nostril shape can be used to identify *V. salvator* (including *V. s. komaini*) and *V. b. nebulosus*. Snout-nostril length of *V. salvator* is shorter than *V. b. nebulosus*, which means that the nostril of *V. salvator* is closer to its snout whereas the nostril of *V. b. nebulosus* is closer to its eyes. In addition to the shape of nostril, *V. salvator* has short and nearly round nostril while *V. b. nebulosus* has elongate and oblique nostril.

In general, *V. salvator* and *V. s. komaini* can be separated clearly by their color. The comparative study on the morphology of these two monitors cannot be performed completely because of the small sample size of *V. s. komaini*.

V. salvator, *V. rudicollis* and *V. b. nebulosus* show significantly difference in some morphological characters between sexes i. e. male *V. salvator* has larger base of tail circumference length and deeper genital pocket length than female. Male *V. rudicollis* has longer upper leg length and larger base of tail circumference length than female. Male *V. b. nebulosus* has longer hindlimb length, upper leg length and deeper genital pocket length than female. The sexual dimorphic traits of these three species can be explained by the sexual selection hypothesis.

5.1.3 Habitat of monitor lizards

Varanus salvator was found in tropical rain forest, mangrove forest and freshwater swamp areas. In agricultural areas, it was found in orchard plantations, farmlands and shrimp farms. Most of them were seen near or in watercourses.

Varanus bengalensis nebulosus was found in tropical rain forest areas, rubber plantations, farmland near villages, orchard plantations and coconut plantations. It spent most of the time basking on the trees and often seen far away from watercourses.

Varanus rudicollis was found in dense evergreen forest at high elevation. In dry season, sometime, it was found near the watercourse in coffee plantation, which surrounded by tropical rain forest at lower elevation.

Varanus dumerilii was also seen near to watercourse. In this study, they were found in four habitat types; tropical rain forest, rubber plantation, coffee and rubber plantation within tropical rain forest and peat-swamp forest.

5.1.4 Egg size and Clutch size

V. salvator has the largest egg size while *V. rudicollis* is the second, and *V. b. nebulosus* has the smallest egg size. The clutch size of *V. salvator*, *V. rudicollis* and *V. b. nebulosus* are about 4-30 eggs, 4-16 eggs and 6-30 eggs per clutch, respectively. Incubation period depends on temperature and humidity of ambience. No detailed information and references about the egg of *V. dumerilii* are available at the time of study.

5.1.5 The proposed status of monitor lizards in southern Thailand

From this study, only *V. salvator* is agreed to continuously stay in the Appendix II due to its common in the wild and it has high potential for international trade. Other varanids are recommended to classify in Appendix I.

The relative abundance based on this survey, *V. salvator* and *V. b. nebulosus* in southern Thailand are common and uncommon, respectively. For other species, *V. rudicollis* and *V. dumerilii* should be classified as rare while *V. s. komaini* is very rare.

Based on the criteria of IUCN, *V. salvator* and *V. b. nebulosus* should be classified as vulnerable. *V. rudicollis* and *V. dumerilii* should be listed as endangered and *V. s. komaini*, in case it is considered as a separate group of *V. salvator*, as critically endangered, because the wild populations of these varanids especially *V. s. komaini* are small and rarely found

5.2 Recommendations

5.2.1 The study on species diversity, relative abundant and distribution of varanids in southern Thailand should be continuously conducted and expanded to the other parts of Thailand. Present status of monitor lizards in Thailand should also be reconsidered.

5.2.2 Immediate protection and detailed studies on the population biology and taxonomic status of *V. s. komaini* should be carried out as soon as possible before it disappears from the wild. This should also be applied to *V. rudicollis* and *V. dumerilii* since these two species are rare and still less known.

5.2.3 Sustainable management and environmentally educative programs including public awareness in attitude and knowledge about reptiles and their ecological values especially in local areas where the rare varanids are found should be organized and promoted immediately in order to conserve the wild population.

5.2.4 Varanid is the largest lizard, some species are rare and are facing extinction from their native areas. Trapping and handling for measurement or for research purposes are difficult and dangerous to the animal. Killing and removing them out of their habitats for studying are not recommended. Only the proper technique will be allowed under the consideration from experts. Cooperation from relevant government agency personal in carrying on field research is also needed. The agencies concerned should be contacted, both officially and personally, before the project starts. The biological research institutes should have permanent and long-term contracts with the Government Agencies concerned on permission to study and collecting wild specimens in the areas.

5.2.5 The Royal Forest Department should define rules and regulations for the proper captive-breeding program of monitor lizards, especially for *V. salvator* and *V. b. nebulosus*, which have high potential in commercial trade. *V. rudicollis*, *V. dumerilii* and *V. s. komaini* should also be bred for advanced researches and for species survival.

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APPENDIX I
(Latitude and longitude of study areas)

Province	Location	GPS
Chumphon	Prince Chumphon Park (South Section) WS.	No data
	Amphur Pa Thiu	10°N 53' 06" 099°E 28' 23"
Ranong	Lumnam Kraburi NP.	10°N 05' 00" 098°E 39' 44"
	Mu Ko Payam NP.	09°N 50' 42" 098°E 34' 33"
	Amphur Suksamran	09°N 22' 23" 098°E 25' 03"
Surat Thani	Khao Sok NP.	08°N 54' 40" 098°E 36' 21"
	Klong Bang Bai Mai Amphur Muang	09°N 12' 02" 099°E 18' 18"
	Amphur Kanchanadit	09°N 05' 08" 099°E 26' 53"
	Khao Krung Sator (Ban Khao Nang)	08°N 55' 19" 099°E 33' 44"
Phang Nga	Sri Phang Nga NP.	08°N 59' 46" 098°E 28' 00"
	Ao Phang Nga NP.	08°N 24' 22" 098°E 30' 40"
	Amphur Takua Pa	08°N 46' 58" 098°E 24' 23"
	Amphur Muang	08°N 32' 37" 098°E 33' 18"
Nakhon Sri Thammarat	Amphur Thung Song	08°N 10' 39" 099°E 40' 48"
	Amphur Chawang	08°N 22' 37" 099°E 32' 31"

