อนุกรมวิธานของปลาหลดปลากระทิง (SYNBRANCHIFORMES: MASTACEMBELIDAE) ในประเทศไทย

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TAXONOMY OF SPINY EELS (SYNBRANCHIFORMES: MASTACEMBELIDAE) IN THAILAND

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ในการศึกษาเรื่องอนุกรมวิธานของปลาหลดปลากระทิง (SYNBRANCHIFORMES: MASTACEMBELIDAE) ได้ดำเนินการโดยศึกษาจากตัวอย่างที่ทำการเก็บรวบรวมขึ้นใหม่จากลุ่มน้ำต่างๆ ทั่วประเทศไทย ระหว่างเดือนมิถุนายน 2549 ถึง เดือนกันยายน 2550 นอกจากนี้ยังได้ทำการตรวจสอบตัวอย่างที่ถูกเก็บรวบรวมไว้ในพิพิธภัณฑ์และสถาบันต่างๆ ในประเทศไทย โดยมีวัตถุประสงค์หลักในการแก้ปัญหาเรื่องการใช้ชื่อวิทยาศาสตร์ของปลาหลดและปลากระทิงในแต่ละชนิดให้มีความถูกต้อง อีกทั้งเพื่อทราบถึงจำนวนชนิดของปลาหลดและปลากระทิงที่มีการแพร่กระจายภายในประเทศไทย จากการศึกษาพบปลาหลดและปลากระทิงทั้งสิ้น 2 สกุล 12 ชนิด ได้แก่ *Macrognathus aculeatus*, *M. circumcinctus*, *M. maculatus*, *M. meklongensis*, *M. semiocellatus*, *M. siamensis*, *M. zebrinus*, *Mastacembelus alboguttatus*, *M. armatus*, *M. erythrotaenia*, *M. favus* และ *M. tinwini* สมาชิกทั้งหมดในวงศ์ Mastacembelidae เป็นปลาที่พบอยู่ในแหล่งน้ำจืด อย่างไรก็ตามสามารถพบ *M. erythrotaenia* ได้ทั้งในแหล่งน้ำจืดและในแหล่งน้ำกร่อย การศึกษาในครั้งนี้ได้รายงานการพบปลากระทิงชนิด *M. tinwini* เป็นครั้งแรกในประเทศไทย

การศึกษาวิเคราะห์ชนิดของปลาหลดและปลากระทิง มีลักษณะที่ใช้บ่งบอกหรือถือว่าเป็นหลักสำคัญ ได้แก่ ลวดลายที่อาจปรากฏหรือไม่ปรากฏบนลำตัวและครีบ จำนวนก้านครีบแข็งของครีบหลังและครีบก้น จำนวนก้านครีบอ่อนของครีบหลัง ครีบก้น ครีบอก และครีบหาง รวมทั้งจำนวนกระดูกสันหลัง นอกจากนี้ยังได้เสนอคีย์เพื่อใช้สำหรับการจัดจำแนกทั้งในระดับสกุลและระดับชนิด อีกทั้งยังมีรายการของชื่อวิทยาศาสตร์ ชื่อพ้อง ชื่ออ้างอิง ชื่อภาษาอังกฤษ ชื่อท้องถิ่น ตัวอย่างที่ใช้ศึกษา ลักษณะเด่น ลักษณะทั่วไป สภาพแวดล้อมที่พบ ขอบเขตการกระจายในประเทศ ตารางแสดงข้อมูลทางมอร์โฟเมตริก ตารางแสดงความถี่ของก้านครีบแข็ง ก้านครีบอ่อน และกระดูกสันหลัง รูปภาพประกอบ และเดนโดแกรม

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SALINEE KHACHONPISITSAK: TAXONOMY OF SPINY EELS (SYNBRANCHIFORMES: MASTACEMBELIDAE) IN THAILAND. THESIS ADVISOR: ASSOC. PROF. KUMTHORN THIRAKHUPT, Ph.D., THESIS CO-ADVISOR: PROF. THOSAPORN WONGRATANA, Ph.D., 260 pp.

The present taxonomic study is the update revision of spiny eels (Synbranchiformes: Mastacemeblidae) found in Thailand. It is based on specimens deposited in local reference collections and newly collected specimens throughout Thailand during June 2006 to September 2007. It represents an attempt to alleviate difficulties with the species identification of individual specimens by providing a treatment of the nomenclature and taxonomy of all available local members. Two genera and twelve species, *Macrognathus aculeatus*, *M. circumcinctus*, *M. maculatus*, *M. meklongensis*, *M. semiocellatus*, *M. siamensis*, *M. zebrinus*, *Mastacembelus alboguttatus*, *M. armatus*, *M. erythrotaenia*, *M. favus* and *M. tinwini* were recognized. All of them are freshwater fish. However *M. erythrotaenia* can be found in both fresh and brackish waters. Upon this study, *M. tinwini* is a newly recorded species.

The species identification of the family Mastacembelidae is based largely on configurations and the presence or absence of colour markings on body and fins and different numbers of spines, fin rays and vertebrae. The dichotomous keys to genera and to species are provided. The information about the scientific names, synonyms and citations, common names, local names, examined material, diagnosis, descriptions, distribution, habitats, frequency distribution of spines, fins and vertebrae and photographs are available. Morphometric and meristic dendograms using Hierarchical cluster analysis were constructed.

Department	Biology	Student's signature..... Salinee Khachonpisitsak
Field of Study	Zoology	Advisor's signature..... K. Thirakhupt
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ABBREVIATIONS

Institutional Abbreviations

The following institutional abbreviations are used to denote the location of specimen deposited.

CUMZ	Chulalongkorn University Museum of Zoology, Bangkok
KUMF	Kasetsart University Museum of Fisheries, Bangkok
NIFI	National Inland Fisheries Institute, Department of Fisheries, Bangkok
UMMZ	University of Michigan Museum of Zoology
uncat.	uncatalogue

The following institutional abbreviations are used to denote the location of specimen cited.

NRM	Naturhistoriska Riksmuseet (Stockholm)
BMNH	British Museum of Natural History
USNM	Smithsonian National Museum of Natural History
CMK	Collection of Maueice Kottelat, Cornol

Basins of Thailand

The following abbreviations of Basin in Thailand are employed to indicate the locality of specimens captured.

Cp	Chao Phraya Basin
Sw	Salween Basin
Mk	Mekong Basin
Mkl	Meklong Basin
S	Southern Basins
E	Eastern Basins

Morphological Measurements

mm L_T	mm Total Length
mm L_S	mm Standard Length
% L_T	percentage of the mm Total Length
% L_S	percentage of the mm Standard Length

Meristic Counts

D	Dorsal fin
P	pectoral fin
A	Anal fin
C	Caudal fin
PV	Predorsal Vertebrae
AV	Abdominal Vertebrae
CV	Caudal Vertebrae
TV	Total Vertebrae

Countries

Laos	Lao People's Democratic Republic
Myanmar	Union of Myanmar
Cambodia	Kingdom of Cambodia
China	People's Republic of China
Vietnam	Socialist Republic of Vietnam

CHAPTER I
INTRODUCTION

Thailand has been considered as one of diversified habitats of aquatic faunas and floras of the world. Thailand is not only located in tropical and subtropical zones but also is situated in the Indo-China and Malay Peninsula which has been described as a **"Biogeographical Crossroad"**. Consequently, the location of Thailand can provide an extremely richness in biological diversity. All river basins supported freshwater ecosystems in Thailand can be divided into six major basins (the Chao Phraya, the Salween, the Mekong, the Meklong, the Southern and the Eastern basins). The classification of basins in Thailand is modified from **Kottelat (1989)**, **Rainboth (1991)** and **Vidthayanon *et al.* (1997)**.

However, freshwater fish species in many taxa are steadily declining due to increase in various stresses from human overpopulation and anthropogenic activities which are placed on freshwater sources all over Thailand. Habitat destruction, land use change and over fishing have been considered as primary causes leading to decrease in myriad fish species. In Thailand several species of spiny eels particularly fire spiny eels, *Mastacembelus erythrotaenia*, have been threatening by causes stated above. *M. erythrotaenia* were captured from their natural habitats in high quantities for trading in ornamental fish markets. Their status seems to be endangered in the near future. Therefore, creating an effective plan for conservation or management really needs some basic information especially classification, distribution, ecology and biology. A tool for correct identification of mastacembelid species should be done as soon as possible because the correct identification of species is a basic starting point for any type of biological studies.

Spiny eels are eel-shaped with compressed tail and have been classified in the family Mastacembelidae belonging to the order Synbranchiformes. They possess a row of short isolated spines along their back and lack pelvic fins. Their snouts are elongated and are modified into fleshy proboscises with a pair of tube-like nostrils situated at subdistal tip of their rostrums. Spiny eels can attain a maximum length of about one meter. They can habit in both fresh and brackish waters of tropical Africa,

the Euphrates region, South Asia and Southeast Asia north to Beijing. There are four genera of spiny eels throughout the world. In Asia two genera *Macrognathus* and *Mastacembelus* are recognized, but the rest of the genera *Aethiomastacembelus* and *Caecomastacembelus* are restricted to Africa.

The taxonomic studies of Asian mastacembelid fish were last revised by Roberts (1986). Several mastacembelid species have been recognized in Thailand; however, the information on anatomy, morphology and distribution is still poorly known and some previous reports are uncertain. Moreover, the exact number of mastacembelid species is still unknown.

For distinguishing mastacembelid species their colourations are usually employed in species identification, even though their colour patterns may vary intraspecifically due to environmental, ontogenetic, or dietary factors as well as genetic variation or fade in museum specimens. Consequently, species identification based only on colour patterns may lead to misidentification. From literature review and specimen investigation the *Mastacembelus armatus* species-complex is an obvious example of species misidentification caused by using only colourations. The misidentification in the *Mastacembelus armatus* species-complex was often occurred. For instance in Thailand *Mastacembelus armatus* is often identified as *Mastacembelus favus* due to their similar colourations. Moreover, the *Mastacembelus armatus* species-group is poorly understood due to its wide distribution and high variability in colour patterns and meristic characters (Sufi 1956; Roberts, 1986, 1989).

As mentioned above, the causes may lead to several problems in classification. Therefore, the taxonomic study on the family Mastacembelidae is necessary to carry out in order to obtain more information on biological diversity of freshwater fish in Thailand. In this study the main purposes are to review and to investigate mastacembelid taxonomy based on morphological and anatomical characters from newly collected specimens throughout Thailand and specimens of reference collections deposited in museums and institutions. For statistical analyses the mean comparison and the cluster analysis using between-groups linkage method in SPSS program were performed. Eventually, keys to genera and species and also distribution maps in Thailand are provided.

OBJECTIVES

The main purposes of this study are to reinvestigate and to update Thai mastacembelid classification using anatomical and morphological characters particularly meristic counts and morphometric measurements with additional statistical analyses for morphometry.

ANTICIPATED BENEFITS

The results of this study will improve taxonomic studies of the family Mastacembelidae and provide a key to species and distribution maps of each species in Thailand.

CHAPTER II

LITERATURE REVIEW

2.1 MASTACEMBELID SPECIES

2.1.1 OVERVIEW OF TAXONOMIC HISTORY

Spiny eel is one of primary freshwater fishes of the Old World which for some times have been considered as belonging to the order Perciformes or the order Opisthomi but more recently it has been placed in the order Synbranchiformes by **Gosline (1983)** and **Travers (1984b)**. The family Mastacembelidae and the related family Synbranchidae are perhaps the most highly modified percomorph families which are entirely or almost entirely restricted to freshwater **(Roberts, 1989)**. Their relationships to other percomorphs are still unknown.

Spiny eels have eel-like appearances which are enhanced by lack of pelvic fins, their long body with small and numerous vertebrae, a tendency for their dorsal and anal fins to be confluent with their caudal fin and their narrow and tapered cranium terminating in a pointed rostral appendage. They are characterized by a long series of isolated spines at anterior to their dorsal fin ray, hence their name **"spiny eel"**, the gill opening reduced due to a connection of the opercular membrane with the lateral body wall. Furthermore, spiny eels have peculiar rostrums bearing two tubular anterior nostrils, one on each side at subdistal tip of their rostral appendages. Most mastacembelid species have a large number of minute cycloid scales. Compared to many tropical and subtropical fish groups, the mastacembelid species have medium to large size (up to about 1-m long).

The classification of the Mastacembelidae can be summarized as below:

Kingdom Animalia
Phylum Osteichthyes
Class Teleostei (Actinopterygii)
Order Synbranchiformes
Suborder Mastacembeloidei (Opisthomi)
Family Mastacembelidae
Subfamily Mastacembelinae
Genus *Mastacembelus* Lacepède, 1800
Macrognathus Scopoli, 1777
Subfamily Afromastacembelinae
Genus *Caecomasatacembelus* Poll, 1958
Aethiomastacembelus Travers, 1988

Mastacembelid species are classified in the order Synbranchiformes, which comes from the Greek words ***"syn"*** meaning together, or adhesion and ***"brangchia"*** meaning gills (Brown, 1956), which together translate as fused gill shape, and are placed in the family Mastacembelidae which is derived from the Greek words ***"mastax"***, meaning bite or mouthful, and ***"emballo"*** meaning to throw oneself into (Brown, 1956). They are translated together as "a fish that likes to throw itself into the bite".

The suborder Mastacembeloidei, a distinctive group of approximately seventy freshwater species belonging to four genera is widely distributed in tropical and subtropical regions of the Africa, the Southeast Asia and the Middle East (Ethiopian and Oriental zoogeographic regions respectively) **(Roberts, 1986; Berra, 2001; Atack, 2006; Britz, 2007)** (see **FIGURE 2.1**). In addition, mastacembelid species are also distributed in China and Korea **(Nelson, 2006)**. In the past the majority of members belonging to the family Mastacembelidae has been placed only in the genus *Mastacembelus* by without any consideration on their genealogical relationships. Moreover, the suborder Mastacembeloidei has not been seriously studied in both taxonomic and anatomical reviews. Consequently, the number of mastacembelid species is not exactly known and new species have been describing continually.

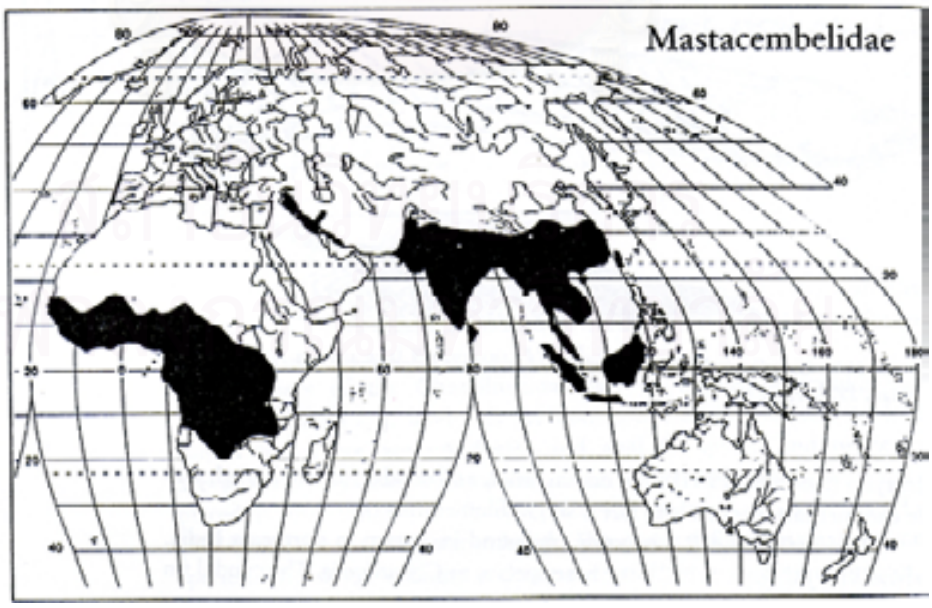

FIGURE 2.1. Distribution of the family Mastacembelidae.
(above: Sterba (1973); middle: Traver (1984b); below: Berra (2001))

The family Mastacembelidae is currently subdivided into two subfamilies, Mastacembelinae and Afromastacembelinae, by **Travers (1984a and 1984b)**. There are four genera belonging to the family Mastacembelidae. Two genera, *Mastacembelus* Scopoli, 1777 and *Macrognathus* Lacepède, 1800, within the subfamily Mastacembelinae are restricted to the Asian continent, while the subfamily Afromastacembelinae consists of two genera *Aethiomastacembelus* Travers, 1988 and *Caecomastacembelus* Poll, 1985 which are endemic to the African continent **(Travers, 1984a, 1984b and 1988)** (summarized in **FIGURE 2.2**).

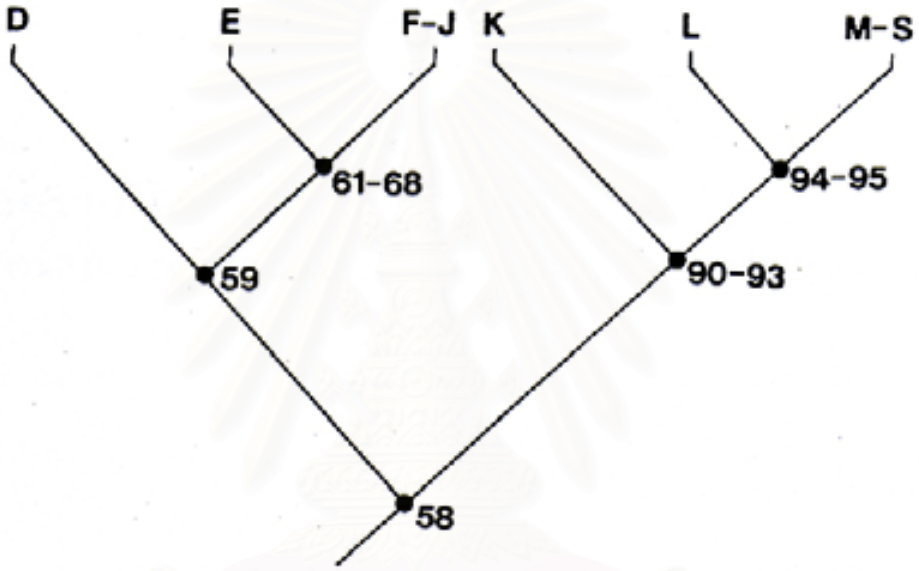

FIGURE 2.2. Phylogeny of the family Mastacembelidae as proposed by **Travers (1984b)**. Numbers are from **Travers (1984b)** and refer to principal synapomorphies. 58, Mastacembelidae; 59, Mastacembelinae; 61-68, *Macrognathus* (E, F-J); 90-93, Afromastacembelinae; 94-95, *Caecomastacembelus* (L, M-S); D, *Mastacembelus*; K, *Afromastacembelus* (Vreven, 2005). For more details see **Travers (1984a, 1984b)**.

In the past, all African mastacembelids were described within the genus *Mastacembelus*. Until Poll (1958) created a new genus *Caecomastacembelus* with *C. brichardi* as its type species. However **Roberts and Stewart (1976)** disagreed with **Poll (1958)** and rejected the genus *Caecomastacembelus*. In contrast, **Travers (1984b)** recognized the genus *Caecomastacembelus* but changed certain concepts of the genus described by **Poll (1958)**. Moreover, **Travers (1984b)** added the new genus *Afromastacembelus* belonging to the subfamily Afromastacembelinae.

Next, **Travers (1988)** placed the genus *Afromastacembelus* in synonymy with the genus *Caecomastacembelus*. Some species in the genus *Afromastacembelus* were transferred to the genus *Caecomastacembelus*. For other species which can not be transferred to the genus *Caecomastacembelus*, they were allocated to a new genus *Aethiomastacembelus* introduced by **Travers (1988)**. After Travers's actions **(Travers 1984b, 1988)**, the generic position of many of these species subsequently was confounded **(Seegers, 1996; Vreven and Teugels, 1996, 1997; Vreven 2005a)**. Moreover, the nomenclature of the African genera has been highly bewildering **(Vreven, 2005a)**. **Britz (1996) and Vreven (2005a)** disagreed with some of the taxonomic changes introduced by **Travers (1984b, 1988)**.

Vreven and Teugels (1996, 1997) discussed some problems of the type material of both genera. The study revealed several inaccuracies and contradictions in the diagnoses of both genera. At present, there is no phylogenetic evidence supporting their validity (monophyly) and there are no straightforward diagnostic characters available for their diagnoses. The present status is harmful to the stability of the generic nomenclature of the African Mastacemeblidae. Consequently, **Vreven (2005a)** seriously evaluated the status of both subfamilies and also African generic division again by considering from X-ray analyses and osteological studies, the results pointed out that there is no any supporting evidence for a split into two subfamilies and proved that the present diagnosis of the African genera is unworkable. Eventually **Vreven (2005a)** suggested that the genus *Caecomastacembelus* and the genus *Aethiomastacembelu*s should be abandoned and the both genera are placed in synonymy with the genus *Mastacembelus*.