Province	Location	GPS
Phuket	Khao Pra Taew WC.	08° N 04' 35" 098° E 19' 00"
Krabi	Mu Ko Lunta MNP.	07° N 32' 20" 098° E 01' 49"
	Khao Pra Bang Kram WS.	07° N 55' 34" 099° E 16' 10"
		08° N 22' 05" 098° E 58' 48"
Phatthalung	Khao Pu Khao Ya NP.	07° N 40' 40" 099° E 52' 23"
	Thale Noi NA.	07° N 46' 36" 100° E 07' 33"
	Ban Tha Mot WPU. (Khao Banthd WS.)	07° N 15' 18" 100° E 02' 22"
Songkhla	Ton Nga Chang WRS.	07° N 00' 04" 100° E 19' 15"
	Hat Yai NWSC.	06° N 56' 46" 100° E 14' 22"
	Amphur Rattaphum	07° N 07' 01" 100° E 08' 32"
Trang	Peninsular Khaochong Botanic Gardens	07° N 33' 28" 099° E 46' 37"
	Had Chao Mai MNP.	07° N 25' 27" 099° E 20' 48"
Satun	Nong Prag Praya NA.	06° N 44' 45" 100° E 03' 00"
	Thaleban NP.	06° N 42' 37" 100° E 10' 03"
	Mo Ko Phetra NP.	06° N 50' 09" 099° E 45' 19"
	Klong Pak Ba Ra (Amphur La Ngu)	06° N 51' 55" 099° E 43' 45"

Province	Location	GPS
Pattani	Amphur Sai Buri	No data
Yala	Ban Kotabaru (Amphur Mueng)	06° N 27' 50" 101° E 21' 02"
	Betong Public Park (Amphur Betong)	05° N 46' 54" 101° E 03' 49"
	Ban Bo Nam Ron (Amphur Betong)	05° N 52' 35" 101° E 12' 30"
Narathiwat	Amphur Rue Soe	06° N 23' 28" 101° E 30' 56"
	Amphur Sungi Kolok	06° N 00' 08" 101° E 56' 23"
	Hala-Bala WS.	05° N 48' 28" 101° E 50' 39"
	Papru To Dang	No data

Note: MNP. = Marine National Park.
NA. = Non-hunting Area.
NP. = National Park.
NWSC. = Nature and Wildlife Study Center.
RNC. = Research and Nature Study Center.
WC. = Wildlife Conservation Development and Extension Center.
WPU. = Wildlife Protection Unit.
WRS. = Wildlife Research Station.
WS. = Wildlife Sanctuary.

APPENDIX II
(Primary data of monitor lizards)

Table-1 The Primary data of *Varanus salvator*

Provinces	Satun	Ranong	Ranong	Ranong	Ranong	Ranong	Ranong	Surat	Phatthalung	Ranong
sexes	M1	M2	M3	M4	M5	F1	F2	F3	U1	U2
SVL	75	61	58	54	46	52	41.6	43.5	24.6	16.8
TL	104	94	86.5	72	72	75.5	60	58.5	41.8	26.2
HL	10.81	9.8	9.65	8.38	8.155	8.46	7.5	7	5.025	3.82
SNL	1.67	1.32	1.41	1.34	1.27	1.37	0.98	0.87	0.74	0.615
SEL	6.75	6.1	5.75	5.18	5.05	5.2	4.5	4.33	2.69	1.99
SEaL.	11.37	10.32	9.66	8.64	8.3	8.82	7.35	7.35	5.07	3.72
SML.	10.35	9.58	8.48	7.87	7.57	7.82	0.64	6.565	4.6	3
SPL	12.25	10.93	10.18	9.51	8.87	9.3	8.25	8	5.35	4.05
NEL	4.4	4.16	3.8	3.265	3.26	3.32	2.95	2.645	1.8	1.27
NEaL	8.94	8.4	7.76	6.975	6.66	6.82	5.97	6.09	4.06	3.12
NL	0.92	0.57	0.6	0.635	0.58	0.57	0.47	0.34	0.11	0.21
EEaL	3.82	3.44	3.15	2.78	2.55	2.785	2.34	2.31	1.44	1.2
EL	1.18	1.07	1.06	1.045	1.015	0.81	0.9	0.84	1.05	0.58
NW	2.22	1.87	1.6	1.535	1.51	1.63	1.44	1.28	0.9	0.68
EW	4.57	4.15	3.73	3.41	3.34	3.631	3	3.01	2.2	1.08
CVL	45	41	38	34	31.5	32	24.3	25.2	14.4	9.95
UAL	9.4	8.5	7.11	6.53	6.39	7.1	5.53	5.42	3.58	2.21
FAL	8.48	8.27	6.47	6.2	5.31	6.44	5.2	4.98	3.1	1.845
HaL	9.42	9.8	7.87	7.18	6.475	6.99	6.06	5.96	3.69	2.24
FLL	27.3	26.57	21.45	19.91	18.175	20.53	16.79	16.36	10.37	6.295
ULL	11.83	9.27	9	8.48	7.45	7.6	7.16	6.57	4.14	2.79
LLL	8.93	8.9	7.25	7.22	6.43	6.65	6.285	5.75	3.42	2.27
FL	11.3	10.4	8.66	8.81	8	8.82	7.3	7.52	4.85	3.235
HLL	32.06	28.57	24.91	24.51	21.88	23.07	20.745	19.84	12.41	8.295
TCL	25	22.5	17.5	17	14.5	15.5	11.8	12.5	7.7	5.1
ACL	36	25.7	22.5	22	21	22	14.5	17.5	11.5	6.6
LCL	30.5	25.5	22	20	17	20	15.5	16	11.4	5.4
MCL	43	38	31.5	24.5	22.5	27	20.5	20.5	16.2	7.9
TW	7.5	4	2.8	2	1.5	2	1.2	1.3	0.5	0.1
TTL	179	155	144.5	126	118	127.5	101.6	102	66.4	43
SCL	30	20	20	20	14.5	20	17.3	18.3	10.2	6.85
GPL	12	5.14	4.76	3.5	4	2.8	2.2	2.3	2.5	-

Note: M = Male; F = Female; U = Unknown

Table-1 (cont.) The Primary data of *Varanus salvator*

Provinces	Ranong	Ranong	Ranong	Ranong	Ranong	Ranong
sexes	U3	U4	U5	U6	U7	U8
SVL	50	68.5	47.5	46.5	58	53.5
TL	49.5	66	73	71.5	76	71.1
HL	7.88	10.34	8.16	7.96	9.18	9.11
SNL	1.35	1.61	1.2	1.26	1.55	1.41
SEL	4.88	6.77	4.87	4.74	5.51	5.31
SEaL.	8.2	11.12	8.425	8.01	9.19	8.61
SML.	7.46	9.54	7.36	7.4	8.37	7.72
SPL	8.51	11.58	8.86	8.4	9.71	9.28
NEL	3.08	4.31	3.35	3.16	3.57	3.41
NEaL	6.45	8.75	6.69	6.3	7.385	6.82
NL	0.615	0.74	0.54	0.57	0.57	0.66
EEaL	2.615	3.55	3.68	2.51	3.02	2.77
EL	1.05	1.2	0.86	0.94	1.02	0.845
NW	1.485	2.06	1.34	1.52	1.7	0.65
EW	3.3	4.48	3.32	3.33	3.67	3.575
CVL	33	44.5	30.5	29.5	38.5	33.5
UAL	6.23	9.2	6.22	6.16	7.4	7.01
FAL	5.7	8.3	5.72	5.91	6.49	6.31
HaL	6.46	9.1	6.285	6.2	6.51	6.86
FLL	18.39	26.6	18.225	18.27	20.4	20.18
ULL	7.69	13.71	7.76	8.2	9.83	7.81
LLL	6.7	8.6	6.2	7.02	7.46	6.25
FL	8.06	10.79	7.9	8.27	8.74	8.62
HLL	22.45	33.1	21.86	23.49	26.03	22.68
TCL	13.3	23.5	14	14.3	17	17
ACL	19	29	20.5	20	24	21.5
LCL	17.5	27	18.5	19	24	21.5
MCL	21	34.5	24	28	31	27
TW	1.45	5	1.4	1.9	2.8	2.2
TTL	99.5	134.5	120.5	118	134	124.6
SCL	17	24	17	17	19.5	20
GPL	-	5.3	3.5	3.5	4.6	3.6

Note: M = Male; F = Female; U = Unknown

Table-2 The Primary data of *Varanus rudicollis*

Provinces	Unknown	Unknown	Saovabha	Unknown	Surat	Unknown	Surat	Surat	Unknown	Unknown
sexes	F1	F2	F3	F4	F5	F6	M1	M2	M3	U1
SVL	27	34.5	62.5	52.2	48	24	55.5	40.6	36.8	26.2
TL	35	46	75.3	61.5	62	30.7	60.5	54.4	48.2	37.8
HL	5.285	6.61	9.68	8.45	8.5	4.825	9.565	7.82	6.89	5.58
SNL	1.74	2.2	3.15	2.85	2.34	1.535	3.34	2.66	1.575	1.71
SEL	3.175	4.35	6.44	6.025	5.43	2.94	6.215	4.95	4.4	3.42
SEaL.	5.25	6.51	10	9.235	8.45	4.63	9.715	7.55	6.85	5.37
SML.	4.65	6.27	9.4	8.65	7.8	4.36	8.975	6.82	6.41	5.19
SPL	5.68	7.225	10.4	9.875	9.1	5.19	10.38	8.24	7.235	5.9
NEL	0.77	1.32	1.7	1.5	1.52	0.84	1.705	1.42	1.25	1.03
NEaL	2.98	3.575	5.32	4.9	4.73	2.535	5.12	3.96	3.71	3.1
NL	0.63	0.825	1.635	1.6	1.64	0.63	1.37	1.1	1.75	0.62
EEaL	1.225	1.73	3	2.4	2.22	1.2	2.565	1.91	1.81	1.295
EL	0.76	0.865	1.3	0.855	1.125	0.735	1.175	0.76	0.65	0.83
NW	1.24	1.55	2.6	2.15	2.1	1	2.64	2.02	1.575	1.23
EW	1.74	2.8	4	3.5	3.62	2	4.065	3.14	2.815	2.27
CVL	15.2	20.5	41	33.5	30	15	33.7	24.5	21.1	16.08
UAL	3.68	4	7.6	5.565	7.14	2.95	8.19	6.35	5.26	3.67
FAL	3.24	3.925	6.875	7.25	6.725	2.765	7.75	5.68	4.45	3.49
HaL	3.9	5.025	9.45	7.975	7.27	3.4	9.39	6.34	5.31	4.2
FLL	11.82	12.95	23.925	20.79	21.135	9.115	25.33	18.37	15.02	11.36
ULL	4	5.325	10.525	8	8.1	3.91	10.45	6.93	6.54	4.4
LLL	3.63	5.1	8.225	7.265	7.18	3.12	7.82	5.42	5.185	3.94
FL	4.8	6.55	10.27	9.575	9.03	4.11	9.86	7.53	6.57	5.36
HLL	12.43	16.975	29.02	24.84	24.31	11.14	28.13	19.88	18.295	13.7
TCL	6.8	9	19	13.4	13	5.8	18.5	12	11.5	6
ACL	10.4	17	24.7	25	22	13.7	27.5	17	18.3	9.5
LCL	9.5	14.5	21	21.4	20	10	22.5	15	14.5	9
MCL	12.5	19.5	46.5	36.5	29.5	15.5	33	22	21.5	13
TW	0.5	0.7	5	2.85	1.8	0.22	2.8	0.65	0.8	0.2
TTL	62	80.5	137.8	113.7	110	54.7	116	95	85	64.5
SCL	11.8	14	21.5	18.7	18	9	21.8	16.1	15.7	10.12
GPL	-	2.41	-	-	2.8	-	4.1	3.8	3.075	-