At present, there is no any revision of the entire family and the present state of certain mastacembelid species particularly the genus *Mastacembelus* is confused. According to **Travers (1984a, b)**, since the first scientific description of the mastacembelid group many species have been described, the majority of which were placed in the genus *Mastacembelus* Scopoli, 1777. Exceptionally, one species, originally described by **Bloch (1786)** was placed in another genus, *Macrognathus* Lacepède, 1800. Presently, numerous species were placed in the genus *Macrognathus*, which is only distributed in Oriental zoogeographic regions.

Based on comparative anatomical analyses **Travers (1984b)** indicated that the mastacembeloids should be reallocated to the Synbranchiformes and all members of the family Mastacembelidae belong systematically to the monophyletic order Synbranchiformes including families Synbranchidae and Chuadhuriidae **(Travers, 1984a, 1984b, Britz, 2007)**. The intrarelationships of the suborder Mastacembeloidei were illustrated in **FIGURE 2.3.** Nevertheless the intrarelatioships of the mastacembeloids proposed by **Travers (1984b)** cannot be retained because most of the categories are demonstrably non-monophyletic.

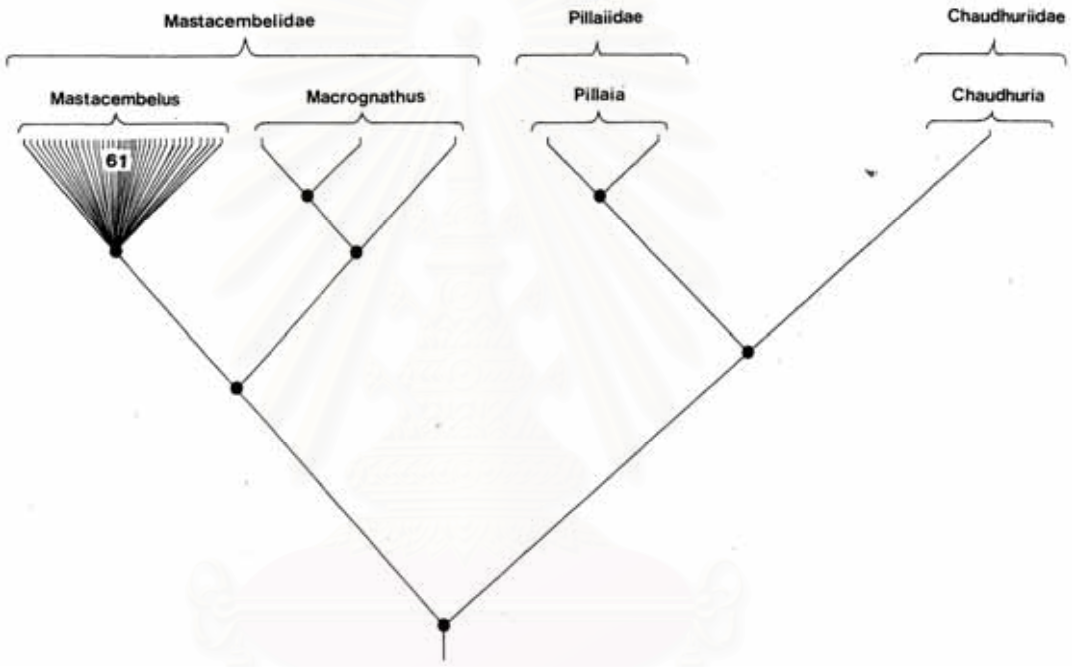

FIGURE 2.3. Relationships of mastacembeloid taxa, as shown by the classification of **Travers (1984b)**.

By the middle of the nineteenth century, **Günther (1861)** had considered spiny eels as **"acanthopterous eels"** related to the family Bleniidae and placed them in the order Blenniformes, while **Boulenger (1904)** had placed spiny eels in the suborder Opisthomi between the suborder Acanthopterygii and the suborder Pediculati and stated that the Mastacembelidae is possibly derived from the Blenniidae. **Jordan (1923)** also placed mastacembelid species in the order Opisthomi immediately preceding the Apodes**. Johnson and Patterson (1993)** believed that Synbranchiform was formed a monophyletic group with the mugilomorphs,

atherinomorphs, elassomatids and gasterosteiforms. Next, mastacembelid group was elevated to ordinal rank named Mastacembeliformes within the teleosts **(Regan, 1912)**; however, **Nelson (1994)** reduced the taxon to subordinal status and included the suborder Mastacembelodei as one of their 20 suborders in the order Perciformes. Eventually, the mastacembelid group has been placed in the order Synbranchiformes due to its unique characteristics (**Gosline, 1983; Travers, 1984b)**.

According to **Boulenger (1912)**, the last study of spiny eels was published in Günther's Catalogue of Fishes, Vol. III (1861), only eight species were known from Indian region and Euphrates. After the Boulenger's exploration of the fresh waters in Africa finished, the knowledge about the family Mastcembelidae has been substantially increased by the exploration of freshwaters in Africa.

A synopsis of the fishes of the genus *Mastacembelus* covering both the Oriental and African mastacembelids was published by **Boulenger (1912)**. Forty-five mastacembelid species were recognized and distributed as follows: 30 species from the tropical Africa, twelve species from the Southeast Asia, two species from the Southwest Asia, and one species from China. All forty-five mastacembelid species were classified in the genus *Mastacembelus* and twenty-seven of which have been named by him. There are fifteen species from the oriental region. Since then ten nominal oriental species have been added to genus *Mastacembelus.* After that many surveys and studies on the family Mastacembelidae have been started.

Fowler (1934, 1935, 1935b, 1937 and 1939) started to study the species diversity of freshwater fish in Thailand under the project named the zoological of the de Schauensee Siamese Third Siamese Expedition**.** The more details of surveys are given as follows:

From the zoological of the de Schauensee Siamese Third Siamese Expedition, Part I.-fishes, the freshwater fish specimens were obtained between November 16 and 23 in 1932. These fish specimens were represented by 77 species, of which 3 mastacembelid species, *Rhynchobdella aculeata*, *Mastacembelus armatus*, and *Mastacembelus circumcinctus* were recorded **(Fowler, 1934)**.

In 1934, four species of spiny eels were reported: *Rhyncobdella aculeata*, *Mastacembelus armatus*, *Mastacembelus argus* and *Mastacembelus taeniagaster* **(Fowler, 1935a)**. Moreover, there was a new species, *Mastacembelus taeniagaster*, described by **Fowler (1935a)**. *M. taeniagaster* was described as a new species despite the fact that Fowler has reported it as *Mastacembelus circumcinctus* in **Fowler (1934)**.

In 1935, a small collection was obtained from North Siam and the Shan States during February to April. One species of spiny eels was reported: *Rhyncobdella aculeate* (Bloch) which was secured in April at Chieng Sen (presumably expected to Chiang Saen district in Chiang Rai province) (**Fowler, 1935b)**.

In 1936, all collection of fish was obtained from Siam, or Thailand and comprised over 8,200 specimens representing 351 species. Two species of spiny eels were reported: *Rhyncobdella aculeata* and *Mastacembelus favus* (**Fowler, 1937)**.

From zoological of the third de Schauensee Siamese Expedition, Part IX.- fishes obtained in 1936, all collection of fish was secured from Siam and comprised over 2,453 specimens representing 124 species. Two species of spiny eels were reported: *Mastacembelus argus* and *Mastacembelus paucispinis*. *M. paucipinins* was described as a new species. It can be diagnosed by its free caudal fin and its colouration, the oblique dark bands not extending across the belly (**Fowler, 1939)**.

Smith (1945) studied species diversity of freshwater fish in Thailand and reported that the family Mastocembelidae, belonging to the order Opisthomi, comprises two closely related genera, *Macrognathus* and *Mastocembelus*, which both represented in Thailand, the former by a single species: *Macrognathus aculeatus* and the latter by eight species: *Mastocembelus maculatus, M. armatus armatus, M. armatus favus, M. circumcinctus, M. argus, M. taeniagaster, M. erythrotaenia*, and *M. paucispinis*.

Due to the scattered knowledge about the family Mastacembelidae and some inaccuracies in Boulenger's revision, the genera *Macrognathus* and *Mastacembelus* in Asia were revised again by **Sufi (1956)**. The order Opisthomi was redefined and the

family Mastacembelidae was placed in the order Synbranchiformes. Sixteen mastacembelid species belonging to two genera, *Macrognathus* and *Mastacembelus*, were recognized. Only one species, *M. aculeatus*, was placed in the genus *Macrognathus* and fifteen species were allocated in the genus *Mastacembelus*: *M. alboguttatus*, *M. Mastacembelus*, *M. sinensis*, *M. maculatus*, *M. perakensis*, *M. keithi*, *M. pancalus*, *M. guentheri*, *M. zebrinus*, *M. oatesii*, *M. unicolor*, *M. erythrotaenia*, and *M. armatus*. **Sufi (1956)** did not refer to *M. favus* and placed *Mastocembelus armatus favus* cited by **Smith (1945)** as a synonym with *M. armatus*.

Weber and Beaufort (1962) studied fishes in the Indo-Australian archipelago. They reported seven mastacembelid species which of one species belonged to the genus *Macrognathus* and six species were placed in the genus *Mastacembelus*. They also classified and placed mastacembelids in the order Opisthomi.

The genus *Macrognathus* in Asia has been revised again by **Roberts (1980).** He revised three oriental mastacembelid species, *M. aral*, *M. aculeatus*, and *M. siamensis*. He proposed three main characters for distinguishing the species of the genus *Macrognathus*. The first character is number of rostral toothplates pairs. The second character is color pattern and the last character is projections on rim of tubular anterior nostril.

For the subfamily Mastacembelinae, **Roberts (1986)** reviewed classification of fourteen Asian mastacembelid species of Thailand and Myanmar and described two new species, *Macrognathus meklongensis* and *M. semiocellatus*, from Thailand. Fourteen revised species were *Macrognathus siamensis*, *M. meklongensis*, *M. aral*, *M. semiocellatus*, *M. aculeatus*, *M. circumcinctus*, *M. zebrinus*, *M. caudiocellatus*, *Mastacembelus favus*, *M. erythrotaenia*, *M. armatus*, *M. oatesii*, *M. alboguttatus*, and *M. dayi*. **Roberts (1986)** distinguished the genus *Macrognathus* from the genus *Mastacembelus* by its number of dorsal spines, its rim of the tubular anterior nostril, and its position of adductor arcus palatine muscle inserted. Almost all members in the genus *Macrognathus* have their rim with six frimbrae, whereas all members of the genus *Mastacembelus* have their rim with two fimbrae and two broad-based flaps. In species level **Roberts (1986)** used the several meristic characters including the

number of rostral toothplate pairs, vertebrae, spines and fin rays for distinguishing among mastacembelid species.

Roberts (1989) surveys the species diversity of freshwater fish in western Borneo. Two genera and five species were recorded. Moreover he also described *Mastacembelus notophthalmus* (from Perak, west Malaysia) as a new species. The *M. notophthalmus* differs readily from all other mastacembelid species, but closely related to *M. armatus*.

Vreven and Teugels (1996) described a new species, *Aethiomastacembelus robertsi*, from the lower and Middle Zaire River basin in Africa. *A. robertsi* is morphologically close to *A. congicus* and *A. marchei*. The new species is distinguished from its congeners by its reduced eye size and its unique colour pattern.

Vreven and Teugels (1997) described a new species, *Aethiomastacembus traversi*, from the same locality of *A. robertsi*. The *A. traversi* is morphologically close to the *A. paucispinis* and the *A. congicus* species-complex. It is diagnosed by its long postanal length, its number of dorsal spines and its unique colouration.

Vreven (2004) described a new species, *Aethiomastacembelus shiloangoensis*, from the Shiloango River basin in Africa. It is distinguished from all other African mastacembelids by the following unique combination of characters: 1) 24-26+1 dorsal spines; 2) no preorbital or preopercular spines; 3) origin of soft part of dorsal fin situated anterior to origin of soft part of anal fin; 4) origin of first dorsal spine situated just behind posterior edge of pectoral fin and 5) its colour pattern.

Vreven (2005b) investigated the collections of the endemic *Mastacembelus ophidium* from the Lake Tanganyika using morphometrics and meristic counts. On each specimen 27 measurements and 12 meristic characters were carried out. Eventually, he discovered a new species, *Mastacembelus polli*, from the specimens previously identified as *M. ophidium*. The *M. polli* can be distinguished mainly from *M. ophidium* by its lesser dorsal spine number (21+1 to 28+1 (24+1) versus 27+1 to 33+1 (28+1)), its lesser caudal vertebrae number (48-58 (53) versus 63-70 (66)), and its related greater total vertebrae number (72-84 (77) versus 90-101 (95)). It also was

separated from *M. ophidium* by some measurements as diagnostic characters, which are the distance from anterior border of snout to last externally visible anal spine (%SL), the post anal length (%SL), and the body depth (%SL).

Vreven and Teugels (2005) confirmed that the *Mastacembelus reticulatus* Boulenger, 1911 and *M. laticulada* Ahl, 1937 should be placed in synonymy with *M. liberiensis*. They also documented and discussed about intraspecific meristics and morphometrics and colour pattern within *M. liberiensis*. Finally, a new species, *Mastacembelus kakrimensis* was identified and described. *M. kakrimensis* is most similar to *M. liberiensis*, but it differed from *M. liberiensis* by its lesser caudal and total vertebrae.

As can be seen from the number of new mastacembelid species described, the most new mastacembelid species have been found and reported from Africa. Nevertheless, **Britz (2007)** described two new species of *Mastacemeblus* from Myanmar. He is really interested in *M. armatus* species-complex because **Roberts (1986, 1989)** pointed out that there are at least three forms of the *M. armatus* species-group which are remarkable enough to warrant species status. After Roberts actions, there are numerous taxonomic difficulties particularly identification of *M. armatus* species-complex**.** Finally, **Britz (2007)** diagnosed two new species, *Mastacembelus tinwini* and *M. pantherinus,* from the *M. armatus* species-complex by unique colour patterns and number of vertebrae.

2.1.2 THE PREVIOUS STUDIES ON MASTACEMBELIDS IN THAILAND.

The most previous studies on spiny eels in Thailand are about species diversity surveys, whereas the information on taxonomy, morphology, anatomy, distribution and geographical variation of each species of mastacembelid fish is poorly less known.

First of all, **Suvatti (1936)** desired to bring together the widely scattered data on fishes of Thailand to serve as a foundation for further investigation. The classification was carried out based essentially on David S. Jordan, **"A Classification of Fishes"**, Stanford University, California, 1923. From the book named **"Index to Fishes of Siam"**, six mastacembelid species, *Mastacembelus argus*, *Mastacembelus armatus*, *Mastacembelus erythrotaenia*, *Mastcembelus armatus var. favus*, *Mastacembelus circumcinctus* and *Rhynchobdella aculeate*, were reported.

Next, the study on freshwater fish of Thailand had been begun to classify systematically when **Smith (1945)** studied the species diversity of freshwater fish and published the book named **"The Fresh-water Fishes of Siam, or Thailand"**, which is one of the most important books for identifying species of freshwater fish in Thailand. For the family Mastacemeblidae, two genera, *Macrognathus* and *Mastacembelus*, were recognized. Only one species belonged to the genus *Macrognathus* and eight species were placed in the genus *Mastacembelus*.

Nine mastacembelid species were reported *viz. Macrognathus aculeatus*, *Mastocembelus maculatus*, *Mastocembelus armatus armatus*, *Mastocembelus armatus favus*, *Mastocembelus argus*, *Mastocembelus circumcinctus*, *Mastocembelus taeniagaster*, *Mastocembelus erythrotaenia* and *Mastocembelus paucispinis*. Three mastacembelid records were additionally listed from **Suvatti (1936)**. Moreover, the *Rhychobdella aculeata* was changed to *Macrognathus aculeatus*. *Mastacembelus armatus* was separated two mastacembelid subspecies, *Mastacembelus armatus armatus* and *Mastacembelus armatus favus*.

Roberts (1980) revised the genus *Macrognathus* in Asia. Three mastacembelid species, *M. aral*, *M. aculeatus*, and *M. siamensis*, were reported. In

Thailand *M. aral* has not been reported, but it might present in parts of Thailand drained by the Salween River. Nevertheless**, Suvatti (1981)** did not add the *Macrognathus siamensis* to the species list of the family Mastacembelidae in the book named **"Fishes of Thailand"**.

The new list of freshwater fish of Thailand was published by **Vidthayanon *et al*. (1997)**. For the family Mastacembelidae twelve species, belonging two genera, were recognized as below:

I. Genus *Macrognathus* Lacepède, 1800

1. *Macrognathus aculeatus* (Bloch, 1787)
2. *Macrognathus circumcinctus* (Hora, 1924)
3. *Macrognathus maculatus* (Val. In Cuv. & Val., 1831)
4. *Macrognathus meklongensis* Roberts, 1986
5. *Macrognathus semiocellatus* Roberts, 1986
6. *Macrognathus siamensis* (Günther, 1861)
7. *Macrognathus zebrinus* (Blyth, 1858)

II. Genus *Mastacembelus* Scopoli, 1777

8. *Mastacembelus alboguttatus* Boulenger, 1893
9. *Mastacembelus armatus* (Lacepède, 1800)
10. *Mastacembelus erythrotaenia* Bleeker, 1853
11. *Mastacembelus favus* Hora, 1923
12. *Mastacembelus* sp.

The previous studies on spiny eels were grouped by accordance with the basins in order to be easily accessible. They are given as follows:

1) The Chao Phraya Basin

Somjaiwong (1962) surveyed aquatic fauna caught by the winged set bag in the Samut Sakhon estuaries from August 1961 to January 1962. Only one mastacembelid species, *Macrognathus aculeata*, was found.

Junlapong (1962) studied on the species of salted fishes sold in Bangkok. Two mastacembelid species, *Macrognathus aculeata* and *Mastacembelus armatus armatus*, were reported. However, the *M. aculeata* salted was produced in Phetchaburi province, not Bangkok, while the *M. armatus armatus* salted was produced in Phetchaburi and Samut Sakhon provinces. The both species were most largely sold during November to December.

Srikomut (1964) investigated on the fishes caught by Sao (Pong Pang) in Phra Nakhon Si Ayutthaya province from November 1963 to February 1964. There are two mastacembelid species, *Macrognathus aculeatus* and *Mastocembelus armatus armatus*. The number of *Mastocembelus armatus armatus* caught by Sao was more than that of *M. aculeatus*.

Srisomsab (1964) investigated on species diversity of aquatic fauna caught by Lee in Lop Buri province between November 1963 and January 1964. Two mastacembelid species, *Macrognathus aculeatus* and *Mastocembelus armatus armatus*, were recorded.

Thiencharoen (1964) investigated on the fishes caught by set bag at Pakret in Nonthaburi province between November 1963 and May 1964. One mastacembelid species, *Mastocembelus argus*, was found.

Taweesit (1964) studied on species diversity of fishes caught by crane lift net at Bangplee in Samutprakarn provice during December 1963 to March 1964. Two mastacembelid species, *Macrognathus aculeatus* and *Mastocembelus armatus armatus*, were found.

Chookajorn (1967) studied on species diversity of freshwater fishes caught by gill-net and set line at Phumipol Reservoir in Tak province during April to October in 1966. Two mastacembelid species, *Mastocembelus maculatus* and *Macrognathus aculeatus*, were found.

Champasi (1999) studied the species diversity of freshwater fish in the Yom River and its tributaries from June 1997 to May1998. There were 144 species

belonging to 28 families. Five mastacembelid species, *Macrognathus semiocellatus, M. siamensis, M. maculatus, Mastacembelus armatus* and *M. favus*, were recorded.

Phanthanit (2000) studied the species diversity of freshwater fishes in the Chao Phraya River from Nakhon Sawan to Phra Nakhon Si Ayutthaya provinces, which is approximately 250 kilometers in length in order to find out the number of fish species. There were 34 families and 131 species obtained from this study. Three species of spiny eels, *Macrognathus siamensis*, *M. semiocellatus* and *Mastacembelus favus*, were found.

Kaw-anantakul *et al.* (2003) investigated the number of fish species in the Bueng Boraphet Swamp (lower Chao Phraya basin), Nakhon Sawan province. There were 33 families and 150 species. Three mastacembelid species, *Macrognathus siamensis*, *Mastacembelus armatus* and *M. favus* were reported.

2) The Mekong Basin

Phukasawan (1966) surveyed the species diversity of freshwater fishes at Ubonratana (Pong Neep) Reservoir area before damed at Nampong, Khon Kaen province between April and June in 1965. Two mastacembelid species, *Macrognathus aculeatus* and *Mastocembelus armatus armatus*, were found.

Sakulphon (1966) surveyed the species diversity of freshwater fishes in Nong Han, Sakon Nakhon during April to June in 1965. Two mastacembelid species, *Macrognathus aculeatus* and *Masacembelus armatus armatus*, were reported.

Chookajorn (1988) carried out a survey of hydrological and fishery resources in Sirinthron Reservoir, Ubon Ratchathani province in 1987 after 17 years of impoundment. There are four mastacembelid species: *Macrognathus siamensis, M. semiocellatus, M. circumcinctus* and *Mastacembelus armatus*.

Jutagate *et al.* (2001) studied the fish diversity and ichthyomass at Pak Mun reservoir. There are fifty-nine species, of which three species, *Macrognathus semiocellatus*, *Mastacembelus armatus* and *M. circumcinctus* were mastacembelid fish. *M. semiocellatus* was one of the common species in the Pak Mun reservoir.

Pilasemorn *et al*. (2006) studied on fish community structure and its distribution in the Chi River by electrofishing and a set of gill net sampling during 2003-2005. Eighty-eight species in twenty-three families were found. Three mastacembelid species, *Macrognathus siamensis*, *Macrognathus taeniagaster*, and *Mastacembelus armatus*, were known.

3) The Meklong Basin

Wongrattana (1965) reported the species diversity of the Pla Soi (Cyprinidae) in Nong Bang Ngu, Ratchaburi province during October 1964 to February 1965. There are three species of spiny eels: *Mastocembelus armatus favus*, *Mastocembelus argus* and *Mastocembelus circumcinctus*.

Chookajorn *et al*. (1984) conducted a survey on fish population in Srinakarin Reservoir, Kanchanaburi province. Fourteen freshwater fish species were found by electrofishing method and there are two mastacembelid species, *Macrognathus aculeatus* and *Mastacembelus armatus*.

Chantsavang *et al*. (1986) carried out a survey of fishery resources and aquatic ecosystem in Nam Choan, Kanchanaburi province during April 1985. There are 10 families and 33 fish species. Only one mastacembelid species, *Mastacembelus armatus*, were found.

4) The Southern Basins

Based on the species diversity surveys (Sirimontaporn, 1984; Lertsuthichawan *et al*, 2001; Vidthayanon, 2002; Suthin *et al*, 2007), at least seven mastacembelid species were recorded in the southern basins.

Sirimontaporn (1984) studied the fish diversity in the Songkhla Lake, where has been divided into 6 areas, between 1981 and 1983. Three hundred and twenty-seven species were found and one mastacembelid species, *Mastacembelus circumcinctus*, was recorded in area V covering from a line between Ko Yai and Lam Chong Tanon to the northern end of Thale Luang and in area VI covering Thale Noi, the freshwater reservoir connected to Thale Luang.

Lertsuthichawan *et al*. (2001) surveyed the species diversity of freshwater fish in the areas of watershed in Nakhon Si Thammarat province. The survey had been conducted during October 2000 to September 2002. The result shows that 11 orders, 31 families, 67 genera and 112 species were recorded. They reported that seven mastacembelid species were found. However, based on picture plate 18 and 19, there are just six mastacembelid species: *Macrognathus aculeatus*, *M. circumcinctus*, *Mastacembelus armatus*, *M. erythrotaenia*, *M. favus* and *M. tinwini*.

Vidthayanon (2002) reported that four mastacembelid species, *Macrognathus aculeatus*, *M. circumcinctus*, *M. maculatus* and *Mastacembelus armatus*, were found in peat swamps of southern Thailand.

Sutin *et al*. (2007) examined freshwater fish diversity and water quality in the streams of the waterfalls at the Khao Luang Natioanl Park in Nakhon Si Thammarat. Twenty fish species belonging to nine families were found from nine waterfalls. Two mastacembelids reported were *Macrognathus aculeatus* and *Mastacembelus armatus*. The former species was only found at the Promlok waterfall and the latter species was found at the Kralom, the Thapae, and the Suankun waterfalls.

5) The Eastern Basins

Kittivorachate *et al*. (1985a) investigated fish landing statistics and socio-economics of the fisherman in the Bang Phra Reservior, Chonburi province from April 1984 to January 1985. Only one mastacembelid species, *Macrognthus aculeatus* was recorded in the reservoir. In the same year, **Kittivorachate *et al*. (1985b)** also investigated fish landing statistics and socio-economics of the fisherman in the Dokgrai Reservior, Rayong province over the same period. Only one mastacembelid species, *Macrognthus aculeatus* was found in the reservoir.

Soonthornkit (2001) studied on fish species diversity at the Khao Kitchakut National Park and the Khao Soi Dao Wildlife Sanctuary in Chanthaburi province. There are twenty-one families, forty-two genera, and sixty-seven species. Four mastacembelid species were found. Two species belongs to the genus *Macrognathus* (*M. siamensis and M. circumcinctus*), while the rest of species belongs to the genus *Mastacembelus* (*M. armatus*, and *M. favus*).

2.1.3 THE PREVIOUS REPORTS ON MASTACEMBELID SPECIES IN OTHER ASIAN COUNTRIES.

Fowler and Bean (1920) found one mastacembelid species, *Mastacembelus sinensis*, from Soochow, China.

Munro (1955) reported that two mastacembelid species, *Macrognathus aculeatus* and *Mastacembelus armatus* in Ceylon

Inger (1962) reported three species of spiny eels from the north Borneo. They are *Mastacembelus maculatus*, *M. keithi* and *M. armatus*.

Shrestha (1994) reported three mastacembelid species, *Macrognathus aculeatus*, *Mastacembelus armatus* and *M. pancalus*, in Nepal.

Lim and Ng (1995) reported one species, *Macrognathus maculatus*, in Singapore.

Rainboth (1996) reported seven mastacembelid species, *Macrognathus maculatus*, *M. taeniagaster*, *M. siamensis*, *Macrognathus* sp., *Mastacembelus armatus*, *M. erythrotaenia* and *M. favus* in the Mekong River, Cambodia.

Ng and Tan (1999) investigated on species diversity of freshwater fishes in the Endau basin, Peninsular Malaysia. A total of 108 species belonging to twenty-six families, of which four mastacembelid species, *Macrognathus aculeatus*, *M. maculatus*, *Mastacembelus erythrotaenia* and *M. favus*, were recorded.

Ng, Tan and Lim (1999) studied on species diversity of inland fishes at the Pulau Tioman, Peninsular Malaysia. Forty-eight species were known from the inland drainages, of which one species, *Macrognathus maculatus*, was mastacembelid fish and it was first recorded from the Pulau Tioman in 1995. The present specimen was obtained from the same drainage in a rocky area with clear and fast flowing water.

Lim *et al.* (1999) researched the diversity and spatial distribution of freshwater fish in the Great Lake and the Tonle Sap River in Cambodia. One

hundread and twenty species were found, of which six species, *Macrognathus siamensis*, *M. maculatus*, *M. taeniagaster*, *Mastacembelus erythrotaenia*, *M. favus*, and *M. armatus* were mastacembelid species.

Nyanti, Yee and Adha (1999) investigated on freshwater fish communities at Bario, Kelabit Highlands Sarawak. Twenty-four species belonging to seven families and nineteen genera were recorded from the area. One mastacembelid species, *Mastacembelus unicolor*, was found.

Türkmen and Alpbaz (2001) investigated the importing of ornamental fish and imported species in Turkey. According to this investigation 227 freshwater fish species and 51 species of marine fish have been imported. There are two mastacembelid species, *Macrognathus siamensis* and *M. zebrinus*, which were imported from Asia.

Ng and Tan (2004) described *Ompok platyrhynchus* collected from Borneo as a new species and reported that *Macrognathus maculatus* is one of syntopic fishes of *Ompok platyrhynchus*.

Kakarabdullahzai and Kakarsulemankhel (2004) conducted the survey of fish fauna of river, Balochistan, Pakistan during July to August 2001. As a result, twenty-two species were recorded. Out of these, two species, *Mastacembelus armatus* and *M. pancalus* were mastacembelid fish which was a new record from Balochistan.

Ali *et al*. (2004) investigated the fish species in the fish landing centers of Khulna district, Bangladesh. A total of one hundred and twenty-six species belonged to fin fish, of which fifty-three species were freshwater fish and two species, *Macrognathus aculeatus* and *M. pancalus*, were mastacembelid fish.

Rachmatika *et al*. (2005) studied the fish species diversity of the Middle Malinau watershed located in the Indonesian province of the East Kalimantan on the island of Borneo. Forty-seven species belonging to 32 genera, 13 families and 3 orders were recorded. There are two mastacembelid species, *Macrognathus maculatus* and *Mastacembelus unicolor*, found in the Seturan watershed.

Vidthayanon, Termvidchakorn, and Pe (2005) surveyed the species diversity of freshwater fish in Yangon, Bago, Ba-U-Min, Mandalay, and the Lake Inle including the Salween and the Tennasserim basin during December 2002. Over 280 species were found and four mastacembelid species, *Macrognathus caudiocellatus*, *M. aral*, *M. zebrinus*, and *Mastacembelus armatus* were recorded.

Atack (2006) surveyed the species diversity of fish inhabiting the rivers of Kuching, Sarawak, and Malaysian Borneo. One species of spiny eel, *Mastacembelus erythrotaenia*, was found.

2.1.4 BIOLOGY OF MASTACEMBELID SPECIES

- **Anatomical studies**

Britz (1996) studied on ontogeny of the ethmoid region and hyopalatine arch in *Macrognathus pancalus*.

- **Chromosome Studied**

Donsakul and Magtoon (1989) studied the chromosome and karyotype of *Mastacembelus favus* and *M. erythrotaenia* from Thailand. They found that the diploid chromosome number of *M. favus* and *M. erythrotaenia* were 48 but the karyotype pattern of the former was different from the latter. The former comprised 5 pairs of metacentric, 2 pairs of submetacentric, 2 pairs of subtelocentric, and 15 pairs of acrocentric chromosomes and the total arm number is 62, whilst the latter comprised 6 pairs of metacentric, 1 pair of submetacentric, and 17 pairs of acrocentric chromosomes and the total arm number is 62.

This result might be concluded that *M. favus* was closely related to *M. erythrotaenia*. The chromosome numbers of *M. favus* and *M. erythrotaenia* were the same as that of the previous study in *Rhynchobdella aculeata* **(Kaur and Srivastava, 1966).**

Donsakul and Magtoon (1992) studied the chromosome and karyotype of *Macrognathus siamensis*, *M. circumcinctus*, *M. aculeatus*, and *Mastacembelus armatus* from Thailand. They found that the diploid chromosome number of *M. siamensis*, *M. circumcinctus*, *M. aculeatus*, and *M. armatus* were 48 but the karyotype patterns were different among all species.

The karyotype of *M. siamensis* comprised 4 pairs of metacentric, 1 pair of subtelocentric, and 19 pairs of acrocentric chromosomes. The karyotype of *M. circumcinctus* comprised 7 pairs of metacentric, 1 pair of submetacentric, and 16 pairs of acrocentric chromosomes. The karyotype of *M. aculeatus* comprised 7 pairs of metacentric, 2 pairs of subtelocentric, and 15 pairs of acrocentric chromosomes. The karyotype of *M. armatus* comprised 6 pairs of metacentric, 1 pair of submetacentric,

and 2 pairs of subtelocentric and 15 pairs of acrocentric chromosomes. The total arm numbers were 56, 64, 62, and 62 respectively.

- **Reproductive biology**

Das and Kalita (2003) attempted to breed *Macrognathus aculeatus* under captive conditions at first. They found that a size of around 16 to 20 cm in length was suitable for induced breeding and in Assam, the breeding season will start in April and will be peak in June to July. They also conducted their breeding trials in a small glass aquarium and maintained the suitable water quality for them to study courtship behaviour and larval rearing.

- **Ecology**

Suresh *et al*. (2006) studied about food habits, reproductive biology, length-weight relationship, fishery resource status of barred spiny eel *Macrognathus pancalus* for artificial propagation programs and fisheries guidelines for conservation of its natural populations.

- **Behaviours**

Abe (1998) studied about social organization and parental care of a spiny eel, *Aethiomastacembelus platysoma*, in the Lake Tanganyika. This study was considered as the first report demonstrating the occurrence of parental care in mastacembelids.

- **Others**

Kritsky *et al*. (2004) studied monogenoids from the gills of four mastacembelid species, *Macrognathus pancalus, M. aculeatus, Mastacembelus armatus* and *M. mastacembelus* in India and Iraq. *Mastacembelocleidus* gen. n. (Monogenoidea: Dactylogyridae) was proposed to included two species collected and redescribed from the gills of *Macrognathus pancalus* (new host record) and *Macrognathus aculeatus* from India; and *Mastacembelocleidus heteranchorus* from the gills of *Mastacembelus armatus* from India and *Mastacembelus Mastacembelus* from Erbil, Iraq.

2.2 THE RIVER SYSTEMS OF THAILAND

In Thailand, the Royal Irrigation Department has divided river system of Thailand into 25 River basins **(FIGURE 2.3)** as below:

1. Salween River basin
2. Mekong River basins
3. Kok River basin
4. Chi River basin
5. Mun River basin
6. Ping River basin
7. Wang River basin
8. Yom River basin
9. Nan River basin
10. Chao Phraya River basin
11. Sakae Krang River basin
12. Pa Sak River basin
13. Tha Chin River basin
14. Meklong River basin
15. Prachin Buri River basin
16. Bang Pakong River basin
17. Tonele Sap River basin
18. Eastern coast River basin
19. Phetchaburi River basin
20. Coast of Prachuap Khiri Khan River basin
21. Southern River basin of Thailand on the East side
22. Tapi River basin
23. Songkla Lake River basin
24. Pattani River basin
25. Southern River basin of Thailand on the West side

However, twenty-five river basins are grouped to six major basins (the Chao Phraya, the Salween, the Meklong, the Mekong, the Southern and the Eastern basins). The classification of the basins was modified from **Kottelat (1989)**, **Rainboth (1991)** and **Vidthayanon *et al*. (1997) (FIGURE 2.4)**.

- **The six major basin of Thailand**

1. Chao Phraya basin: Ping, Wang, Yom, Nan, Chao Phraya, Lop Buri, Thachin, Sakae Krang, Pa Sak rivers.

2. Salween basin: Moei, Pai, Yuam, Salween rivers.

3. Meklong basin: Meklong Yai, Kwae Yai, Kwae Noi, Mae Klong, Phetchaburi rivers.

4. Mekong basin: Mekong, Chi, Mun, Songkhram rivers.

5. Southern basin: Trang, Krabi, Golok, Tapi rivers.

6. Eastern basin: Bang Pakong, Prachin Buri, Rayong, Welu, Chanthaburi, Trat rivers.

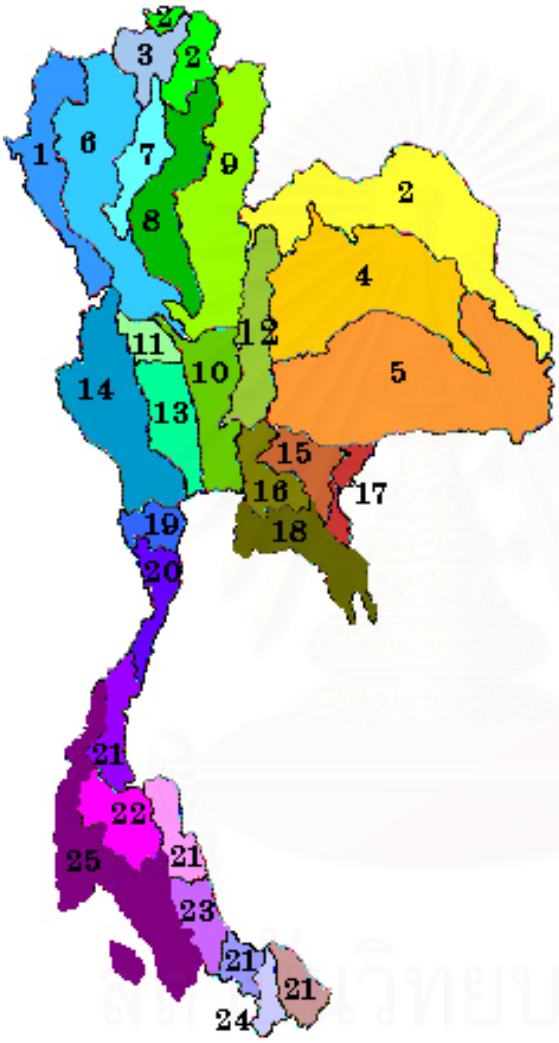

FIGURE 2.4. River basins map of Thailand (Royal Irrigation Department, Thailand).

No.	River Basin
1	Salween
2	Mekong
3	Kok
4	Chi
5	Mun
6	Ping
7	Wang
8	Yom
9	Nan
10	Chao Phraya
11	Sakae Krang
12	Pa Sak
13	Thachin
14	Meklong
15	Prachinburi
16	Bang Pakong
17	Tonle Sap
18	Eastern coast
19	Phetchaburi
20	Coast of Prachuap Khiri Khan
21	Southern basin on the east side
22	Tapi
23	Songkhla Lake
24	Pattani
25	Southern basin on the west side

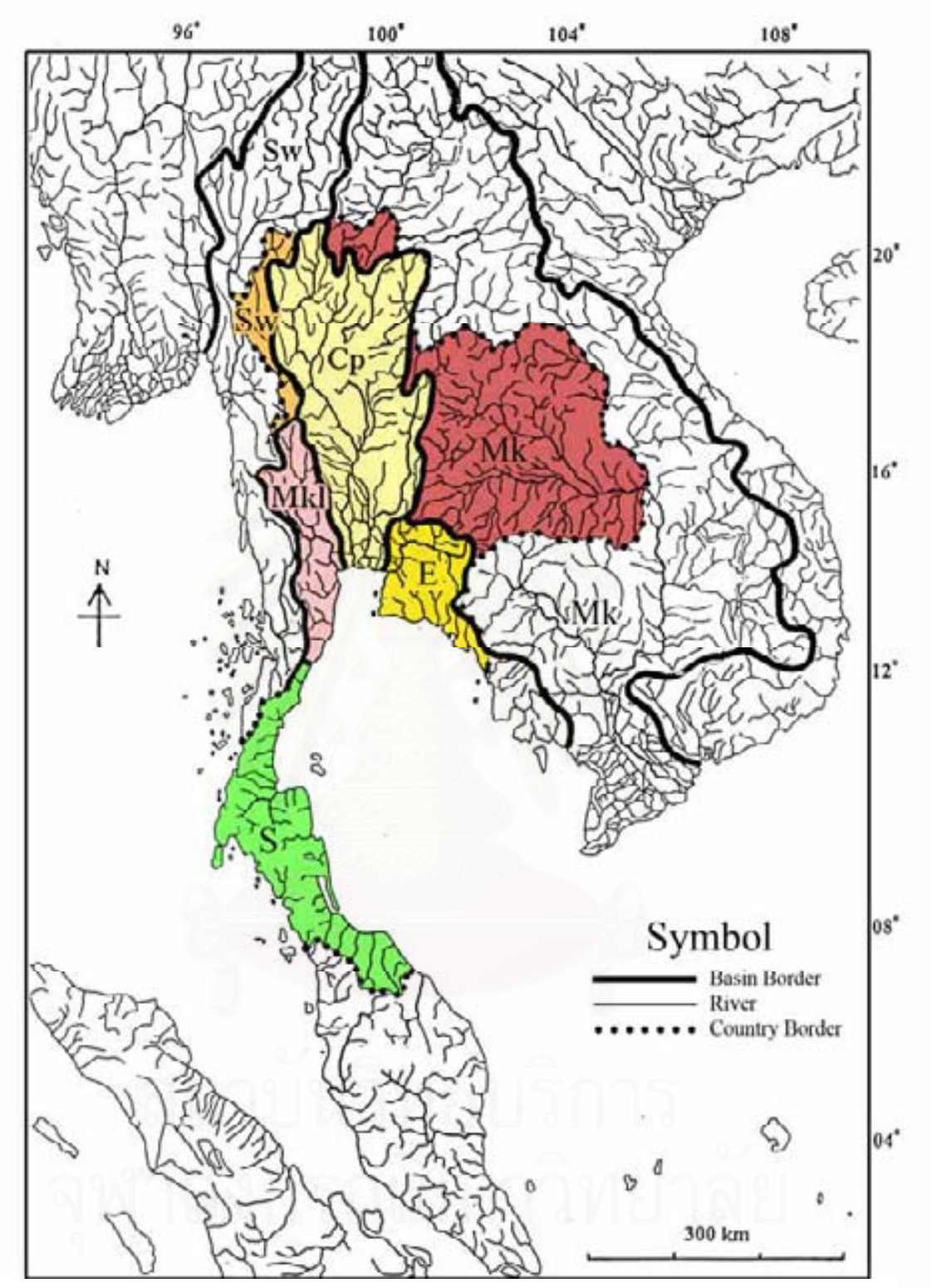

FIGURE 2.5. Main basins of Thailand. Cp = the Chao Phraya basin, Sw = the Salween basin, Mk =the Mekong basin, Mkl = the Meklong basin, S = the Southern basins, E = the Eastern basins.