Note: M = Male; F = Female; U = Unknown

Table-3 The Primary data of *Varanus bengalensis nebulosus.*

Provinces	Nara	Nara	Nara	Nara	Nara	Nara	Nara	Nara	Nara	Nara
sexes	M1	M2	M3	M4	M5	M6	M7	F1	F2	F3
SVL	45.5	47.2	47	40	42.4	40.4	43.5	36.8	41.8	42.5
TL	75.8	60	75	64	65.2	61.9	55.5	40.8	60.2	73.5
HL	7.5	7.23	7.64	6.73	6.86	6.65	7.97	6.11	7	7.25
SNL	2.2	2.12	1.95	1.975	2.13	2.07	2.335	1.68	2	2.002
SEL	4.72	4.36	4.63	4.07	4.37	4.09	4.88	3.795	4.15	4.26
SEaL.	7.5	7.22	7.285	6.52	6.82	6.46	7.78	5.97	6.73	7.203
SML.	6.97	6.5	6.75	5.945	6.21	5.82	6.61	5.8	6.185	6.62
SPL	8.25	7.895	8.06	7.365	7.56	7.27	8.305	6.6	7.42	7.74
NEL	1.535	1.47	1.36	1.33	1.52	1.32	1.73	1.26	1.235	1.63
NEaL	4.38	4.2	4.19	3.94	4.03	3.97	4.84	4.67	3.9	4.28
NL	1.065	1	1.25	0.98	0.94	0.79	0.935	0.75	1.07	1.21
EEaL	1.86	2.1	1.9	1.93	2.07	1.74	2.11	1.67	1.67	2.16
EL	0.95	0.98	0.94	0.91	0.86	0.83	1.075	0.79	0.88	1.25
NW	2.2	2.16	2.2	1.63	2.02	1.675	1.71	1.45	1.75	1.7
EW	3.46	3.34	3.59	2.895	3.12	2.94	3.4	2.75	3.01	3.24
CVL	30.8	31.2	29.8	26.4	28	27.5	29	22.6	28.4	28.5
UAL	6.165	7.05	6.78	5.75	6.335	5.685	6.54	5.08	5.72	6.3
FAL	5.85	6.1	6	5.185	5.3	5.02	6.34	4.64	5.12	6.06
HaL	7.93	6.7	7.1	5.62	5.855	5.34	6.73	5.3	5.4	6.1
FLL	19.945	19.85	19.88	16.555	17.49	16.045	19.61	15.02	16.24	18.46
ULL	9.24	9.23	9.68	7.54	8.02	7.9	9.05	5.98	7.28	8.155
LLL	7.1	7.45	7.04	6.69	7.05	6.75	8.41	5.39	6.4	7.1
FL	8.14	7.92	8.01	7.5	7.39	7.45	7.12	6.38	6.985	7.4
HLL	24.48	24.6	24.73	21.73	22.46	22.1	24.58	17.75	20.665	22.655
TCL	18	17	17.2	14.4	16.2	14.5	19	12.5	14	17
ACL	21.5	22.5	21.8	18	19.9	18	23.5	16.5	18.6	22.5
LCL	22	28	29.3	17	18.3	17	24.5	15.7	17.5	21.5
MCL	26.7	20.5	20.3	21.7	24.8	23.7	28	20	25	25
TW	2.6	2.6	2.2	1.3	1.7	1.4	2.5	1	1.5	2
TTL	121.3	107.2	122	104	107.6	102.3	99	77.6	102	116
SCL	14.7	16	17.2	13.6	14.4	12.9	14.5	14.2	13.4	14
GPL	6	6.58	5.75	5.79	5.2	4.68	5.05	2.85	3.43	3.5

Note: M = Male; F = Female; U = Unknown; Nara = Narathiwat

Table-3 (cont.) The Primary data of *Varanus bengalensis nebulosus.*

Provinces	Yala	Nara	Nara	Nara	Nara	Nara	Nara	Nara	Songkhla
sexes	F4	U1	U2	U3	U4	U5	U6	U7	J1
SVL	42	42.5	41	34.7	39.2	46.5	40.7	45	14.05
TL	57	62	49.3	50.1	61.8	62.9	62	58.9	21.5
HL	5.96	6.97	7	5.17	6.41	7.37	6.23	6.7	3.39
SNL	2.02	2.04	2.15	1.41	1.975	2.08	1.905	1.82	0.93
SEL	3.87	4.31	4.32	2.85	3.94	4.575	3.87	4.18	1.9
SEaL.	6.2	6.76	6.7	5.19	6.2	7.4	6.195	6.7	3.025
SML.	6.1	6.35	6.2	4.55	5.8	6.79	5.57	5.85	2.915
SPL	6.92	7.47	7.5	5.75	6.79	7.965	6.86	7.41	3.58
NEL	1.27	1.38	1.44	0.85	1.33	1.335	1.26	1.38	0.85
NEaL	3.78	4.035	3.9	3.28	3.72	4.315	3.67	4.3	1.97
NL	0.75	1	0.89	0.54	0.79	1.16	0.835	1	0.28
EEaL	1.74	1.9	1.6	1.61	1.81	2.11	1.8	2.19	0.96
EL	1.03	0.87	0.89	0.83	0.87	1	0.785	1.15	0.55
NW	1.97	1.5	1.9	1.3	1.66	1.94	1.49	1.61	0.76
EW	2.71	3.02	2.98	2.34	2.835	3.195	2.745	3.1	1.57
CVL	26.5	25.9	27.3	22.2	25	31	27.5	29.9	8.8
UAL	5.52	5.5	5.42	4.33	5.36	5.71	5.435	6.12	1.87
FAL	5.2	5.24	5.31	4.07	4.79	5.32	4.92	5.45	1.7
HaL	4.66	4.84	6.32	4.315	5.58	6.44	5.7	5.95	2.15
FLL	15.38	15.58	17.05	12.715	15.73	17.47	16.055	17.52	5.72
ULL	6.9	7.84	7.58	5.745	6.67	7.4	6.84	7.415	2.465
LLL	6.13	6.5	6.6	4.765	5.98	6.43	5.96	6.33	2.1
FL	6.37	6.275	8	5.06	7.1	7.23	7.73	7.06	2.69
HLL	19.4	20.615	22.18	15.57	19.75	21.06	20.53	20.805	7.255
TCL	16	14	14	11.1	14.3	14.2	12.2	15.5	5
ACL	26	19	17.5	13	17	19.6	18.8	20.2	8
LCL	20	16.4	16.5	13.5	16.5	18.7	16.6	18	7
MCL	35	23.5	22	20	21.9	23.5	20	26.6	8.5
TW	2.1	1.3	1.2	0.7	1.2	1.5	0.9	1.6	0.2
TTL	99	101.5	90.3	84.8	101	109.4	102.7	103.9	35.55
SCL	15.5	16.6	13.7	12.5	14.2	15.5	13.2	15.1	5.25
GPL	2.3	3.16	4.94	3.51	4.98	4.2	1.9	4.4	-