2.2.1 THE CHAO PHRAYA BASIN

The Chao Phraya basin is seemed to be the most important blood vessels of the northern and central Thailand. The system originates from watersheds of the two mountainous ranges, Thanon Thongchai and Peepunnam Ranges. The Chao Phraya basin has been drained by four major rivers: Ping, Wang, Yom and Nan rivers which are linked to the mainstream of the Chao Phraya River at **"Pak Nampho"**, Nakhon Sawan province. Next the Chao Phraya River flows through central plains before running off into Gulf of Thailand.

The principal tributaries of the Chao Phraya River are the Pa Sak River, the Sakae Krang River, the Nan River (along with its principal confluent the Yom River), the Ping River (with its principal confluent the Wang River), and the Tha Chin River. The Nan and the Yom River flow nearly parallel from Phitsanulok province to Chum Saeng district in Nakhon Sawan province. The Wang River enters the Ping River near Sam Ngao district in Tak province. The Chao Phraya River connects with Sakae Krang and Thachin from western and is also confluent with the Pa Sak River from the Phetchabun Range.

The climate is dominated by the Southwest monsoon occurring between May and October. About 90 percent of annual rainfall occurs during this period and causes heavy flood every year. The scarcity of rain between November and April makes unfavorable agricultural conditions. The most important reservoir is the Chao Phraya Reservoir in Chai Nat province.

The basin can be characterized geographically into upper and lower basins. The upper basin is mountainous, with 40 percent forest cover and 41 percent cultivated land, while the lower basin is the floodplain areas, which was mainly employed for agriculture and crop plantation especially rice. The total area of the basin is about 21,725 km^2.

As mentioned above, the Chao Phraya basin is the largest and most important geographical unit in terms of land and water resources development. The more details of some main rivers are given as follows:

- **Chao Phraya River**

The Chao Phraya River is one of the main rivers in Thailand, with its low alluvial river plain, marking the mainland of the country. The Chao Phraya River originates at the confluence of the Ping and Nan rivers at “Paknam Pho”, Nakhon Sawan province. Then it flows from north to south with 372 kilometers, via the central plains before running off into Gulf of Thailand. In Chai Nat province the Chao Phraya River splits into the main river course and the Tha Chin River. The low alluvial plain begins below the Chao Phraya Reservoir and many small canals (khlong) split off from the main river. Many provinces are located along the Chao Phraya River including Nakhon Sawan, Uthai Thani, Chai Nat, Sing Buri, Ang Thong, Phra Nakhon Si Ayutthaya, Pathum Thani, Nonthaburi, Bangkok and Samut Prakan provinces, listed from north to south.

- **Ping River**

The Ping River is one of the two main tributaries of the Chao Phraya River. The Ping River originates at Doi Chiang Dao in Chiang Dao district, Chiang Mai province. After passing Chiang Mai town, it flows through the Lamphun, Tak and Kamphaeng Phet provinces. At the confluence with the Nan River in Nakhon Sawan province named “Paknam Pho”, it forms the Chao Phraya River.

- **Wang River**

The Wang River has a length of 335 kilometers and it runs in a south to north direction. It flows from Lampang province and extends north towards Chiang Rai province. However it is linked with the Ping River at the Mueang Tak district in Tak province. The Wang basin is a part of the Greater Ping and the Chao Phraya basins.

- **Yom River**

The Yom River is the main tributary of the Nan River. The Yom River originates in Pong district, Phayao province. It flows from Phayao province through Mae Yom National Park (Phrae province) and Mueang Sukhothai district (Sukhothai province) as the main water source of both provinces before draining into the Nan

River at Chum Saeng district, Nakhon Sawan province. The Yom River and its tributaries drain a total area of 23,616 km^2 in the provinces including Sukhotahi, Phitsanulok, Pichit, Phrae and Lampang province. The Yom basin is a part of the Greater Nan and the Chao Phraya basins.

- **Nan River**

The Nan River is one of the most expansive tributaries of the Chao Phraya River. The Nan River originates in Nan province. It flows through Uttaradit, Phichit and Phitsanulok provinces. The Nan River joins the Yom River at Chum Saeng district, Nakhon Sawan province. It becomes the Chao Phraya River when the Nan River joint together with the Ping River at Pak Nam Pho within Muaeng Nakhon Sawan district, Nakhon Sawan province.

- **Sakae Krang River**

The Sakae Krang River is one of the tributaries of the Chao Phraya River. It originates in Mae Wong National Park, Kamphaeng Phet province. It flows through Haui Kha Kaeng Sanctuary, Uthai Thani province and it tributes the Chao Phraya River in the town of Uthai Thani province around Tha Sung temple. The Sakae Krang River is a part of the Chao Phraya basin.

- **Pa Sak River**

The Pa Sak River originates in the Phetchabun Mountains in Dan Sai district, Loei province. It flows through Lop Buri and Saraburi provinces before joining with the Chao Phraya River at Phra Nakhon Sri Ayutthaya province. The total length of the Pa Sak River is about 513 kilometers.

The Pa Sak River basin is a long and narrow feature. At present, the Pa Sak River Reservoir was constructed by the Royal Irrigation Department. The purposes of the Dam are to solve the water problem and benefit the agricultural areas of the Pa Sak River Basin, as well to reduce flooding which normally occurs in the Pa Sak River Basin, Bangkok and metropolitan areas.

- **Tha Chin River**

The Tha Chin River is one of distributaries of the Chao Phraya River. It splits near the town of Chai Nat province and then flows in the west direction from the Chao Phraya River through the central plain, until it run off into the Gulf of Thailand at the town of Samut Sakhon province.

It is interesting to note that the Tha Chin River has many regional names. After splitting from the Chao Phraya River at Chai Nat province, it is called the **Makhamthao River**. When it passes Suphan Buri province, it is named Suphan River. Next it runs through Nakhon Pathom province, it becomes the Nakhon Chaisi River. Finally it is called the Tha Chin River again when it run off into the Gulf of Thailand.

- **Lop Buri River**

The Lop Buri River is one of the tributaries of the Chao Phraya River. It splits from the Chao Phraya River at Bang Phutsa district, Sing Buri province. It passes through Tha Wung and Muaeng Lop Buri districts in Lop Buri province and then enters the Chao Phraya River together with the Pa Sak River at the Mueang Phra Nakhon Si Ayutthaya district. It has a length of about 95 kilometers.

2.2.2 THE SALWEEN BASIN

In Thailand there are numerous tributaries of the Salween River. The most tributaries has oriented from east to west and from northwestern except the Yuam and the Moei Rivers which has directed from north to south and from south to north respectively. The most area condition is the Plateau of Tanon Thongchai Mountain. The most tributaries flow along river valleys which have bottom with sand, gravels and boulders.

The important main tributaries of this river basin are the Moei, the Yuam and the Pai Rivers including Huai Mae Krasa and the Suriya-Maekasat River in Thung Yai wildlife Sanctuary, Kanchanaburi province. The more details of certain rivers are given as below:

- **Salween River**

The Salween River is an international river, originating from Tangula Mountain of the Himalayas in the Tibetan plateau. It flows through river valleys that are steep and long narrow then increasingly broad as the river approaches the tropical lowlands. The Salween then runs southward through Yunnan Province of China, down through Shan and Kayah States in the east of Myanmar and along the Thai-Myanmar border, passing through Kayan and Mon States in Myanmar. Eventually it runs off to the Gulf of Martaban in the Andaman Sea.

The watershed area is located in China (53%), Myanmar (42%), and Thailand (5%). The river forms the border boundary between Myanmar and Thailand for about 120 km, before meeting with the Moei River (Thaungyin River in Myanmar), a major tributary of the Salween that also divides the two countries.

The Salween River Basin provides a unique Indo-Burmese fauna is different from the other basins in Thailand, but share similarities with the Ganges and Irrawaddy River faunas.

- **Moei River**

The Moei River is one of tributaries of the Salween River. It rises in Myanmar and runs through Mae Sot, Mae Ramat and Tha Song Yang districts. Finally it joins the Salween River at Sob Moei district, Mae Hong Son province. Unlike most rivers in Thailand, it has flowed up to north and formed the natural border boundary between Myanmar and Thailand. The river is approximately 355 kilometers long.

- **Yuam River**

The Yuam River originates in Doi Khun Yuam, Khun Yuam district, Mae Hong Son province. It flows through Mae La Noi, Mae Sariang, and Sob Moei districts. It then has formed border line between Sob Moei district, Mae Hong Son and Tha Song Yang districts, Tak province. It eventually meets to the Moei River. The river is about 240 kilometers long.

- **Pai River**

The Pai River originates in Doi Luang in Tanon Thong Chai Mountain which has formed a border boundary between Thailand and Myanmar at Pai district, Mae Hong Son province. It then through from Mueang Mae Hong Son district to border boundary between Thailand and Myanmar at Nam Phiang Din village. It finally enters to Myanmar and joins the Salween River. The river is roughly 190 kilometers long.

2.2.4 THE MEKONG BASIN

The Mekong basin, the twenty-first largest basin in the world, is an area of high genetic, species and ecosystem diversity nourished by the Mekong River and by its tributaries. The Mekong basin is divided into **"Upper Mekong Basin"** and **"Lower Mekong Basin"** by considering from characters of subwatershed and biogeographical zone. Thailand is located in Lower Mekong Basin and the most area of the Lower Mekong basin is Khorat plateau.

Besides the Mekong River, the Mekong basin is also drained by three main tributaries, the Chi-Mun Rivers, the Nam Nguem and the Nam Teun Rivers of Laos PDR and the Tonle Sap river of Cambodia where connected with the Great Lake. It is interesting to note that some streams in the eastern side of Khao Soi Dao are also linked with the Great Lake. The more details of certain rivers are given as below:

- **Mekong River**

The Mekong River is one of the world's 12^{th} longest river in its river length and the world's 10^{th} largest river by volume (MRCS, 1992). It has considered as the major international rivers and considerably influenced upon nature, culture and societies of the Indo-china Peninsula. The Mekong River originates from the eastern Tibethan Plateau and drains through seven countries (China, Myanmar, Laos PDR, Thailand Cambodia and Vietnam), before running off into the South China Sea at the Mekong Delta of Southern Vietnam.

In Thailand, the Mekong River runs through Chiang Sean and Chiang Kong districts in Chiang Rai province, and then it flows through Laos. After that it runs

through Thailand again by flowing from Chiang Khan district in Loei province to Kong Chiam district in Ubon Ratchathani province. In addition, there are Mun and Chi Rivers which are important tributaries of the Mekong basin in Thailand.

- **Mun River**

The Mun River, is one of tributaries of the Mekong River. The Mun River originates in the Khao Yai National Park near Nakhon Ratchasima province. Then it runs east through southern Isan (Buri Rum, Surin and Si Sa Ket provinces) with 673 kilometers before joining the Mekong River at Khong Chiam in Ubon Ratchatani.

- **Chi River**

The Chi River is the longest river in Thailand. It has a length of 765 kilometers, but it can carry the amount of water less than the second longest river, the Mun River. The Chi River originates in the Phetchabun Mountains, and then it runs east through Chaiyaphum, Khon Kaen and Maha Sarakham province before turning south in Roi Et and then running through Yasothon to meet the Mun River in Kanthararom district in Si Sa Ket province. The Chi River basin is one of the important river basins located in the middle of eastern part of Thailand.

- **Kok River**

The Kok River originates in Shan state, Myanmar. It flows down and across the Myanmar-Thailand border to Mae Ai district in Chiang Mai province. Most of its length is in Chiang Rai province passing the Mueang Chaing Rai district, Mae Chan, Chiang Saen and Wiang Chai districts in Chiang Rai province. The Kok River drains to the Mekong River at Chiang Saen district.

2.2.4 THE MEKLONG BASIN

The Meklong basin is located in the western Thailand. The Meklong basin is supported by several important water sources including Meklong Yai, Kwae Yai (Si Sawad), Kwae Noi (Siyok), Meklong, Pa Chi, and Phetchaburi Rivers and other drainages above the Kra Isthmus. The watersheds have been supported by the vast

areas of the western rain forest, the Umpang, Thungyai and Huai Kha Khaeng Wildlife Sanctuaries and the Kaeng Krachan National Park, which have been internationally recognized as the World Heritage Sites. The more details of certain rivers are given as below:

- Meklong River

The Meklong River originates at the confluence of the **"Khwae Noi"** or Kwai Sai Yoke and the **"Khwae Yai"** River or Kwai Si Sawasdi in the Khuean Srinagarindra National Park of Kanchanaburi. It passes Ratchaburi province and run off into the Gulf of Thailand at Samut Songkhram province.

2.2.5 THE SOUTHERN BASINS

The Southern basins are located on the Peninsular Thailand. The western part has steeper coasts, but on the east side river plains dominate. The watershed areas begins at southward of the Kra Isthmus, extending throughout the Malay Peninsula. There are several relatively short rivers to drain the southern basins of Thailand, including the Chumphon, the Tapi, the Pakpanang, the Pattani, the Sai Buri, and the Go Lok Rivers, which run off into Gulf of Thailand, while the Kra buri, the Krabi, and the Trang Rivers, which run off into Andaman Sea.

The longest river of the south is the Tapi, which together with the Phum Duang River drains more than 8,000 km², more than 10% of the total area of southern Thailand. Smaller rivers include the Pattani, the Saiburi, the Krabi and the Trang. The biggest lake of the southern Thailand is the Songkhla lake (1,040 km² altogether), the largest artificial lake is the Ratchaprapha reservoir with 165 km² within the Khao Sok National Park. The more details of certain rivers are given as follows:

- **Tapi – Phum Duang River**

The Tapi River originates at the Khao Luang and has a length of 230 kilometers. The river drains an approximately area of 5,460 km^2.

The Phum Duang River (rarely also named the Khirirat River) is the most important main tributary of the Tapi River. The river joins the Tapi estuary (roughly 15 km) at Phunphin district in Surat Thani province.

- **Pattani River**

The Pattani River runs west to east from the central peninsular mountain range to the gulf of Thailand at Pattani Bay. The Pattani river basin covers an area including Yala and Pattani provinces, with the Pattani River as the main tributary with a length of 210 kilometers.

- **Golok River**

The Golok River Basin is located at the north-eastern tip of Peninsular Malaysia, which borders Thailand. The main river has a total length of about 76 kilometers.

- **Kraburi River**

The Kraburi River (also called the Pakchan River) is one of the boundary rivers between Thailand and Myanmar at the Kra Isthmus of the Malay Peninsula. The river flows into the Andaman Sea.

- **Trang River**

The Trang River flows through the Trang province from its origin in the Khao Luang mountain range and the Palian River from the Banthat mountain range.

2.2.6 EASTERN BASINS

The Eastern basins covers areas of southeastern Thailand, drained by several main rivers including the Bang Pakong, the Prachin Buri, the Rayong, the Pra Sae, the Chanthaburi, the Welu and the Trat Rivers. The Eastern basins particularly watershed drained by the Rayong, the Chanthaburi, the Welu and the Trat Rivers has the aspect of climatic and species occurrence which are similar to the Peninsular Thailand (southern basins). More details of certain rivers are given as follows:

- **Bang Pakong River**

The Bang Pakong River starts at the confluence of the Nakhon Nayok River and the Prachin Buri River at Pak Nam Yotaka in Bang Sang district, Prachin Buri province. Then it passes Prachin Buri province, Bang Nam Priao and Bang Khla districts of Chachoengsao province before running into the Gulf of Thailand at Bang Pakong district, Chachoengsao province with the distance of 230 kilometers.

- **Prachin Buri River**

The Prachin Buri river starts at the confluence of the Phra Prong, Hanuman and Prachantakham Rivers in Kabin Buri district, Prachin Buri province. It then passes Si Maha Phot, Mueang Prachin Buri and Ban Sang districts. Finally, the Prachin Buri river merges to the Nakhon Nayok river to be the Bang Pakong River at the border of Ban Sang district in Prachinburi province and Bang Nam Priao district in Chachoengsao province.

- **Rayong and Pra Sae Rivers**

Rayong has two major rivers, namely Rayong and Pra Sae Rivers. The Rayong River called Khlong Yai flows through Pluak Daeng, Ban Khai, and Mueang Rayong districts before running off into the Gulf of Thailand with the distance of about 50 kilometers. The Pra Sae River originates in Chanthaburi mountain range and flows through Khao Chamao sub-district, Klaeng district before running off into the Gulf of Thailand with the distance of 120 kilometers.

- **Chanthaburi River**

The North of Chanthaburi is marked by a mountain range, a mountain-base plain which is the origin of the Chanthaburi River, with shore plain and low land of a river mouth in the South.

- **Trat River and Khao Rakham Reservoir**

The Trat River originates from Khao Banthat mountain range and it then flows through Bo Rai and Khao Saming districts before running off into the Gulf of Thailand at Muaeng Trat in Trat province.

CHAPTER III

MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Specimens

Specimens for this study were taken from two sorts: the first from the collections deposited in museums and institutions in Thailand and the second from specimens newly collected throughout Thailand.

3.1.2 Collecting tools

1) Collecting jars in various sizes
2) Permanent labeling pens
3) Labeling papers

3.1.3 Laboratory tools

1) Vernier caliper
2) Standard ruler
3) Dissecting tools
4) Digital camera

3.1.4 Microscope

1) Stereo microscope
2) Fiber optic light source

3.1.5 Computer Programs

1) Software program Adobe Photoshop CS 3 and SPSS 16.0
2) Software program eFilm Workstation^{TM} 2.1

3.1.6 Chemicals for Clearing and Staining

1) 10% formalin

2) 0.5% and 10% aqueous KOH solution

3) 3% H_2O_2 solution

4) Alcian blue solution: 10 mg of alcian blue 8GN, 80 ml of 95% ethyl alcohol and 20 ml of glacial acetic acid

5) Alizarin red S solution: enough alizarin red S add to 0.5% aqueous KOH until the solution turns to deep purple

6) Glycerine

7) Thymol

3.2 METHODOLOGY

3.2.1 Mastacembelid Materials and Sampling Collection

This study is based on examination of mastacembelid specimens deposited in Chulalongkorn University Museum of Zoology, CUMZ; Kasetsart University Museum of Fisheries, KUMF; National Inland Fishery Institute, NIFI and University of Michigan Museum of Zoology, UMMZ. In addition, numerous lots of freshly specimens were newly collected throughout Thailand from June 2006 to September 2007.

All specimens were fixed in 10% formalin and subsequently transferred to 70% ethyl alcohol. All mastacembelid materials collected during this study period were registered the collection number for each set and individual number for each specimen in each set too. Other information of each collection number were labeled on labeling paper for record including the collection number, scientific name, locality, collecting date, collector's name and fishing gear. After cataloging, all specimens were deposited in the Chulalongkorn University Museum of Natural History.

Specimens of mastacembelid species were classified and identified by following main literatures: Smith (1954), Sufi (1956), Roberts (1980, 1986, 1989), Vreven & Teugels (1996, 1997, 2005) and Vreven (2005a) and Britz (2007).

The best specimens of each species were chosen for photograph and describing. The collection number of specimens and collected localities are presented in Appendix 1.

3.2.2 Study Sites

This study was conducted throughout basins of Thailand. In general, the river system of Thailand can be divided into 25 River basins (see Figure 3). However, all river basins are grouped to six major river systems or basins: the Chao Phraya, the Salween, the Meklong, the Mekong, the rivers of southern Peninsula (Southern basin) and rivers of southeastern part (Eastern Basin) by **Kottelat (1989)**, **Rainboth (1991)** and **Vidthayanon *et al***. (1997). Mastacembelid materials were collected from 6 basins of Thailand (see FIGURE 3.1).

1. Chao Phraya basin: Ping, Wang, Yom, Nan, Chao Phraya, Lop Buri, Thachin, Sakae Krang, Pa Sak rivers.

2. Salween basin: Salween, Moei, Pai, Yuam rivers.

3. Mekong basin: Mekong, Chi, Mun, Songkhram, Kok rivers.

4. Meklong basin: Meklong, Kawe Yai, Kawe Noi, Phetchaburi rivers.

5. Southern basins: Pattani, Tapi, Trang, Chumporn, Saiburi, Kolok rivers.

6. Eastern basins: Bang Pakong, Prachin Buri, Prasae, Weru, Chanthaburi, Trat rivers.

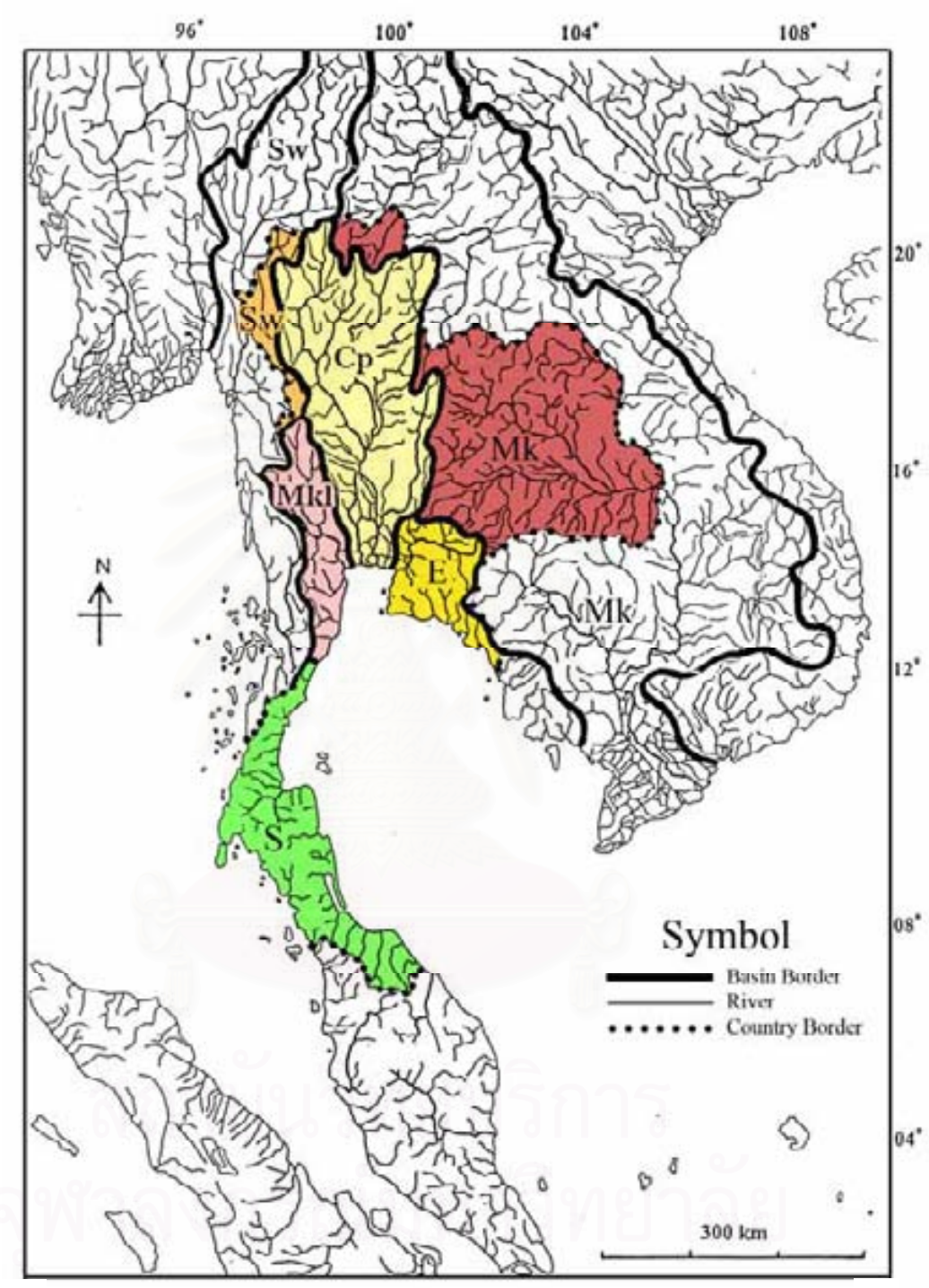

FIGURE 3.1. Study sites for sampling specimens. Cp = the Chao Phraya basin, Mk = the Mekong basin, Sw = the Salween basin, Mkl = the Meklong basin, S = the Southern basins, E = the Eastern basins.

3.2.3 Morphometric Measurements and Meristic Counts.

Morphometrics and meristics were taken according to Sufi (1956), Roberts (1980, 1986), Vreven & Teugels (1996, 1997, 2005) and Vreven (2005a). On each specimen 44 measurements and 13 meristics were taken.

All measurements were taken point to point with a vernier caliper or standard ruler (for measurements longer than 120 mm.), on the left side of the specimens, whenever possible. Standard length is expressed in millimeters (mm.) and all other measurements of adults are expressed as percent of standard length (%L_S), except subunits of the head, which are expressed as percent of head length (%L_H). On each specimen forty-four measurements and thirteen meristic characters were taken. Numerical data was recorded and applied to further statistically calculate and analyze.

A complete description of the morphometric features and meristic counts examined is given below.

MORPHOMETRIC MEASUREMENTS (see FIGURE 3.2-3.3).

1) Total Length (TL): from tip of rostrum (fleshly appendage) to tail tip;

2) Standard Length (SL): from tip of rostrum to base of caudal fin;

- ***In percentage of Head Length (%L_H)***

3) Snout Length (SnL): from tip of rostrum to anterior edge of eye;

4) Horizontal Eye Diameter (ED): distance between anterior and posterior borders of orbit;

5) Head width (HW): width of skull between orbits at the posterior edges of eyes;

6) Rostral Appendage Length (RAL): from anterior tip of rostral appendage to anterior edge of snout;

7) Angle of jaws to tip of rostral appendage (AjTRA): from angle of jaws to tip of rostral appendage;

8) Postorbital Length (PoL): from posterior edge of eye to dorsal edge of pectoral-fin base;

9) Postjaw angle Length (PjaL): from angle of jaws to dorsal edge of pectoral fin base;

10) Post-preorbital spine Length (PpsL): from posterior tip of preorbital spine to dorsal edge of pectoral-fin base;

11) Upper Jaw Length (UjL): from anterior edge of premaillae to angle of jaws;

12) Lower Jaw Length (LjL): from anterior edge of dental bone to angle of jaws;

13) Pectoral-fin Length (PecfL): from base of median pectoral-fin rays to posterior edge of pectoral fin;

14) Pectoral-fin base length (PecfbL): from dorsal edge to ventral edge of pectoral-fin base;

15) Dorsal edge of pectoral fin base to anterior base of first dorsal spine: from the dorsal edge of pectoral-fin base to anterior base of first dorsal spine;

16) Ventral edge of pectoral fin base to anterior base of first dorsal spine: from the ventral edge of pectoral fin to anterior base of first dorsal spine;

17) Posterior edge of pectoral fin base to anterior base of first dorsal spine: indicated "+" when anterior base of first dorsal spine lies behind posterior edge of pectoral fin; indicated "-" when anterior base of first dorsal spine lies before posterior edge of pectoral fin;

18) Angle of jaws to eye (AjE): from angle of jaws to anterior edge of eye;

19) Angle of jaws to posterior external nare (AjPen): from angle of jaws to anterior border of posterior external nare;

20) Posterior external nare to eye (PenE): from anterior border of posterior external nare to anterior border of eye;

21) Pre-posterior external nare Length (PPenL): from the tip of rostral appendage to anterior border of posterior external nare;

22) Distance between base of tubular anterior nostril and posterior external nare (DTanPen): from the base of tubular anterior nostril to anterior border of posterior external nare.

- ***In percentage of Standard Length (%L_S)***

23) Head Length (HL): from the tip of rostrum to posterior angle of gill-opening, including rostral appendage;

24) Snout to first dorsal spine (SnFDs): from the tip of rostrum to anterior base of first dorsal spine;

25) Snout to last externally visible dorsal spine (SnLDs): from the tip of rostrum to posterior tip of last externally visible dorsal spine;

26) Snout to first anal spine (SnFAs): from the tip of rostrum to anterior base of first anal spine;

27) Preanal Length (PreAnL): from the tip of rostrum to posterior edge of anus;

28) Postanal Length (PostAnL): from posterior edge of anus to caudal-fin base;

29) Head depth at posterior eye margin (HD): vertical distance at the posterior edge of eye;

30) Body depth at the origin of dorsal spine (BDds): vertical distance at the anterior base of first dorsal spine;

31) Body depth at the origin of dorsal-fin ray (BDdfr): vertical distance at the anterior base of first dorsal-fin ray;

32) Body depth at anus (BDan): vertical distance at the posterior edge of anus (depth of dorsal fin not included);

33) Body depth at anal-fin ray (BDafr): vertical distance at the anterior base of first anal-fin ray;

34) Caudal fin Length (CL): from base of caudal fin to posterior edge of caudal fin;

35) Anal fin base Length (AfbL): from anterior base of first anal-fin ray to posterior base of last anal-fin ray;

36) Spinous dorsal-fin base Length (SpdfbL): from anterior base of first dorsal-fin spine to posterior base of last dorsal-fin spine;

37) Soft dorsal-fin base Length (SodfbL): from anterior base of first dorsal-fin ray to posterior base of last dorsal-fin ray;

38) Distance from posterior edge of anus to anterior base of first anal-fin spine (DPeAnFAs);

39) Distance from posterior edge of anus to anterior base of first anal-fin ray (DAnFAr);

40) Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray (DFDfrFAfr);

41) Dorsal spine origin to anal-fin ray origin (DsoAfro): from anterior base of first dorsal spine to anterior base of first anal-fin ray;

42) Dorsal spine termination to anal-fin ray termination (DstAfrt): from the tip of last externally visible dorsal spine to posterior base of last anal-fin ray;

43) Anal-fin ray origin to Dorsal-fin ray termination (AfroDfrt): from the posterior base of last dorsal-fin ray to anterior base of first anal-fin ray;

44) Dorsal edge of pectoral-fin base to dorsal-fin ray origin (DepfbDfro): from dorsal edge of pectoral-fin base to anterior base of first dorsal-fin ray.

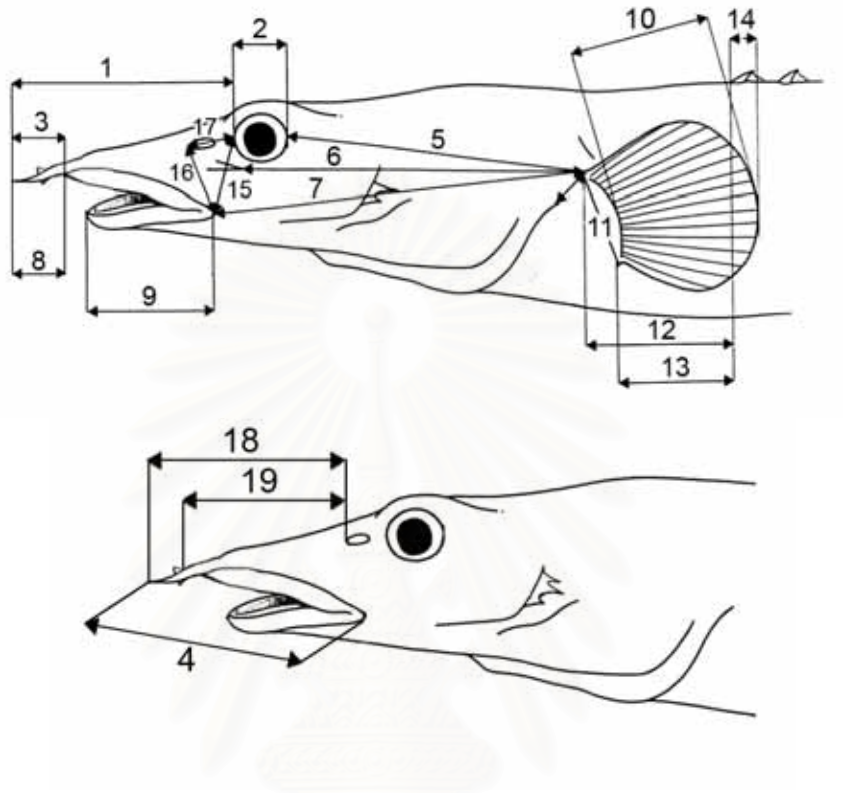

FIGURE 3.2. Morphometric measurements: 1, Snout Length; 2, Horizontal Eye Diameter; 3, Rostral Appendage Length; 4, Angles of jaws to tip of rostral appendage; 5, Postorbital Length; 6, Post preorbital spine Length; 7, Postjaw angle Length; 8, Upper Jaw Length; 9, Lower Jaw Length; 10, Pectoral-fin Length; 11, Pectoral-fin base length; 12, Dorsal edge of pectoral fin base to anterior base of first dorsal spine; 13, Ventral edge of pectoral-fin base to anterior base of first dorsal spine; 14, Posterior edge of pectoral fin base to anterior base of first dorsal spine; 15, Angle of jaws to eye; 16, Angle of jaws to posterior external nare; 17, Posterior external nare to eye; 18, Pre-posterior external nare Length; 19, Distance between anterior tubular nostril and posterior external nare (modified from Vreven and Teugels, 1996).

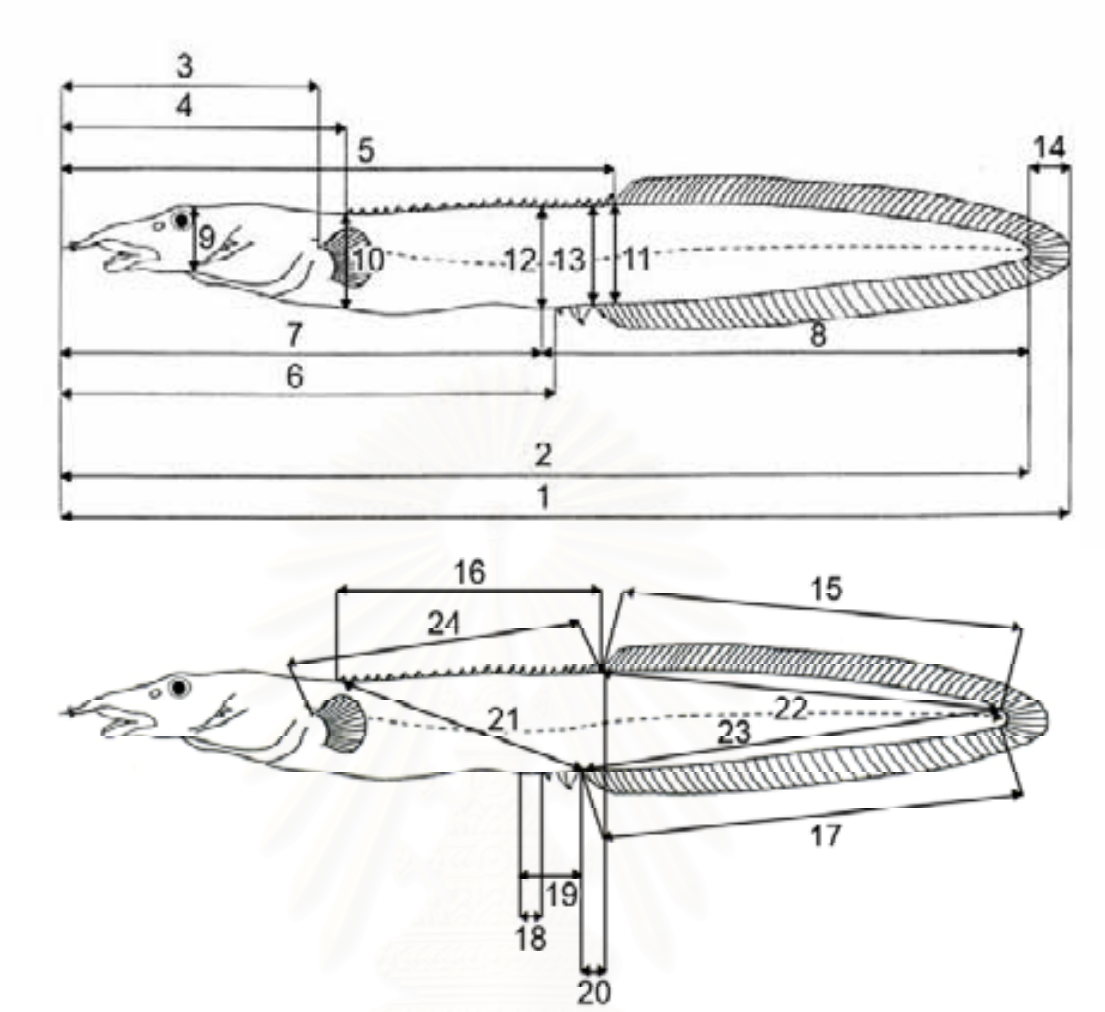

FIGURE 3.3. Morphometric Measurements: 1, Total Length; 2, Standard Length; 3, Head Length; 4, Snout to first dorsal spine; 5, Snout to last externally visible dorsal spine; 6, Snout to first anal spine; 7, Preanal Length; 8, Postanal Length; 9, Head depth at posterior eye margin; 10, Body depth at the origin of dorsal fin spine; 11, Body depth at the origin of dorsal fin ray; 12, Body depth at anus; 13, Body depth at anal fin; 14, Caudal fin Length; 15, Anal fin base Length; 16, the spinous dorsal-fin base Length; 17, the soft dorsal-fin base Length; 18, Distance from posterior edge of anus to anterior base of first anal-fin spine; 19, Distance from posterior edge of anus to anterior base of first anal-fin ray; 20, Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray; 21, Dorsal spine origin to anal fin origin; 22, Dorsal spine termination to anal fin termination; 23, Dorsal-fin ray termination to anal fin origin; 24, Dorsal edge of pectoral fin to dorsal-fin ray origin (modified from Vreven and Teugels, 1996).

MERISTIC COUNTS (see **FIGURE 3.4-3.5**).

1. Dorsal fin spines

2. Dorsal fin rays

3. Caudal-fin rays: all fin rays in contact with the hypural bones and the parhypural bone.

4. Anal spines

5. Anal fin rays

6. Pectoral fin rays

7. Rostral toothplate

8. Preorbital spines: presence or absence of a preorbital spine is noted.

9. Preopercular spines: presence and number of preopercular spines are noted.

10. Predorsal vertebrae

11. Abdominal vertebrae

12. Caudal vertebrae

13. Total vertebrae

According to Vreven & Teugels (1996), definitions of vertebral counts in mastacembelid specimens are:

Predorsal vertebrae = number of vertebrae from skull to first vertebra (included) whose neural spine supports pterygiophore of first dorsal spine.

Abdominal vertebrae = number of vertebrae from skull to vertebra (not included) whose haemal spine supports pterygiophore of the first anal spine.

Caudal vertebrae = number of vertebrae from first anal pterygiophore supporting vertebra to last vertebra (the last vertebra is defined here as the one who supports the hypural bones and the parhypural bone).

Total vertebrae = number of vertebrae from skull to last vertebra.

Vertebrae between dorsal and anal spine supporting pterygiophores = number of vertebrae between vertebra whose neural spine supports pterygiophore of last externally visible dorsal spine and first anal pterygiophore supporting vertebra. (Indicated “+” when the former lies before the latter; “-” by reversed sequence; and

“0” when the former and the latter are one and the same vertebra or two successive vertebrae.)

Vertebral numbers were counted from digital radiographs (Kodak Point of Care CR 120 system). The radiographs were interpreted by a software program named eFilm Workstation^{TM} 2.1. Fin rays were counted under Stereo microscope.

Some meristic characters were shown by frequency distribution of meristic counts in Mastacembelidae.