Note: M = Male; F = Female; U = Unknown; Nara = Narathiwat

Table-4 The Primary data of *Varanus dumerilii.*

Provinces	Surat	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Songkhla	Phattha.
sexes	M 1	M 2	M 3	M 4	M 5	F 1	U 1	U 2	U 3	U 4	U 5	U 6
SVL	40	38	37.7	37.5	44.3	28.5	38.5	36	33	36.7	10	12.4
TL	62	53.5	49.3	50.5	56.2	41	50	48.5	55.4	50.8	14.3	14.1
HL	6.655	6.05	5.65	6.05	6.87	4.92	5.93	6.12	5.81	5.8	2.425	2.62
SNL	2.1	2	1.94	1.9	2.525	1.585	2.14	1.97	2.175	1.97	0.76	0.815
SEL	4.16	3.68	3.315	3.57	4.16	2.6	3.76	3.56	3.52	3.535	1.39	1.395
SEaL.	6.76	6.05	5.67	5.85	6.85	4.97	6	6.03	5.915	5.8	2.41	2.5
SML.	6.275	5.63	5.2	5.34	6.1	4.58	5.61	5.42	5.325	5.245	2.14	2.22
SPL	7.62	6.71	6.485	6.6	7.68	5.475	6.675	6.64	6.57	6.44	2.68	2.71
NEL	1.32	0.9	1.05	1.275	1.235	0.625	1	1.025	1.05	1.075	0.38	0.43
NEaL	4.23	3.58	3.52	3.67	3.82	3.02	3.32	3.6	3.44	3.65	1.47	1.575
NL	0.58	0.67	0.47	0.37	0.58	0.405	0.54	0.45	0.45	0.58	0.17	0.18
EEaL	1.88	1.17	1.87	1.9	1.82	1.53	1.725	1.7	1.79	1.66	0.64	0.72
EL	0.945	1.02	0.53	0.66	0.88	1.035	0.76	0.77	0.64	0.8	0.4	0.5
NW	2.01	1.86	1.71	2	1.975	1.62	1.75	1.77	1.73	1.7	0.73	0.78
EW	2.945	2.75	2.66	2.935	3.05	2.28	2.45	2.63	2.27	2.8	1.025	1.175
CVL	26.2	25.5	25	23.5	28.7	18	27	23.5	22.5	24.2	5.65	7.63
UAL	6.14	4.55	4.8	4.13	5.3	3.56	4.15	4.51	3.93	4.69	1.2	1.58
FAL	5.175	4.09	4.09	3.88	4.47	3.11	3.775	4.05	3.78	3.7	1.05	1.255
HaL	6.22	5.93	4.5	4.335	5.4	4.06	5.875	5.42	4.315	5.08	1.5	1.64
FLL	17.535	14.57	13.39	12.345	15.17	10.73	13.8	13.98	12.025	13.47	3.75	4.475
ULL	6.715	5.16	5.68	5.5	6.3	4.15	5.475	6.165	4.78	5.5	1.36	1.64
LLL	5.73	4.52	4.245	4.36	4.46	3.53	4.8	4.6	4.24	4	1.23	1.285
FL	7.1	6.47	6.07	5.7	6.88	4.745	6.2	6.24	6.05	6.05	1.75	2
HLL	19.545	16.15	15.995	15.56	17.64	12.425	16.475	17.005	15.07	15.55	4.34	4.925
TCL	13	10	6.2	11	12	8	9.5	9	8.8	9.2	3	2.3
ACL	20	21.3	14.3	21.5	23.5	13	20.5	17	13	17.8	5.5	4.5
LCL	13	17	12.7	13.5	15.8	10.5	15	13	12.5	13	5	4.2
MCL	23	24	15	23.5	25	14	23.6	20.5	14	21	6	5.4
TW	1.2	0.7	0.45	0.7	1	0.4	1	0.65	1	0.7	0.1	0.1
TTL	102	91.5	87	88	100.5	69.5	88.5	86.5	88.4	87.5	24.3	26.5
SCL	13.8	12.5	12.7	14	15.6	10.5	11.5	12.5	10.5	12.5	4.35	4.77
GPL	4.2	-	1.9	3.05	2.6	1.7	-	1.91	-	1.7	-	-

Note: M = Male; F = Female; U = Unknown; Phattha. = Phatthalung

Table-5 The Primary data of Black Water Monitor.

Provinces	Zoo	Zoo	Unknown
sexes	M 1	M 2	U 1
SVL	60	28.5	58.5
TL	90	59	83.5
HL	10.29	5.01	8.92
SNL	1.61	0.965	1.23
SEL	6.435	2.55	5.33
SEaL.	10.58	5.13	9.35
SML.	10.04	4.1	8.22
SPL	11.185	5.58	10.3
NEL	4.26	1.42	3.65
NEaL	8.58	3.92	7.64
NL	0.8	0.25	0.765
EEaL	3.78	1.87	3.05
EL	0.97	0.86	1.175
NW	2.05	1.02	1.93
EW	4.245	2.24	3.85
CVL	42.5	20	37.5
UAL	7.925	4.66	7.68
FAL	7.58	4.2	6.87
HaL	7.67	5.33	7.95
FLL	23.175	14.19	22.5
ULL	9.68	4.86	9.395
LLL	7.84	4.44	7.32
FL	8.8	6.5	9.6
HLL	26.32	15.8	26.315
TCL	23.5	8	18.2
ACL	36	12	26.2
LCL	28.5	11	24.3
MCL	41.5	15.5	33.6
TW	4.5	0.7	3.2
TTL	150	87.5	142
SCL	17.5	8.5	21
GPL	14		16

Note: M = Male; F = Female; U = Unknown

APPENDIX III

(Discriminant Function Analysis for sexual differences)

Varanus salvator

Summary Table

Canonical Discriminant Functions

Fcn	Eigenvalue	Pct of Variance	Cum Pct	Canonical Corr		After Fcn	Wilks' Lambda	Chi-square	df	Sig
					:	0	.001616	22.496	5	.0004
1*	617.6247	100.00	100.00	.9992	:					

* Marks the 1 canonical discriminant functions remaining in the analysis.

Standardized canonical discriminant function coefficients

	Func 1
AXILLA	-9.23179
FALR	-24.88595
NELR	4.35416
SNLR	7.07436
VENT5CM	26.99193

Structure matrix:

Pooled within-groups correlations between discriminating variables and canonical discriminant functions (Variables ordered by size of correlation within function)

	Func 1
ULLR	-.77074
SCL	-.63160
CVL	.63160
NLR	-.48353
NNL	-.42458
GPL	-.32011
HLLR	-.28304
NEALR	.21583
HLR	.20989
SEALR	.19823
EEALR	.16597
FLR	.12143
LLLR	-.10693
TOTAL	-.10258
TL	-.10258
LUMBAR	-.09913
ULR	.09720
VENT5CM	.04825
AXILLA	.03531
SELR	.03352
SNLR	.00490
NELR	.00129
FALR	.00066

Unstandardized canonical discriminant function coefficients

	Func 1
AXILLA	-269.9882068
FALR	-2815.6020481
NELR	821.6613275
SNLR	2533.5578533
VENT5CM	1211.5296941
(Constant)	-44.8127540

Canonical discriminant functions evaluated at group means (group entroids)

Group	Func 1
1	16.67127
2	-27.78544

Test of Equality of Group Covariance Matrices Using Box's M

All-groups Stacked Histogram

Canonical Discriminant Function 1

```
       4 +                                                            +
         I                                                            I
         I                                                            I
 F       I                                                            I
 r     3 +2                                                           +
 e       I2                                                           I
 q       I2                                                           I
 u       I2                                                           I
 e     2 +2                                                 1 1       +
 n       I2                                                 1 1       I
 c       I2                                                 1 1       I
 y       I2                                                 1 1       I
       1 +2                                                 111       +
         I2                                                 111       I
         I2                                                 111       I
         I2                                                 111       I
          X---------+---------+---------+---------+---------+---------X
        out      -16.0      -8.0        .0       8.0      16.0       out
   Class  2222222222222222222222222221111111111111111111111111111111111111
 _ Centroi2s                                                   1
```

Varanus rudicollis

Summary Table

Canonical Discriminant Functions

```
                 Pct of   Cum   Canonical  After  Wilks'
 Fcn Eigenvalue Variance  Pct     Corr      Fcn  Lambda    Chi-square  df
Sig

                                      :    0 .004973     23.867     5
.0002
  1*  200.0904  100.00  100.00    .9975 :
```

* Marks the 1 canonical discriminant functions remaining in the nalysis.

Standardized canonical discriminant function coefficients

	Func 1
NEALR	-18.52190
SEALR	23.77427
SNLR	-2.20762
ULR	2.84342
VENT5CM	5.53014

Structure matrix:

Pooled within-groups correlations between discriminating variables
and canonical discriminant functions
(Variables ordered by size of correlation within function)

	Func 1
EEALR	.83311
NELR	.60392
FALR	-.59035
FLR	-.54767
TL	.39851
TOTAL	.39851
ULLR	.39466
HLR	-.37038
AXILLA	.34600
SELR	.17995
SCL	-.17157
CVL	.17157
NNL	-.13747
LLLR	-.09743
VENT5CM	.08926
LUMBAR	.08475
ULR	.06758
HLLR	.03885
NLR	.03446
NEALR	-.01253
SNLR	-.00636
SEALR	.00286

Unstandardized canonical discriminant function coefficients

	Func 1
NEALR	-2311.5935352
SEALR	2047.7835940
SNLR	-249.7990875
ULR	215.3168304
VENT5CM	264.0185231
(Constant)	-232.8118218

Canonical discriminant functions evaluated at group means (group entroids)

Group	Func 1
1	17.64233
2	-8.82116

Test of Equality of Group Covariance Matrices Using Box's M

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

Group	Label	Rank	Log Determinant
1	male	< 3	(Too few cases to be non-singular)
2	female	5	-55.586940
Pooled within-groups covariance matrix		5	-52.195454

No test can be performed without at least two non-singular group covariance matrices.

Case Number	Mis Val	Sel	Actual Group	Highest Probability Group	P(D/G)	P(G/D)	2nd Highest Group	P(G/D)	Discrim Scores
1			2	2	.2303	1.0000	2	1.0000	-10.0208
2			2	2	.4284	1.0000	2	1.0000	-8.0292
3			2	2	.4556	1.0000	2	1.0000	-8.0750
4			2	2	.1089	1.0000	2	1.0000	-10.4242
5			2	2	.2330	1.0000	2	1.0000	-7.6285
6			2	2	.9426	1.0000	2	1.0000	-8.7492
7			1	1	.6153	1.0000	1	1.0000	-17.1398
8			1	1	.8162	1.0000	1	1.0000	-17.8747
9			1	1	.7871	1.0000	1	1.0000	-17.9124

Symbols used in plots

Symbol	Group	Label
1	1	male
2	2	female

```
                       All-groups Stacked Histogram

                     Canonical Discriminant Function 1
      4 +                                                              +
        I                                                              I
        I                                                              I
F       I                                                              I
r     3 +                  2                                           +
e       I                  2                                           I
q       I                  2                                           I
u       I                  2                                           I
e     2 +               2  2                                   1       +
n       I               2  2                                   1       I
c       I               2  2                                   1       I
y       I               2  2                                   1       I
      1 +               2 22                                  11       +
        I               2 22                                  11       I
        I               2 22                                  11       I
        I               2 22                                  11       I
         X---------+---------+---------+---------+---------+---------X
       out      -16.0      -8.0       .0        8.0      16.0       out
  Class  2222222222222222222222222222222222222211111111111111111111111
Centroids                 2                                  1
```

Varanus bengalensis nebulosus

Summary Table

Canonical Discriminant Functions

Fcn	Eigenvalue	Pct of Variance	Cum Pct	Canonical Corr		After Fcn	Wilks' Lambda	Chi-square	df	Sig
					:	0	.073326	18.290	4	.0011
1*	12.6378	100.00	100.00	.9626	:					

* Marks the 1 canonical discriminant functions remaining in the analysis.

Standardized canonical discriminant function coefficients

	Func 1
NLR	-1.21212
ULLR	2.74980
EEALR	1.48688
FALR	-2.50153

Structure matrix:

Pooled within-groups correlations between discriminating variables and canonical discriminant functions (Variables ordered by size of correlation within function)

	Func 1
SCL	-.40549
CVL	.40549
ULLR	.36757
TL	.34117
TOTAL	.34117
HLLR	.24226
NEALR	-.23429
VENT5CM	.20056
NNL	.19390
NELR	.16816
UAL	.15607
SNLR	.11503
AXILLA	.09860
LLLR	.09487
SELR	-.09004
HLR	-.08595
FALR	.02376
SEALR	-.02071
EEALR	.01920
NLR	-.01662
LUMBAR	.01022
FLR	-.00566

Unstandardized canonical discriminant function coefficients

	Func 1
NLR	-358.6464404
ULLR	272.7897036
EEALR	364.0441772
FALR	-312.5829651
(Constant)	-19.1460140

Canonical discriminant functions evaluated at group means (group entroids)

Group	Func 1
1	2.43076
2	-4.25383

Test of Equality of Group Covariance Matrices Using Box's M

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

Group Label	Rank	Log Determinant
1 male	4	-45.622684
2 female	< 4	(Too few cases to be non-singular)
Pooled within-groups covariance matrix	4	-43.940018

No test can be performed without at least two non-singular group covariance matrices.