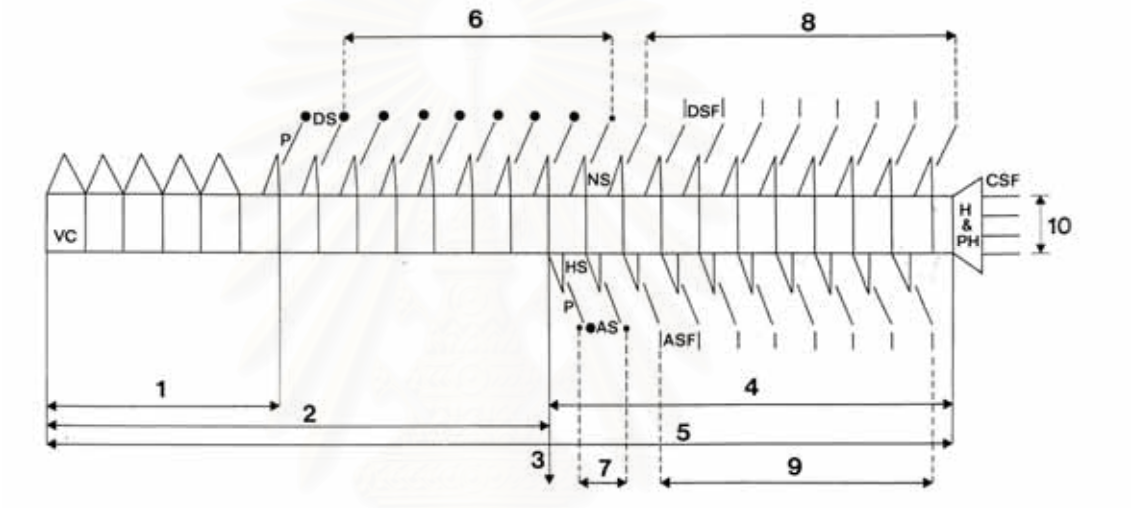

FIGURE 3.4. Schematic illustration of some meristic counts taken on mastacembelid specimens: (1) predorsal vertebrae; (2) abdominal vertebrae; (3) vertebrae between dorsal and anal spine supporting pterygiophores; (4) caudal vertebrae; (5) total number of vertebrae; (6) dorsal spines; (7) anal spines; (8) dorsal-fin rays; (9) anal-fin rays; (10) Caudal-fin rays. Abbreviations: AS = anal spine; ASF = anal soft fin ray; CSF = caudal soft fin ray; DS = dorsal spine; DSF = dorsal soft fin ray; H = hypural; HS haemal spine; NS = neural spine; P =pterygiophore; PH = parhypural; VC = vertebral center (Source: Vreven and Teugels, 1996).

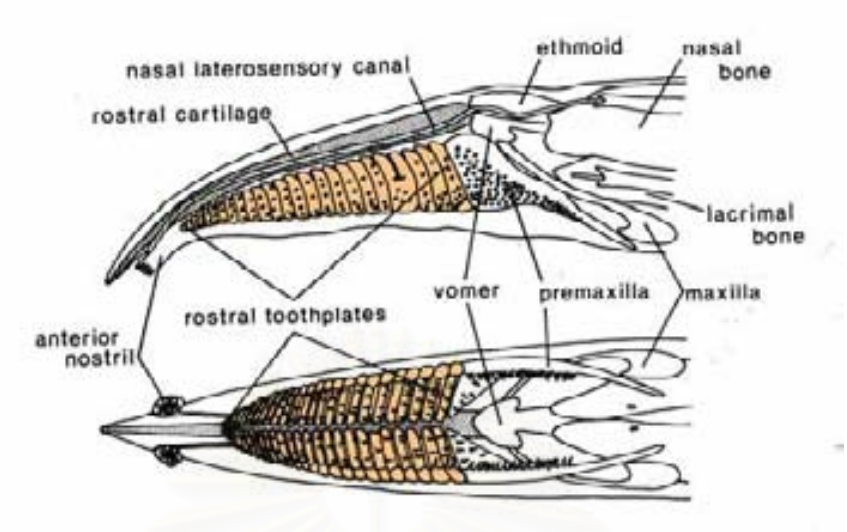

FIGURE 3.5. Meristic count of Rostral toothplates (Source: Roberts, 1980).

3.3.3 Clearing and Staining

1. Fix fresh material in 10% formalin, 2 to 3 days or longer. For Specimens already in formalin or alcohol, ignore step 1, and go directly to step 2.

2. Wash in several changes of distilled water, 2 to 3 days. Skin and eviscerate specimens as far as possible here (also scale fish).

3. Place in a mixture of 10% KOH and 3% H_2O_2 (1:9) for several days until the specimen turns to brown and begin clear and transparent.

4. Transfer to 2 changes 95% ethyl alcohol, 2 to 3 hours in each change.

5. Place directly into a mixture of 10 mg alcian blue 8 GN, 80 ml 95% ethyl alcohol, and 20 ml glacial acetic acid, 24 to 48 hours.

6. Transfer through 75%, 40% and 15% ethyl alcohol, 2 to 3 hours in each, or until specimen sinks.

7. Transfer to 0.5%agueous KOH, to which enough alizarin red S has been added to turn solution deep purple. Leave 24 hours, or until bones are distinctly red.

8. Transfer through a 0.5% KOH-glycerine series (3:2, 1:1, 1:3) to pure glycerine. To the first two KOH-glycerine solutions, 3 or 4 drops of 3% H_2O_2 may be added per 100 ml solution to bleach pigments of dark specimens. Specimens may be left in the bleaching step for several days or until dark pigments are removed.

9. Store specimens in pure glycerine to which a few crystals of thymol have been added. The thymol inhibits growth of molds and bacteria.

3.2.4 Data Analyses

3.2.4.1 Mean Comparison

The means of all morphometric parameters would be used to test whether significant differences among mastacembelid species at univariate level for each of the morphological traits using ANOVA's Scheffe test. The probability of $p \leq 0.05$ was considered to be significantly different.

3.2.4.2 Cluster Analysis

The selected parameters would be applied for further analysis using Between-groups linkage method of Cluster analysis on Squared Euclidian distances in order to construct dendogram based on 38 morphometric measurements and 13 meristic counts.

3.2.5 Distribution Maps

Distribution maps of all mastacembelid fish found in Thailand are based on data from specimens deposited in museums and institutions, previous studies and field surveys throughout Thailand during June 2006 to September 2007.

3.2.6 Keys to genera and species of mastacembelid species

Dichotomous keys to genera and species were constructed and provided in this study.

CHAPTER IV
RESULTS

4.1 TAXONOMY OF FAMILY MASTACEMBELIDAE GÜNTHER, 1861 IN THAILAND

As part of an ongoing revision and examination of the alpha-level taxonomy, two genera and twelve species of the family Mastacembelidae were identified as a classification below:

Genus *Macrognathus* Lacepède, 1800

1. *Macrognathus aculeatus* (Bloch, 1786)
2. *Macrognathus circumcinctus* (Hora, 1924)
3. *Macrognathus maculatus* (Val. in Cuv. & Val., 1831)
4. *Macrognathus meklongensis* Roberts, 1986
5. *Macrognathus semiocellatus* Roberts, 1986
6. *Macrognathus siamensis* (Günther, 1861)
7. *Macrognathus zebrinus* (Blyth, 1858)

Genus *Mastacembelus* Scopoli, 1777

8. *Mastacembelus alboguttatus* Boulenger, 1893
9. *Mastacembelus armatus* (Lacepède, 1800)
10. *Mastacembelus erythrotaenia* Bleeker, 1850
11. *Mastacembelus favus* Hora, 1923
12. *Mastacembelus tinwini* Britz, 2007

Order **SYNBRANCHIFORMES**

Body elongate (eel-like appearance); gill openings confined to lower half of body; pelvic fin absent; ectopterygoid enlarged; endopterygoid reduced or absent; premaxillae nonprotrusible and without ascending process.

Suborder **MASTACEMBELOIDEI**

Body elongate; pelvic fin absent; dorsal and anal fins confluent with or free from the small caudal fin; posttemporal absent, pectoral girdle (supracleithrum) attached to the vertebral column by a ligament; no air duct to swim bladder (physoclistic).

Family **MASTACEMBELIDAE** Günther, 1861

TYPE GENUS. — *Mastacembelus* Scopoli, 1777

DIAGNOSIS. — Body more elongated and eel shaped. Long series of isolated dorsal spines anterior to dorsal fin ray. Gill membrane connected to isthmus. Three anal spines anterior to soft anal fin. Pelvic fin absent. Peculiar rostral appendage with two tubular anterior nostrils originating at the subdistal tip of rostrum. Two genera are found in Thailand: *Macrognathus* and *Mastacembelus*.

Key to the Genera of Mastacembelidae in Thailand

1a. Dorsal spines 32 or less; total vertebrae 77 or less; rostrum relatively large, in some species concave ventral surface bearing toothplates; rim of anterior nostril with 6 digitiform fimbriae except in one species; rostral appendage with rostral toothplate or not……..*Macrognathus* **Lacepède, 1800**

1b. Dorsal spines 33 or more; total vertebrae 81 or more; rostrum relatively small, no rostral toothplate; rim of anterior nostril with 2 digitiform fimbriae and 2 broad-base flaps……..*Mastacembelus* **Scopoli, 1777**

Genus ***MACROGNATHUS*** Lacepède, 1800

Macrognathus Lacepède, 1800 (type-species *Ophidium aculeatum* Bloch, 1786, by subsequent designation of Jordan, 1917).

Rynchobdella Bloch and Schneider, 1801 (misspelling).

Rhynchobdella Bloch and Schneider, 1801 (type-species *Ophidium aculeatum* Bloch, 1786, by subsequent designation of Jordan, 1917).

TYPE SPECIES. — *Ophidium aculeatum* Bloch, 1786

DIAGNOSIS. — *Macrognathus* differs from all other *Mastacembelus* in having 1) rostrum slightly to considerably more elongate, ventrally concave and laterally expansible, with a paired series of numerous rostral toothplates (dentigerous bony plates), but in some species rostral toothplate absent; 2) rim of tubular anterior nostril with six finger-like frimbrae except in one species; 3) dorsal spines relatively few, 11-32; fewer dorsal and anal fin ray (46-66 and 44-67 respectively); 4) preorbital and preopercular spines absent but present in some species; 5) upper corner of gill slit lying anterior to upper half of pectoral-fin base, in some species upper corner of gill slit and dorsal edge of pectoral fin base are at the same level; 6) predorsal vertebrae 4-6 or 15-23, abdominal vertebrae 28-34, caudal vertebrae 35-44, and total vertebrae 64-77. In addition, according to **Roberts (1989)**, *Macrognathus* differs from *Mastacembelus* in having adductor arcus palatine muscle inserted on first infraorbital bone and coronomeckelian bone markedly slender and elongate. Other characters particularly osteological researches are provided by **Travers (1984a, 1984b)**.

Key to Species of genus *Macrognathus*

1a. Rostrum with concave ventral surface lined with paired rostral toothplates; preorbital and preopercular spines absent; dorsal spines 11-20; predorsal vertebrae 15-23, in-between vertebrae absent; dorsal and anal fins entirely separated from caudal fin……..…..……**2**

1b. Rostrum without rostral toothplates; preorbital spine always and preopercular spines usually present; dorsal fin spine 27-32; predorsal vertebrae 4-6, in-between vertebrae 1-5; dorsal and anal fins separated from or confluent with caudal fin……..…….……**4**

2a. Rostrum relatively small with rostral toothplates 7-14; body without dark bars; pectoral fin rays 19-23; predorsal vertebrae 17-23; abdominal vertebrae 32-34, caudal vertebrae 40-43; total vertebrae 72-77……..…..……**3**

2b. Rostrum large with rostral toothplates usually 32-50; body usually with 13-17 obliquely oriented and dark bars; caudal ocellus always absent; pectoral fin rays 24-27; predorsal vertebrae 15-17, abdominal vertebrae 30-32, caudal vertebrae 39-42, total vertebrae 70-74.……..…..…....***Macrognthus aculeatus***

3a. Dorsal fin base with ocelli 1-5 (0 in some specimens); one caudal ocellus usually present; rostral toothplates 8-14; dorsal spine 11-17; rostrum relatively small……..….***Macrognathus siamensis***

3b. Dorsal fin base with small ocelli 8-12; caudal ocellus always absent; dorsal and caudal fins with fine dark stiations; rostral toothplates 8-11; dorsal spine 17-21; rostrum relatively large……***Macrognathus meklongensis***

4a. Rim of tubular anterior nostril with six fingerlike projections …….**5**

4b. Rim of tubular anterior nostril with two fingerlike projections and two broad-based flaps; dorsal, anal and caudal fins entirely confluent; body with 4-10 roundish dark marks along the base of soft dorsal fin, some or all continuous with bars on posterior part of body…….....***Macrognathus semiocellatus***

5a. Dorsal, anal and caudal fins broadly joined; ripe females with elongate genital papilla.……..……..**6**

5b. Dorsal and anal fins separate from caudal fin; ripe females without elongate genital papilla; body with 17-22 dark brown vertical bars but not continued onto abdomen……..…….....***Macrognathus zebrinus***

6a. Body with 16-23 dark vertical bars continued onto abdomen or across abdomen; distributed in the Chao Phraya , the Mekong, the Southern and the Eastern basins……...……...…....***Macrognathus circumcinctus***

6b. Body without vertical bars**,** background uniformly dark or olive brown with irregular pale blotches on the sides of the body, abdomen uniformly pale or with transverse bands, fins with highly variable pale bands or striae, dorsal fin base with 11 dark spots; resticted to the Southern basins.....***Macrognathus maculatus***

1. *Macrognathus aculeatus* (Bloch, 1786)

(FIGURE 4.1a, 4.8a, 4.12a and 4.14a and TABLE 4.1-4.2 and TABLE 4.23-4.34)

SYNONYMS AND CITATIONS.

Ophidium aculeatum Bloch, 1786 (type locality "Süssen Wasser von Ostindien").

Macrognathus aculeatus Lacepède, 1800: 9.

Rhynchobdella orientalis Bloch and Schneider, 1801 (unwarranted substitute name for *Ophidium aculeatum* Bloch, 1786 ("India orientaliad Ceilonam" [= East Indies to Ceylon, not India and Ceylon as cited by Sufi, 1956)]

Ophidium rostratum Shaw, 1803 (no type-locality)

Rhynchobdella aculeata Günther, 1861: Cat. Brit. Mus. III

Mastacembelus paucispinis Fowler, 1939

Macrognathus aculeatus Sufi, 1956: Bull. Raffles Mus. No. 27.

COMMON NAME. — Pea Cock Eel, Spotted Spiny Eel**,** Lesser Spiny Eel.

LOCAL NAME. — Pla Lod Lai, Pla Lod Jud (Thailand).

TYPE LOCALITY. — Süssen Wasser von Ostindien.

MATERIALS EXAMINED.

TOTAL MATERIAL NUMBER. — 28 specimens: 111.4 – 278 mm L_S**.**

***Southern Basins* —** 28 specimens: 111.4 – 278 mm L_S**.**

CUMZ 2006.10.19:1-4, 4: 219.5-244.5 mm L_S, Khlong Cha Uat, Cha Uat, Nakhon Si Thammarat; **CUMZ 2006.10.18:5**, 1: 267.4 mm L_S, Khlong Ro, Khian Sa, Surat Thani; **CUMZ 2006.10.20:6**, 1: 172.5 mm L_S, Mueang Phatthalung, Phatthalung; **CUMZ 2006.10.20:7-18**, 12: 152.0-278.0 mm L_S, Khlong Cha Uat, Cha Uat, Nakhon Si Thammarat.

NIFI 00615, 3: 111.4-120.3 mm L_S, Nakhon Si Thammarat; **NIFI 01219**, 3: 136.5-162.8 mm L_S, Khlong Saeng, Ratchaprapha reservoir, Surat Thani (Tapi River basin); **NIFI 3220**, 3: 231-266.5 mm L_S, Pru Toh Daeng, Narathiwat; **NIFI 3221**, 1: 252.3 mm L_S, the Southern basins.

ETYMOLOGY. — The specific name "*aculeatus*" is derived from the Latin word "*aculeus*", meaning to a sting or thorn. Maybe it refers to a sharp-pointed rostrum.

DIAGNOSIS. — *Macrognathus aculeatus* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XV-XIX 48-54; A. III 44-51; P. 24-27; C. 13-16;
- Predorsal vertebrae: 15-17, abdominal vertebrae: 30-32, caudal vertebrae: 39-42, total vertebrae: 70-74, in-between vertebrae absent **(see TABLE 4.25-4.29)**;
- A concave huge and long rostrum bearing 32-50 pairs of toothplates **(see TABLE 4.33)**;
- Rim of anterior nostril with 6 fingerlike projections**;**
- Preorbital and preopercular spines absent **(see TABLE 4.34)**;
- Dorsal, anal, and caudal fin entirely separate;
- Colouration very distinctive; body with a series of 13-17 obliquely oriented and dark bars.

M. aculeatus is distinguished from all other species in *Macrognathus*, excluding *M. meklongensis* and *M. siamensis*, by fewer dorsal-fin spines (15-19 *vs*. 27-32). It differs from *M. meklongensis* and *M. siamensis* in having more numerous rostral toothplates (32-50 *vs*. 8-11 *vs*. 10-13 respectively), fewer predorsal, abdominal and total vertebrae **(TABLE 4.25-4.29)**. For additional meristic characters see **TABLE 4.24** and **TABLE 4.30-4.34**.

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, *M. aculeatus* can be distinguished from all other mastacembelid species by its long snout length [50.0-54.9 (mean 52.0) %L_H], its long rostral appendage length [25.0-30.0 (mean 27.0) %L_H], its long pre-posterior external nare length [38.6-44.0 (mean 41.1) %L_H], its long distance between base of tubular anterior nostril and posterior external nare [32.6-38.4 (mean 35.5) %L_H] and its long head length [21.0-26.8 (mean 23.1) %L_S].

Additionally, its distance from snout to first dorsal spine, spinous dorsal-fin base length, distance from dorsal spine origin to anal fin origin and distance from anal fin origin to dorsal fin termination can be used for distinguishing *M. aculeatus* from

almost all other species except *M. meklongensis*. Head depth at posterior eye margin can be also employed for distinguishing *M. aculeatus* from almost all other species except in *M. favus*.

For distinguishing *M. aculeatus* from all other species in the genus *Macrognathus*, its distance from angle of jaws to tip of rostral appendge and the short postjaw angle length can be employed [36.0-41.4 (mean 38.0) %L_H and 62.5-68.3 (65.3) respectively]. Its distance from snout to last externally visible dorsal spine can be also used for distinguishing *M. aculeatus* from both *M. meklongensis* and *M. siamensis*.

In addition, *M. aculeatus* can be distinguished from *M. meklongensis* by its large head width [10.5-16.3 (mean 12.9) %L_H *vs.* 9.2-13.4 (11.0)], its short postorbital length [41.8-47.1 (mean 44.1) %L_H *vs.* 43.2-49.5 (46.5)], its long distance from snout to last externally visible dorsal spine [66.8-72.0 (mean 69.4) %L_S *vs.* 65.0-68.3 (67.2)]. Head depth of *M. aculeatus* is deeper than *M. meklongensis* [5.0-6.1 (mean 5.4) %L_S *vs.* 4.4-5.1 (4.7)] and body depth at anus is also deeper than *M. meklongensis* [11.2-15.8 (mean 14.2) %L_S *vs.* 11.5-13.9 (12.9)].

M. aculeatus can be distinguished from *M. siamensis* by its short upper jaw length [12.1-16.8 (mean 14.1) %L_H *vs.* 13.4-19.8 (16.8)], its short lower jaw length [8.4-15.2 (mean 10.7) %L_H *vs.* 10.1-16.0 (12.8) respectively], its short pectoral fin length [26.1-31.7 (mean 29.2) %L_H *vs.* 30.0-36.5 (33.1)], its long distance from posterior external nare to eye [9.4-12.9 (mean 11.6) %L_H *vs.* 8.2-11.2 (9.9)], its long preanal length [60.2-64.6 (mean 62.2) % L_S *vs.* 57.3-67.2 (60.7)], its long post anal length [36.1-40.3 (mean 38.0) %L_S *vs.* 36.9-42.7 (39.4)] and its short distance from dorsal edge of pectoral fin base to dorsal-fin ray origin [42.3-50.0 (mean 46.3) %L_S *vs.* 45.3-51.8 (48.0)].

For other diagnoses of *M. aculeatus* see account under *M. meklongensis* and *M. siamensis*.

DESCRIPTION. — Morphometric features and meristic counts are given respectively in **TABLE 4.1-4.2** and **TABLE 4.24-4.34**. For general appearance see **FIGURE 4.1a**.

Macrognathus aculeatus has a relatively large and long rostrum [25.0-30.0 (mean 27.0) %L_H]. Snout is more elongate than *M. meklongensis* and *M. siamensis* [50.0-54.9 (mean 52.0) %L_H *vs*. 46.2-52.0 (48.6) *vs*. 40.5-48.5 (44.1) respectively]. Its head length is the longest among all mastacembelid speices. A pair of tubular anterior nostrils is situated at subdistal tip of rostrum. Each aperture of rim tubular anterior nostrils is guarded by six finger-like frimbrae.