Case Number	Mis Val	Sel	Actual Group	Highest Probability Group	P(D/G)	P(G/D)	2nd Highest Group	P(G/D)	Discrim Scores
1			1	1	.9058	1.0000	2	.0000	-2.5492
2			1	1	.9749	1.0000	2	.0000	-2.3993
3			1	1	.9047	1.0000	2	.0000	-2.3111
4			1	1	.0579	.9999	2	.0001	-0.5346
5			1	1	.4410	1.0000	2	.0000	-3.2013
6			1	1	.1116	1.0000	2	.0000	-4.0218
7			1	1	.6653	1.0000	2	.0000	-1.9981
8			2	2	.4440	1.0000	1	.0000	-5.0192
9			2	2	.7593	1.0000	1	.0000	-4.5602
10			2	2	.2413	1.0000	1	.0000	-3.0820
11			2	2	.9203	1.0000	1	.0000	-4.3539

Symbols used in plots

Symbol	Group	Label
1	1	male
2	2	female

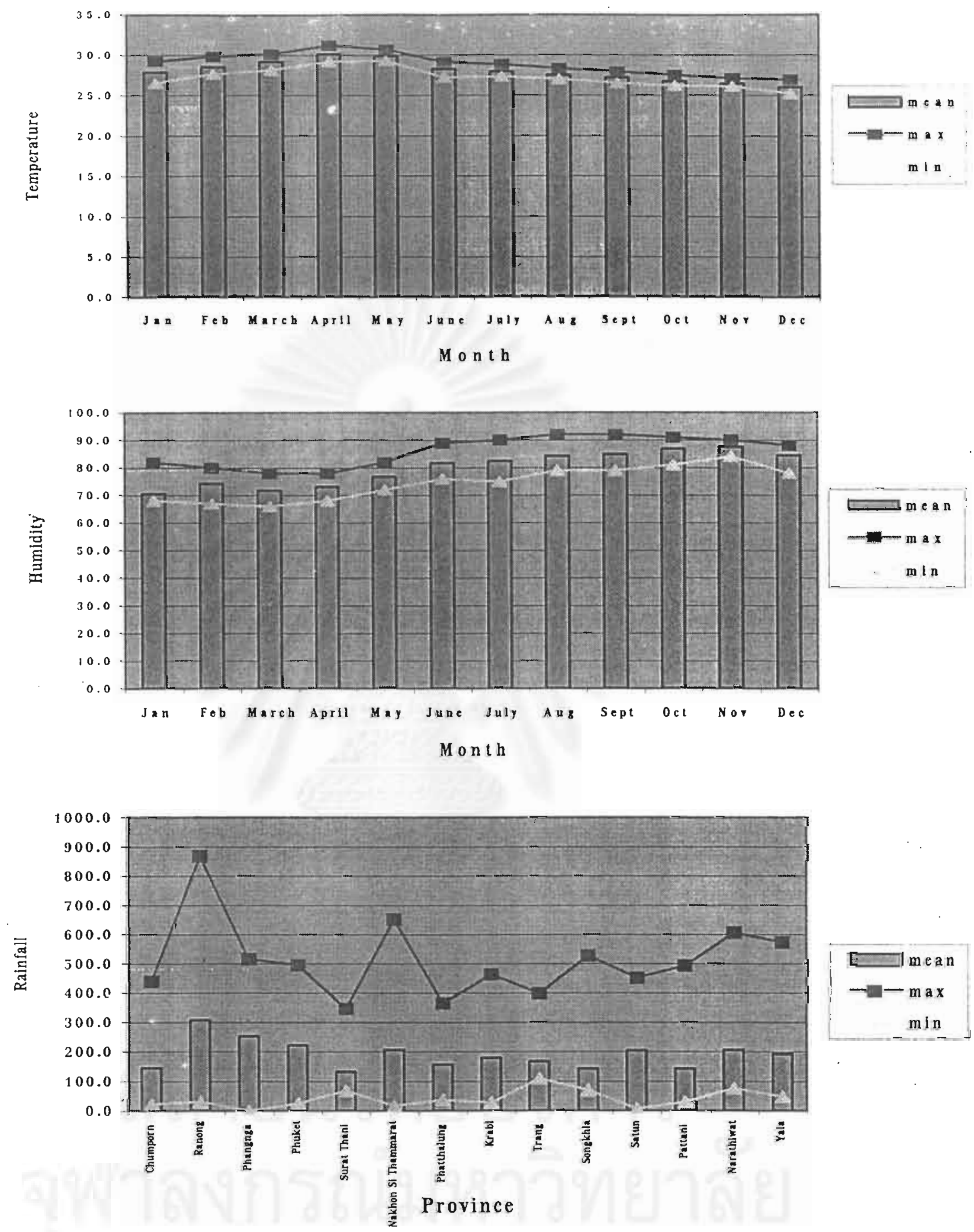
All-groups Stacked Histogram

Canonical Discriminant Function 1

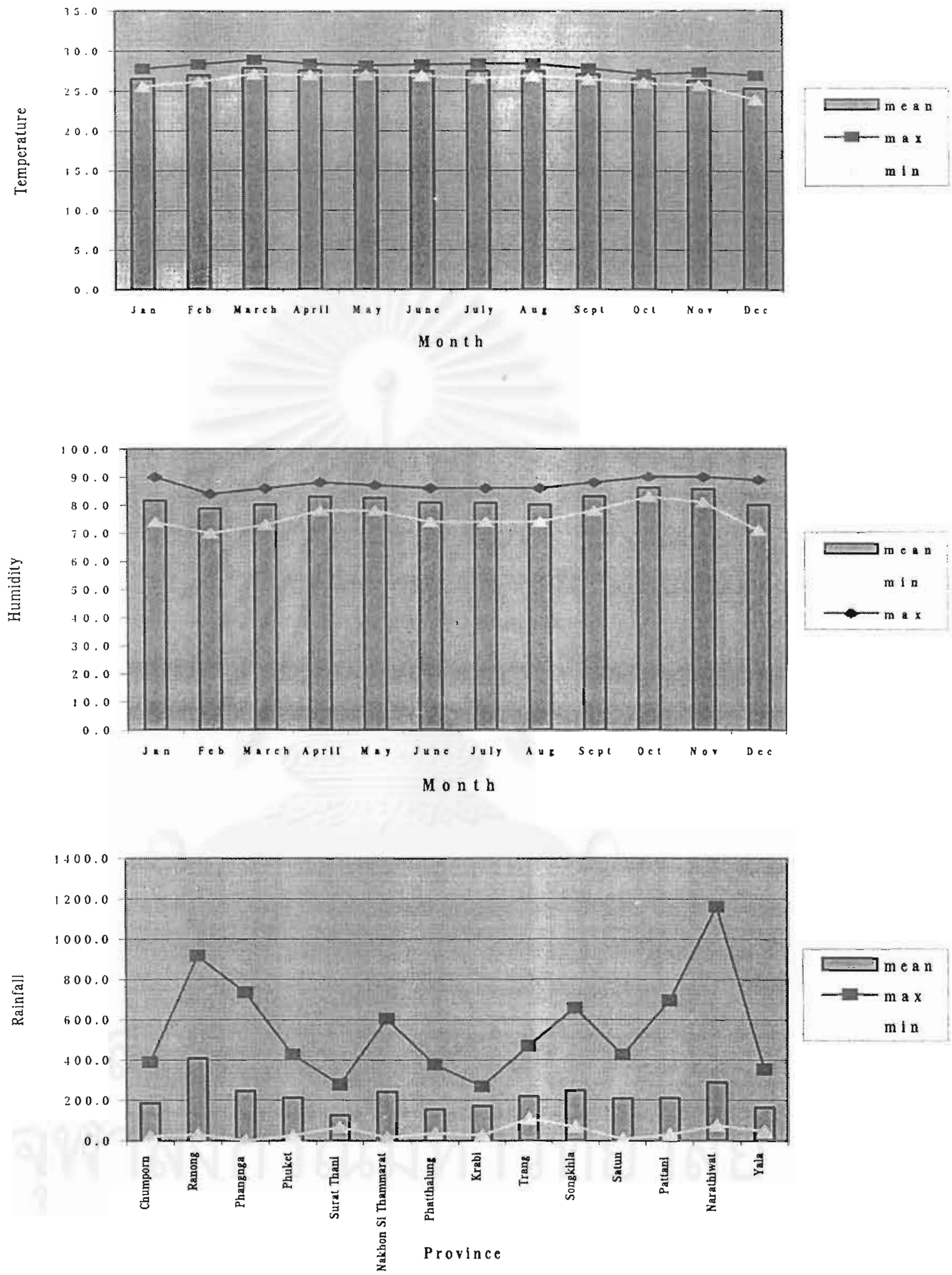
```
        4 +                                                            +
          I                                                            I
          I                                                            I
F         I                                                            I
r       3 +                                                            +
e         I                                                            I
q         I                                                            I
u         I                                                            I
e       2 +                                         1                  +
n         I                                         1                  I
c         I                                         1                  I
y         I                                         1                  I
        1 +      2 22      2                 1      1 11  1   1        +
          I      2 22      2                 1      1 11  1   1        I
          I      2 22      2                 1      1 11  1   1        I
          I      2 22      2                 1      1 11  1   1        I
           X---------+---------+---------+---------+---------+---------X
          out      -4.0      -2.0       .0       2.0       4.0        out
  Class    2222222222222222222222222222111111111111111111111111111111111
Centroids            2                                1
```

APPENDIX IV

(Climatic mean data)



Climatic mean data of southern Thailand during January 1998 to December 1998 (Meteorological Department, 1998).



Climatic mean data of southern Thailand during January 1999 to December 1999 (Meteorological Department, 1999).

APPENDIX V

(Eggs sizes of monitor lizards in this study)

Species	No.	Date	Width (cm.)	Length (cm.)	Weight (g.)	Locality