Gape of mouth is very small. Upper jaw length is slightly longer than lower jaw [12.1-16.8 (mean 14.1) %L_H *vs*. 8.4-15.2 (10.7)]. Eyes are relatively small [8.2-11.8 (mean 9.6) %L_H]. Teeth are small and pointed and present in both jaws. No gill raker. Pectoral fin and caudal fin are relatively large and rounded. Caudal fin is distinctly separated from the dorsal and anal fins. Preanal length is always greater than the postanal length [60.2-64.6 (mean 62.2) %L_S *vs*. 36.1-40.3 (38.0)]. Vent is nearer to base of caudal fin than to snout.

Scales are minute and cycloid and present around eye and posterior external nare, and from the latter to the maxilla. Top of snout, internasal space, interorbital space and top of head as far as hind edge of preoperculum are naked. Snout is not scaly.

Fleshy angle of jaws are situated apparently anterior to the anterior border of the posterior external nare and not extending to below the posterior nostril **(FIGURE 4.8)**. Upper tip of gill slit and dorsal edge of the pectoral-fin base are at the slightly different level and are anterior to ventral edge of the pectoral-fin base **(FIGURE 4.12)**.

The first dorsal spine is situated apparently far behind posterior edge of pectoral-fin base and is originated at the middle of body. *M. aculeatus* has a relatively low number of dorsal-fin spines, with spines increasing in size from first to last (15-19 average 16.81). Three anal spines are close together. There are two externally visible anal spines. The first is smaller than the second. The second is the largest. The last additional anal spine is very short and small, hidden under the skin and situated

anterior to the base of the first anal-fin ray. Anal-fin ray is slightly situated before the origin of dorsal-fin ray.

In all specimens the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on **two different successive vertebrae** and in the others, they are situated **on the same vertebrae** with the following frequencies: 9 and 8 specimens respectively. First dorsal fin pterygiophore is inserted behind 15th, 16th or 17th neural spine. Pterygiophore of last dorsal fin spine is inserted behind 31st, 32nd, 33rd or 34th neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 31st, 32nd or 33rd vertebra.

All specimens lack preorbital and preopercular spines.

Maximum observed standard length: 278 mm (**CUMZ 2006.10.20:7-18**).

COLOURATION.

- **FRESH SPECIMENS. —** Body with 13-16 obliquely oriented and dark bars edged with yellowish margin, not extending onto abdomen. Background colour is iridescent blue-green like colour of peafowl plumage. Caudal fin with numerous vertical dark stritations. One small, dark and round spots on pectoral fin near base. Dark longitudinal stripe and vertical bar across eyes.

DISTRIBUTION. — *Macrognathus aculeatus* was found in Borneo, Sumatra and the Malay Peninsula northwards to the Tapi River basin, Thailand.

M. aculeatus is probably endemic to the Southern basins from Kra isthmus to the southernmost country. There is no any report that *M. aculeatus* was founded in the other basins of Thailand.

- **THAILAND. —** It is distributed in the Southern Basins or Peninsula Thailand only (Surat Thani, Phatthalung, Nakhon Si Thammarat, Trang, and Narathiwat). It has not been recorded from all other basins.

- **OTHER REGIONS. — Malay Peninsula** (Tembling Rier). **Sumatra** (Deli, River Batang Hari, Lahat, Gunung Sahilan, Palembang). **Borneo** (Kapuas,

Sambas, Kayan River). **Java** (northern Java east to Brantas River) **(Roberts, 1980 and 1989)**.

BIOLOGY AND ECOLOGY.

- **HABITAT. —** *Macrognathus aculeatus* was captured in several small canals (called Khlong in Thai) in Nakhon Si Thammarat such as Khlong Cha Uat and Klong Klai. The substrates at the bottom of Klong Cha-Uat are rock gravels and boulders and the water surface was covered by aquatic vegetation particularly water hyacinth.

  According to **Vidthayanon *et al.* (2002)**, *M. aculeatus* is also restricted to lowland wetlands and peat swamps such as Toh Daeng peat swamps in Narathiwat.

- **REPRODUCTION. —** A ripe female of *M. aculeatus* has a protuberance at anus area, not like elongate genital papilla of *M. circumcinctus*.

- **STATUS. —** *M. aculeatus* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**.

- **FISHERIES. —** Local fisheries using bamboo trap, ornamental trap etc.

2. *Macrognathus circumcinctus* (Hora, 1924)

(FIGURE 4.1b, 4.8b, 4.12b and 4.15c and TABLE 4.3-4.4 and TABLE 4.23-4.34)

SYNONYMS AND CITATIONS.

Mastacembelus circumcinctus Hora, 1924: 475 (type locality: "Patelung River, Tale Sap, Siam")

Macrognathus circumcinctus: Travers, 1984b: 144.

Macrognathus circumcinctus: Roberts, 1986: 99.

Mstocembelus circumcinctus: Smith, 1945: 65, fig. 2.

Mastacembelus taeniagaster: Fowler, 1935: 136.

COMMON NAME. — Cross-Band Spiny Eel.

LOCAL NAME. — Pla Lod Lai**,** Pla Lod Thong Lai (Thailand).

TYPE LOCALITY. — Patelung River, Tale Sap, Siam

MATERIALS EXAMINED.

TOTAL MATERIAL NUMBER. — 87 specimens.

***Chao Phraya Basin* —** 6 specimens.

CUMZ 1997.09.04:31, 1: 155.7 mm L_S, Phra Nakhon Si Ayutthaya; **CUMZ 2007.05.12:32**, 1: 84 mm L_S, Chet Khot Waterfall, Kaeng Khoi, Saraburi; **NIFI 00613**, 4, Sarika waterfall near Kao Yai, Chao Phraya Basin, Nakhon Nayok**.**

***Mekong Basin* —** 2 specimens.

NIFI 00622, 2: 67.5-83.5 mm L_S, Oon River, Mekong Basin, Sakon Nakhon.

***Southern Basins* —** 49 specimens.

CUMZ 2006.10.17:1, 1: 167.7 mm L_S, Khlong Ro, Khian Sa, Suratthani; **CUMZ 2006.10.18:2-20**, 19: 156.7-204 mm L_S, Thale Noi, Khuan Khanun, Phatthalung; **CUMZ 2006.10.19:21-30**, 10: 113.5-201 mm L_S, Khlong Cha Uat,

Cha Uat, Nakhon Si Thammarat; **CUMZ 2006.10.18:42-56**, 15, Thale Noi, Khuan Khanun, Phatthalung.

KUMF 1303, 1: 149 mm L_S, Thale Noi, Khuan Khanun, Phatthalung.

NIFI 01168, 1: 163 mm L_S, Wipavadi waterfall, Surat Thani; **NIFI 3222**, 1: 171 mm L_S, Tai Mueang, Pang Nga; **NIFI 3223**, Tai Mueang, Pang Nga; **NIFI 3224**, Sirinthorn Waterfall, Narathiwat.

UMMZ 2704, 1: 69.3 mm L_S, Khlong Toh Daeng, Narathiwat.

***Eastern Basin*s —** 31 specimens.

CUMZ 2007.02.24:33-41, 9: 14.58 mm L_S, Khao Rakam reservoir, Mueang Trat, Trat; **CUMZ 2007.03.18:57-65**, 9, Khao Rakam reservoir, Mueang Trat, Trat.

KUMF 1299, 2: 64-68 mm L_S, Nong Or, foot of Khao Sabap, Chantabun (Chanthaburi); **KUMF 1300**, 1: 158 mm L_S, Thale Sap Khlong Ranawt (Ranant), Chanthaburi; **KUMF 1301**, 2: 95-114 mm L_S, Pong Raed Waterfall, Khao Sabap, Chanthaburi; **KUMF 1302**, 2: 124-129 mm L_S, Khlong Song-Pee Nong, Chakadon, Rayong; **KUMF 1304**, 1: 71.2 mm L_S, Khlong Nakon Noi, Nakhon Si Thammarat; **KUMF uncat**., 1, Khao Chamao-Khao Wong National Park, Huai Thap Mon, Khao Chamao, Rayong; **KUMF uncat**., 1, Klong Reaw, Khao Chamao-Khao Wong National Park, Huai Thap Mon, Khao Chamao, Rayong; **KUMF uncat.**, Khlong Poon, Khao Chamao National Park, Huai Thap Mon, Khao Chamao, Rayong; **KUMF uncat.**, Khlong Nam Pen, Khao Chamao National Park, Rayong; **KUMF uncat.**, Khlong Takhian, Chanthaburi; **KUMF uncat.,** Kang Hang Maew, Chanthaburi; **KUMF uncat.,** Kang Hang Maew, Chanthaburi.

NIFI 01590, 1: 150.2 mm L_S, swamp near Khao Hinson, Chachoengsao; **NIFI 01591**, 1, Khao Hinson, Chachoengsao; **NIFI 00611**, 1, Kra Thing Waterfall, Chanthaburi.

ETYMOLOGY. — The specific name "*circumcinctus*" is derived from the Latin word "*circum*", meaning around or on all sides and "*cinct*" meaning to gird. They are translated together as a fish that has a series of oblique bars each with a narrow extension extending partially or entirely across abdomen.

DIAGNOSIS. — *Macrognathus circumcinctus* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XXVII-XXXI 44-53; A. III 44-56; P. 18-23; C. 12-14;
- Predorsal vertebrae: 4-6, Abdominal vertebrae: 28-31, Caudal vertebrae: 35-38, Total vertebrae: 64-70, in-between vertebrae 1-2 or absent **(see TABLE 4.25-4.29)**;
- Rim of anterior nostril with 6 fingerlike projections**;**
- Preorbital and preopercular spines present **(see TABLE 4.34)**;
- Dorsal, anal, and caudal fin broadly joined;
- Body with 17-22 very regular dark, slightly oblique bars on body, most of them continued by a very narrow extension towards or across belly**.**

M. circumcinctus is distinguished from *M. aculeatus*, *M. meklongensis* and *M. siamensis* by its more numerous dorsal spines and fewer predorsal vertebrae. It differs from all other species by a unique colour pattern with 17-22 slightly oblique dark bars on body, continued by a very narrow extension towards or across abdomen.

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, its distance from snout to first dorsal spine can employed for distinguishing *M. circumcinctus* from all other mastacembelid species, whereas its pectoral-fin length, distance from angle of jaws to eye, pre-posterior external nare length, distance from snout to first dorsal spine, head depth, body depth at soft dorsal fin, body depth at soft anal fin and caudal length can be used for distinguishing *M. circumcinctus* from both *M. semiocellatus* and *M. zebrinus.*

M. circumcinctus is distinguished from *M. semiocellatus* by its short head width [9.8-17.8 %L_H (mean 13.0) *vs*. 10.0-13.8 %L_H (11.6)] and its long distance between base of anterior tubular nostril and posterior externa lnare [24.3-31.2 %L_H (mean 28.6) *vs*. 22.5-28.2 (24.8)]. Moreover some morphometric characters in

percentage of standard length *viz.* body depth at first dorsal spine, body depth at anus, distance from posterior edge of anus to anterior base of first anal-fin spine, distance from posterior edge of anus to anterior base of first anal-fin ray, distance from dorsal spine oigin to anal fin origin and distance from anal fin origin to dorsal fin termination can be also employed for distinguishing *M. circumcinctus* from *M. semiocellatus*.

It is distinguished from *M. zebrinus* by its short postjaw angle length [68.5-74.2 %L_H (mean 71.4) *vs*. 73.4-79.2 %L_H (76.1)] and its short pectoral-fin base length [9.3-14.0 %L_H (mean 11.8) *vs*. 9.8-15.1 (12.6)].

For other diagnoses of *M. circumcintus* see account under *M. semiocellatus* and *M. zebrinus*.

DESCRIPTION. — Morphometric measurements and meristic counts are given respectively in **TABLE 4.3-4.4** and **TABLE 4.24-4.34**. For general appearance see **FIGURE 4.1b**.

Macrognathus circumcinctus has a relatively small snout [40.0-46.0 (mean 42.6) %L_H] and small rostrum, lacking concave ventral surface and rostral toothplates [10.5-17.2 (mean 14.1) %L_H]. A pair of tubular anterior nostrils is situated at subdistal tip of rostrum. Each aperture of rim tubular anterior nostrils is guarded by six finger-like frimbrae. Caudal fin is brodly united with soft-rayed portion of anal and dorsal fins.

Gape of mouth is small. Upper jaw length is longer than lower jaw [16.8-23.4 (mean 19.7) %L_H *vs*. 11.0-18.7 (15.2)]. Eyes are relatively large [8.2-13.3 (mean 10.1) %L_H]. Teeth are small and pointed and present in both jaws. No gill raker. Caudal fin is broadly joined with the dorsal and anal fins. Preanal length is always greater than the postanal length [57.2-63.2 (mean 59.3) %L_S *vs*. 36.4-44.4 (40.7)]. Vent is nearer to base of caudal fin than to snout.

Scales are cycloid and small, occurring between and around eye and posterior nostril, and extending from the latter to gape of mouth. Snout is entirely scaly. Interorbital space and top of head, as far as hind edge of preoperculum are naked.

Fleshy angle of jaws are situated slightly anterior to the anterior border of the posterior external nare and nearly extending to below the posterior nostril **(FIGURE 4.8b)**. Upper corner of gill opening and dorsal edge of the pectoral-fin base are at the slightly different level, anterior to ventral edge of the pectoral-fin base **(FIGURE 4.12b)**.

The first dorsal spine is situated apparently behind the posterior edge of pectoral-fin base. *M. circumcinctus* has a relatively high number of dorsal spines, with spines increasing in size from first to last (27-31 average 28.65). Three anal spines are close together. Two externally visible anal spines, the first is smaller than the second. The last additional anal spine is very short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. Origin of anal-fin ray is slightly situated before origin of the dorsal-fin ray [1.6-4.2 (mean 2.6) %L_S].

The neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on **two different, successive vertebrae**. In the others, they are situated **on two different vertebrae** and **are separated by one to two in-between vertebrae.** The vertebra with the neural spine supporting the pterygiophore of the last externally visible dorsal spine is **situated posterior** to the vertebrae whose haemal spine supports the first anal spine. First dorsal fin pterygiophore is inserted behind 4th or 5th neural spine. Pterygiophore of last dorsal fin spine is inserted behind 31st, 32nd, 33rd, 34th or 35th neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 29th, 30th 31st or 32nd vertebra.

All materials have one preorbital spine (1L/1R), which is hidden under the skin in larger specimens whereas the preopercular spine number varies from 2L/2R to 3L/3R (except one specimen 1L/2R) with the following frequencies: (1L/2R: 1); (2L/2R: 32); (2L/3R: 5); (3L/2R: 3); (3L/3R: 11). The preopercular spines are small and hidden under the skin.

Maximum observed standard length: 210.5 mm. (**KUMF uncat.**: 228 mm L_T).

COLOURATION. — Have body with a series of very regular oblique and dark bars each with a narrow extension extending partially or entirely across abdomen.

- **PRESERVED SPECIMENS. —** Dorsal and sides brown with darker brown bands; ventral surface yellowish or whitish. A dark bar passed over the interorbital. A dark band crossing the eye extending forwards to some distance on the loses its identify. Above and parallel to this band a very narrow whitish streak usually originating behind the eye runs backwards**.** Dorsal and caudal fins pale with short wavy oblique dark bars. Base of the soft dorsal fin with dark spots are continuations of the body bands. Pectoral fin pale with dark transverse bars.

DISTRIBUTION.

- **THAILAND. —** the Chao Phraya basin (Nakhon Nayok, Saraburi and Phra Nakhon si Ayutthaya); the Mekong basin (a single record in Songkram River basin, Sakon Nakhon province); the Southern basin and the Eastern basin of Thailand (Chachoengsao, Rayong, Chanthaburi and Trat).
- **OTHER REGIONS. — Malaysia**: Kiala Brang, Trengganu and Sumatra (Sufi, 1956).

BIOLOGY AND ECOLOGY.

- **HABITAT. —** *Macrognathus circumcinctus* lives in various habitats such as a small stream of waterfall, reservoir, peat swamp and lake. In the Southern basins it was found in Thale Noi (Phatthalung), Songkhla Lake (Songkhla), streams in peat swamp forest (Narathiwat), Klong Ro (Surat Thani) and Klong Cha-Uat and Klong Klai (Nakhon Si Thammarat). It can be found both flowing and running waters.

  It also habits in small streams with clear water over sand and gravel as substrates at Pliew Waterfall, Nakhon Si Thammarat and it was captured in shallow water **(Lertsuttichawan *et al*., 2001)**.

- **DIETS. —** Earthworm and small prawns

- **REPRODUCTION. —** *M. circumcinctus* has a ripe female with a very elongate genital papilla**.**

- **STATUS. —** *M. circumcinctus* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**.

- **FISHERIES**. **—** Local fisheries using ornamental fish trap and bamboo trap.

3. *Macrognathus maculatus* (Val. in Cuv. & Val., 1831)

(FIGURE 4.1c)

SYNONYMS AND CITATIONS.

Mastacembelus maculatus Cuvier in Cuvier and Valenciennes, 1831:461 (Type locality "Moluques", erroneous).

Mastacembelus maculatus var. *chrysogaster* Bleeker, 1852a:93 (type locality Java and Sumatra).

Mastacembelus maculatus var. *dictyogaster* Bleeker, 1852a:93 (type locality Billiton).

Mastocembelus maculatus: Smith, 1945 (Misspelling)

Mastacembelus maculatus: Sufi, 1956: 113

Mastacembelus maculatus: Roberts, 1989: 181

COMMON NAME. — Frecklefin Eel, Frankelfin Eel **(Rachmatika *et al*., 2005)**, Buff-backed spiny eel **(Lim & Ng, 1990)**.

LOCAL NAME. — Pla Lod Dang (Thailand), Trey kchoeung (Cambodia), Lan Kuai (Merap), Telan Kuai (Kenyah), La Kuai (Punan) **(Vidthayanon, 1997; Rainboth, 1996; Rachmatika *et al*., 2005)**.

MATERIAL EXAMINED.

TOTAL MATERIAL NUMBER. — 1 specimen**:** 196.8 mm L_S.

Southern basins

UMMZ 2575, 1: 196.8 mm L_S, Klong Bang Tieu, Khao Nor Chuchi, Krabi.

ETYMOLOGY. — The specific name "*maculatus*" is derived from the Latin word "*macula"*, meaning to spot, stain or mark. It refers to pale spots scattered on the body segment.

DIAGNOSIS. — *Macrognathus maculatus* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XXVI-XXXI 55-70; A. III 58-70; P. 20-24; C. 11-16 (Sufi, 1956);
- Abdominal vertebrae 31-33; caudal vertebrae 45-47; total vertebrae 76-79 **(Sufi, 1956)**;
- Rim of tubular anterior nostril with 6 fingerlike projections**;**
- One preorbital spine and two preopercular spines (1 specimens) in each side;
- Dorsal, anal and caudal fins broadly joined;
- Body without vertical bars**,** background uniformly dark or olive brown with irregular pale blotches on the sides of the body.

DESCRIPTION. — For general appearance see **FIGURE 4.1c**.

Mcrognathus maculatus is similar to *M. circumcinctus* but lack of dark and oblique bands and a body is more elongate. Rostrum lacks concave ventral surface and rostral toothplates. A pair of tubular anterior nostrils is situated at subdistal tip of rostrum. Each aperture of rim tubular nostrils is guarded by six finger-like frimbrae.

Gape of mouth is small. Upper jaw length is longer than lower jaw. Eyes are small [8.6%L_H in 1 specimen]. Caudal fin is broadly joined with the dorsal and anal fins. Preanal length is always greater than the postanal length [52.1 %L_S *vs*. 47.9 in 1 specimen]. Vent is nearer to base of caudal fin than to snout.

Scales are cycloid and small, occurring between eye and posterior eaxternal nare, in some specimens both posterior nostril and eye surrounded by scales on all sides, in others scales present only on lower half of circumference of eye and of posterior nostril and extending from the latter to the maxilla. Snout is entirely scaly. Interorbital space, internasal space and top of head, as far as hind edge of preoperculum are naked.

Fleshy angle of jaws are situated anterior to the anterior border of the posterior external nare, not extending to below the posterior nostril. Upper corner of gill opening and dorsal edge of the pectoral-fin base are at the slightly different level, anterior to the ventral edge of the pectoral-fin base.

The first dorsal spine is situated apparently behind the posterior edge of pectoral-fin base. *M. mulatus* has a relatively high number of dorsal spines, with spines increasing in size from first to last (26-31 but 23 in 1 specimen). Three anal spines are close together. Two externally visible anal spines, the first is smaller than the second. The last additional anal spine is very short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. Origin of anal-fin ray is slightly situated before origin of the dorsal-fin ray.