V. salvator	1.	15 June 99	4.56	7.67	84.50	Snake farm of
	2.	15 June 99	5.13	7.30	95.50	Sowabha Institute,
	3.	15 June 99	5.27	7.53	104.20	
	4.	15 June 99	4.38	7.75	81.50	
	5.	15 June 99	4.57	7.52	83.50	
	6.	15 June 99	4.76	7.77	87.50	
	7.	15 June 99	5.08	7.40	98.00	
	8.	15 June 99	4:37	7.50	79.00	
V. b. nebulosus	1.	29 Oct 98	3.480	5.225	34.50	
	2.	29 Oct 98	3.655	5.380	36.78	Amphur Betong
	3.	29 Oct 98	3.480	5.485	36.01	Yala Province
	4.	29 Oct 98	3.500	5.480	38.19	
V. rudicollis	1.	28 Jan 98	3.000	4.825	24.5	In laboratory
	2.	28 Jan 98	2.952	5.085	25.6	Department of
	3.	28 Jan 98	2.875	4.925	24.1	Biology, Faculty
	4.	28 Jan 98	3.075	4.950	26.2	of Science,
	5.	28 Jan 98	2.900	5.025	24.4	Chulalongkorn
	6.	28 Jan 98	2.955	5.100	24.8	University.
	7.	28 Jan 98	2.920	5.385	25.6	
	8.	29 Jan 98	2.900	5.250	25.4	
	9.	29 Jan 98	2.965	4.950	24.3	
	10.	29 Jan 98	2.975	5.525	26.9	
	11.	29 Jan 98	2.960	5.245	27.3	
	12.	29 Jan 98	2.920	4.925	24.0	
	13.	29 Jan 98	2.920	5.425	24.1	
	14.	29 Jan 98	2.865	5.275	22.9	
	15.	29 Jan 98	2.820	5.475	24.6	

Note: Locality = areas collected eggs

APPENDIX VI
(CITES)

Convention on International Trade in Endangered Species of Wild Fauna and Flora

(CITES)

Appendix I: Shall include all species threatened with extinction which are or may be effected by trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances.

Appendix II: shall include:

a) all species which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival; and

b) other species which must be subject to regulation in order that trade in specimens of certain species referred to in sub-paragraph a) of this paragraph may be brought under effective control.

Appendix III: Shall include all species which any Party identifies as being subject to regulation with its jurisdiction for the purpose of preventing or restricting exploitation, and as needing the co-operation of other Parties in the control of trade (World Conservation Monitoring Centre, 1995)

Biography

Mr. Komsorn Lauprasert was born on the 30th of August 1973 in Bangkok. He graduated his bachelor's degree of science in Fisheries (Aquaculture) in 1994 from the Faculty of Fisheries, Kasetsart University. He continued his graduated study for master's degree of science in zoology at the Department of Biology, Faculty of Science, Chulalongkorn University in 1996. He was awarded a year scholarship by the University Development Committee (UDC), Ministry of University Affairs in 1999. After his graduation, he works as a full-time lecturer at the Department of Biology, Faculty of Science, Mahasarakham University.