An examined specimens has one preorbital spine (1L/1R), which is hidden under the skin and two preopercular spines on each side.

Maximum observed L_S: 196.8 mm (**UMMZ 2575**: 211.2 mm L_T). However specimens collected in Cambodia can size up to 260 mm L_S **(Rainboth, 1996)**.

COLOURATION.

- **PRESERVED SPECIMENS. —** Adults are uniformly dark or olive purplish with irregular pale blotches on the sides of the body, abdomen uniformly pale or with transverse bands, fins with highly variable pale bands or striae, dorsal fin base with 10-12 dark spots.

DISTRIBUTION. — *M. maculatus* is distributed in Sundaland region **(Roberts, 1989; Vidthayanon, 2002; Rachamatika, 2005)**.

- **THAILAND. —** Thailand (Khao Nor Chu-Chi, Krabi and Toh Daeng Peats, Narathiwat**)**.

- **OTHER REGIONS. — Malay Peninsula** (Perak, Singapore). **Sumatra** (Deli. Langkat, Lematang, Tagora River, Petok, L. Korinchi, Lahat, Solok, Kaju Tanam, Pajakumbuk, Wai Lima, Sungei Penoh, Palembang, Kipahiang). **Borneo** (Kina Balu, Kahajan, Seminis, Kapuas). **Java** (Lebak, Bogor, Tjipanas, Tjandjur, Djasinga, Tji Barangbang, Palabuan, Kepong). **Biliton (Roberts, 1989)**. **Vietnam (Rainboth, 1996)**.

BIOLOGY AND ECOLOGY.

- **HABITAT. —** In Thailand, *Macrognathus maculatus* inhabits lowland streams and peats in Thailand **(Vidthayanon *et al*., 2002)**. It also lives in small streams with clear water over sand and gravel as substrates from Pliew Waterfall, Nakhon Si Thammarat and it was captured in shallow water **(Lertsuttichawan *et al*., 2001)**.

  In the Middle Malinau, Borneo, Indonesia, it lives in fast flowing water over sand and gravel substrates **(Rachmatika *et al*., 2005)**. It is also usually occurs in clear water over rocky bottom in flowing steams **(Rainboth, 1996)**.

- **STATUS. —** *M. maculatus* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**; however, it is a relatively uncommon species and a relatively low abundance **(Vidthayanon, 2002; Rachmatika *et al*, 2005)**. From Malay Peninsula to Borneo, only two specimens found in the Middle Malinau, Borneo, Indonesia **(Rachmatika *et al*, 2005)**.

- **DIET. —** Feeds on worms and insect larvae dwelling at the bottom of streams and possibility some small crustaceans **(Rachmatika *et al*, 2005)**.

- **REPRODUCTION. —** Sexually mature females of *Macrognathus maculatus* have an elongate tubular genital papilla which is similar to *Macrognathus circumcinctus*. It may possibly be an ovipositor.

- **FISHERIES. —** It was caught by ornamental fish trap and bamboo trap.

4. *Macrognathus meklongensis* Roberts, 1986

(FIGURE 4.2a, 4.8a, 4.12c and 4.14b and TABLE 4.5-4.6 and 4.23-4.34)

SYNONYMS AND CITATIONS.

Macrognathus meklongensis: Roberts, 1986 (new species; Type locality "Kwae Noi River, Meklong River basin, Thailand").

COMMON NAME. — Meklong Spiny Eel

LOCAL NAME. — Pla Lod Mae-Klong (Thailand).

TYPE LOCALITY. — Thailand: Meklong River basin, Kwae Noi River, Kha Lam Dam area, Tong Pha Phum, Khanchanaburi.

TYPE MATERIAL.

- **Holotype. — NMR TRR/1984120.3002**, 95.0 mm, Thailand: Meklong River basin, Kwae Noi River, Kha Lam Dam area, Tong Pha Phum, Khanchanaburi. Jaranthada Karnasuta, March 19-22, 1984.
- **Paratypes. —** NIFI uncat. and NRM/1984120.3003, 4: 97.0-178 mm, collected with the holotype.

MATERIALS EXAMINED.

TOTAL MATERIAL NUMBER. — 70 specimens.

***Meklong Basin* —** 70 specimens**.**

CUMZ 2006.12.14:1-10, 10: 151-176 mm L_S, Kwae Noi River, Sangkhla Buri, Kanchanaburi; **CUMZ 2006.12.14:11-30**, 20: 163.5-213 mm L_S, fish market, Mae Sod, Tak; **CUMZ 2006.09.13:31-50**, 20, Pak Thongchai, Nakhon Ratchasima (from Myanmar); **CUMZ 2006.09.13:51-70**, 20, Pak Thongchai, Nakhon Ratchasima (from Myanmar).

ETYMOLOGY. — The specific name "*meklongensis*" is named after the Meklong River as type locality.

DIAGNOSIS. — *Macrognathus meklongensis* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XVII-XXI 48-54; A. III 44-51; P. 24-27; C. 13-16;
- A concave rostrum bearing 9-11 toothplate paris **(see TABLE 4.33)**;
- Predorsal vertebrae: 17-20, abdominal vertebrae: 30-33, caudal vertebrae: 41-45, total vertebrae: 73-77, in-between vertebrae 1-2 **(see TABLE 4.25-4.29)**;
- Rim of anterior nostril with 6 fingerlike projections;
- Preorbital and preopercular spines absent **(see TABLE 4.34)**;
- Dorsal, anal, and caudal fin entirely separate;
- Colouration very distinctive from *Macrognathus siamensis* in having 7-12 small ocelli along base of dorsal fin; dorsal and anal fins with fine dark striation (present in *M. aral* but absent *M. siamensis*).

M. meklongensis is distinguished from species in *Macrognathus*, excluding *M. aculeatus* and *M. siamensis*, by its lesser dorsal-fin spines (16-21 *vs*. 27-32). It differs from *M. aculeatus* in having fewer rostral toothplates (8-11 *vs*. 32-50) **(see TABLE 4.32)**. It differs from *M. siamensis* by its distinctive colour pattern consisting of 7-12 small ocelli along base of dorsal fin. *M. meklongensis* also has no caudal ocellus.

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, *M. meklongensis* can be distinguished from all other mastacembelid species by its long snout length [46.2-52.0 (mean 48.6) %L_H], its long rostral appendage length [21.0-24.2 (mean 22.8) %L_H], its short postorbital length [43.2-49.5 (mean 46.5) %L_H but still longer than *M. aculeatus*], its long pre-posterior external nare length [35.5-41.1 (mean 38.3) %L_H], its long distance between base of tubular anterior nostril and posterior external nare [30.5-35.3 (mean 32.9) %L_H] and its long head length [19.4-21.9 (mean 20.5) %L_S]. However, the measurements of *M. meklongensis* are shorter than that of *M. aculeatus* but are longer than that of *M. siamensis*.

Moreover some morphometric characters in percentage of standard length *viz.* distance from snout to first dorsal spine, spinous dorsal-fin base length and distance from dorsal spine origin to anal fin origin can be also employed for distinguishing *M. circumcinctus* from all other species except in *M. aculeatus*.

For distinguishing *M. meklongensis* from all species in *Macrognathus*, the short postjaw angle length can be employed [64.8-71.6 (mean 67.6) %L_H].

M. meklongensis can be distinguished from *M. siamensis* by its long distance from angle of jaws to tip of rostral appendage [31.6-37.5 (mean 33.6) %L_H *vs*. 26.1-35.2 (30.7)]. In addition, it differs from *M. siamensis* by its short upper jaw length [13.0-16.8 (mean 14.9) %L_H *vs*. 13.4-19.8 (16.8)], its long distance from angle of jaws to eye [16.0-20.0 (mean 18.2) % L_H *vs.* 12.0-19.3 (16.2)], its short pectoral-fin length [25.7-32.7 (mean 29.1) % L_H *vs.* 30.0-36.5 (33.1)] and its long distance from posterior external nare to eye [9.8-13.1 (mean 10.9) %L_H *vs*. 8.2-11.2 (9.9)].

For other diagnoses of *M. meklongensis* see account under *M. aculeatus* and *M. siamensis*.

DESCRIPTION. — Morphometric measurements and meristic counts are given respectively in **TABLE 4.5-4.6** and **TABLE 4.24-4.34.** For general appearance see **FIGURE 4.2a**.

Macrognathus meklongensis has a relatively medium snout, compared with *M. aculeatus* and *M. siamensis*. The snout is more elongate than *M. siamensis* [46.2-52.0 (mean 48.6) %L_H *vs*. 40.5-48.5 (44.1) respectively]. A pair of tubular anterior nostrils is situated at subdistal tip of rostrum. Each aperture of rim tubular nostrils is guarded by six finger-like frimbrae.

Gape of mouth is very small. Upper jaw length is longer than lower jaw [13.0-16.8 (mean 14.9) %L_H *vs*. 9.1-14.7 (11.5)]. Eyes are relatively small [8.2-10.0 (mean 9.0) %L_H]. There is no any gill rakers. Caudal fin is distinctly separated from the dorsal and anal fins. Preanal length is always greater than the postanal length [60.0-63.8 (mean 61.6) %L_S *vs*. 36.2-40.0 (38.4)]. Vent is nearer to base of caudal fin than to snout.

Scales are between and around eye and posterior nostril, and from the latter to the maxilla. Snout is not entirely scaly. Internasal space, interorbital space and top of head as far as hind edge of preoperculum are naked.

Fleshy angle of jaws are situated apparently anterior to the anterior border of the posterior external nare and not extending to below the posterior nostril **(FIGURE 4.8c)**. Upper tip of gill slit and dorsal edge of the pectoral-fin base are at the nearly same level and are anterior to the ventral edge of pectoral-fin base **(FIGURE 4.12c)**.

The first dorsal spine is situated apparently far behind posterior edge of pectoral-fin base and is originated at the middle of body. *M. aculeatus* has a relatively low number of dorsal-fin spines, with spines increasing in size from first to last [16-21 average 18.1 (21 in one specimen)]. Three anal spines are close together. There are two externally visible anal spines. The first is smaller than the second. The second is the largest. The last additional anal spine is very short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. Anal-fin ray is slightly situated before the origin of dorsal-fin ray.

The neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on **two different, successive vertebrae**. In the others they are **situated on the same vertebrae** with the following frequencies: 14 and 16 specimens respectively. First dorsal fin pterygiophore is inserted behind 17^{th}, 18^{th}, 19^{th} or 20^{th} neural spine. Pterygiophore of last dorsal fin spine is inserted behind 32^{nd}, 33^{rd}, 34^{th}, 35^{th} or 36^{th} neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 33^{rd}, 34^{th} or 35^{th} vertebra.

All specimens lack preorbital and preopercular spines.

Maximum observed L_S: 213 mm (**CUMZ 2006.12.14:11-30**, MAS 0020: 228.5 mm L_T).

COLOURATION.

FRESH SPECIMENS. — Body without any mark. Background colour is iridescent blue-green (like colour of peafowl plumage). 7-12 small ocelli are along the base of dorsal fin. Dorsal and anal fins with fine dark vertical striation (present in *M. aral* but absent *M. siamensis*).

DISTRIBUTION. — Vidthayanon (2005) stated that *Macrognathus meklongensis* is an endemic species to the Meklong River.

- **THAILAND. —** *M. meklongensis* is distributed in Meklong basin only. It has not been recorded from all other basins. However I strongly believe that *M. meklongensis* might might be found in parts of Thailand drained by the Salween River because I obtained some a lot of *M. meklongensis* materials sold in a fish market in Mae Sot in Tak, but the specimens came from Myanmar. It is not known from other adjacent countries.

BIOLOGY AND ECOLOGY.

- **HABITAT. —** *M. meklongensis* habits in hillstream **(Vidthayanon, 2005)**.

- **STATUS. —** Although *M. meklongensis* is not listed on the IUCN Red List, it has been considered as an endemic species in the Thailand Red Data: Fishes **(Vidthayanon, 2005)**.

- **DIET. —** Earthworm.

5. *Macrognathus semiocellatus* Roberts, 1986

(FIGURE 4.2b-c, 4.9a, 4.12d and 4.15b and TABLE 4.7-4.8 and 4.23-4.34)

SYNONYMS AND CITATIONS.

Macrognathus semiocellatus Roberts, 1986 (new species; locality: Ubon Ratchatani, Thailand).

COMMON NAME. — Back Spotted Spiny Eel.

LOCAL NAME. — Pla Lod, Pla Lod Lang Jud (Thailand).

TYPE LOCALITY. — Thailand: Ubon Ratchathani market (presumably caught in Mun River near Ubon Ratchath ani = Mekong Basin).

TYPE MATERIAL.

- **Holotype. —** NMR TRR/1985260.3004, 157 mm, Thailand: Ubon Ratchatani market (presumably caught in Mun River near Ubon Ratchatani = Mekong Basin). T. Roberts, 28 June - 2 July 1985.
- **Paratypes. —** Meklong basin: NIFI 01676, 2: 100-113 mm L_S, Srinakarin Reservoir, Si Sawat, Kanchanaburi, Sonkphan, 12 August 1983.

MATERIALS EXAMINED.

TOTAL MATERIAL NUMBER. — 164 specimens.

***Chao Phraya Basin* —** 126 specimens.

CUMZ 2006.11.18:1-3, 3: 124-135 mm L_S, Tron, Uttaradit; **CUMZ 2006.11.19:9-17**, 9: 144.5-179 mm L_S, Bueng Boraphet, Nakhon Sawan; **CUMZ 1997.10.08:18-22**, 5; 158.4-191.9 mm L_S, Phra Nakhon Si Ayutthaya; **CUMZ 1997.03.08:23-24**, 2: 130.3-157.8 mm L_S, Chai Nat; **CUMZ 2006.11.18:31** ,1: 143 mm L_S, Yom River basin, Mueang Phrae, Phrae; **CUMZ 1997.11.07:32-35**, 4: 98.6-150.8 mm L_S, Chao Phraya River, Chai Nat; **CUMZ 2006.09.24:36-45**, 10: 124.5-165.3 mm L_S, Yom River, Mueang Sukhothai, Sukhothai; **CUMZ 2006.07.15:46-90**,

45, Bueng Boraphet, Nakhon Sawan; **CUMZ 2006.07.15:91-138,** 47, Bueng Boraphet, Nakhon Sawan.

NIFI 00618, Bueng Boraphet, Nakhon Sawan; **NIFI 01674**, Fresh market, Nakhon Sawan; **NIFI 02109**, Bueng Boraphet, Nakhon Sawan.

***Mekong Basin* —** 8 specimens: 84.2-178 mm L_S.

NIFI 00612, 5: 130-178 mm L_S, Songkhram river, Si Songkhram, Nakhon Phanom; **NIFI 01675**, 2: 110-114 mm L_S, Ubon Ratana reservoir, Khon Kaen; **NIFI 01678**, 1: 84.2 mm L_S, Oon River near Sakon Nakhon; **NIFI 02121**, Ubon Ratana Reservoir, Khon Kaen.

***Eastern Basins* —** 30 specimens.

CUMZ 2006.09.22:4-5, 2: 114.8-145.3 mm L_S, Kabinburi, Prachin Buri; **CUMZ 2006.06.12:6-8**, 3: 166.8-188.8 mm L_S, Mueang Prachin Buri, Prachin Buri; **CUMZ 1997.11.11:25-30**, 6: 118.7-143.6 mm L_S, Khao Soi Dao, Chanthaburi; **CUMZ 1997.11.11:139-153**, 14, Khao Soi Dao, Chanthaburi

KUMF uncat., 2: 100.7-123.7 mm L_S, Khlong Sam Sao, Khao Ang Rua Nai Widlife Sanctuary, Khlong Takrao, Tha Takiap, Chachoengsao; **KUMF uncat.**, 1: mm L_S, Klong Rabompran, Khao Ang Rua Nai Widlife Conservation Area, Khlong Takrao, Tha Takiap, Chachoengsao; **KUMF uncat.**, 2, Khao Ang Rua Nai Widlife Sanctuary, Khlong Takrao, Tha Takiap, Chachoengsao.

ETYMOLOGY. — The specific name "*semiocellatus*" is derived from the Latin word "*semi*", meaning a half and "*ocellatus*" meaning to having little eyes or marked with spots. Together they are translated as a fish that has a series of half ocelli on each the soft of dorsal fin.

DIAGNOSIS. — *Macrognathus semiocellatus* is distinguished from all other oriental mastacembelid species by the following combination of characters:

- D. XVIII-XXXII 46-58; A. III 53-65; P. 22-24; C. 10-13;
- Predorsal vertebrae: 4-5, abdominal vertebrae: 27-30, caudal vertebrae: 42-44 (41 in one specimen), total vertebrae: 70-74, in-between vertebrae 2-5 **(see Table 4.25-4.29)**;
- Rostral toothplate absent;
- Rim of anterior nostril with 2 fingerlike projections and 2 broad-based flaps**;**
- Preorbital always and two or three preopercular spines usually present **(see TABLE 4.33)**;
- Dorsal, anal and caudal fin confluent;
- A series of 4-10 roundish dark marks along the base of soft dorsal fin, some or all continuous with bars on posterior part of body.

M. semiocellatus differs from all other *Macrognathus* species in having two fingerlike projections and two broad-based flaps (*vs*. six fingerlike projections). In addition, it is distinguished from *M. circumcinctus* and *M. zebrinus* by its more in-between vertebrae [2-5 (average 3.13) *vs*. 0-2 (1.17) *vs*. 1-3 (2)].

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, pre-posterior external nare length can be employed for distinguishing *M. semiocellatus* from all other species in the genus *Macrognathus* [29.6-34.5 (mean 32.0)]. Moreover its distance from dorsal spine origin to anal fin origin can be used for distinguishing *M. semiocellatus* from all other species except *Mastacembelus alboguttatus*. The distance from anal-fin ray origin to dorsal-fin ray termination can be also used for distinguishing *M. semiocellatus* from all other species except *Mastacembelus tinwini*.

The distance from angle of jaws to eye, distance between base of tubular anterior and posterior external nare, preanal length, postanal length, soft dorsal-fin base length, anal-fin base length and distance from posterior edge of anus to anterior base of first anal-fin ray are morphometric characters which can be used for distinguishing *M. semiocellatus* from both *M. circumcinctus* and *M. zebrinus*.

Additionally, *M. semiocellatus* is distinguished from *M. circumcinctus* by its short head width [10.0-13.8 (mean 11.6) *vs*. 9.8-17.8 (13.0)] and its distance from snout to first dorsal spine [16.9-23.7 (mean 21.1) *vs*. 20.9-28.6 (23.7)]. It is distinguished from *M. zebrinus* by its long rostral appendage length [11.3-17.0 (mean 14.4) *vs*. 9.7-13.7 (11.6)], its short postjaw angle length [68.7-74.5 (mean 71.3) *vs*. 73.4-79.2 (76.1)] and its short pectoral-fin base length [9.6-14.0 (mean 11.7) *vs*. 9.8-15.1 (12.6)].

For other diagnoses of *M. semiocellatus* see accounts under *M. circumcintus* and *M. zebrinus*.

DESCRIPTION. — Morphometric features and meristic counts are given respectively in **TABLE 4.7-4.8** and **TABLE 4.24-4.34.** For general appearance see **FIGURE 4.2b-c**.

Macrognathus semiocellatus has a relatively small snout. A pair of tubular anterior nostrils is situated at subdistal tip of rostrum. Each aperture of rim tubular nostrils is guarded by two finger-like frimbrae and two broad-based flaps. Upper jaw length is longer than lower jaw length [15.5-22.0 (mean 19.2) %L_S *vs*. 12.2-17.4 (15.0)]. Eyes are small (7.5-12.8 (mean 9.5) % L_H). Preanal length is always greater than the postanal length [52.8-59.2 (mean 56.2) %L_S *vs*. 40.8-47.2 (443.80.7)]. Vent is nearer to base of caudal fin than to snout.

Scales are cycloid and minute, occurring between and around eye and posterior nostril, and extending from the latter to gape of mouth. Snout is entirely scaly. Interorbital and internasal spaces and top of head, as far as hind edge of preoperculum are naked.

Fleshy angle of jaws is situated slightly posterior to the anterior border of the posterior external nare. Upper tip of gill slit and dorsal edge of the pectoral-fin base are at the slightly different level and anterior to ventral edge of the pectoral-fin base. The upper gill slit is slightly higher than the dorsal of pectoral-fin base but the upper gill slit is posterior to the dorsal edge of pectoral-fin base.

The first dorsal spine is situated apparently behind the posterior edge of pectoral-fin base. *M. circumcinctus* has a relatively high number of dorsal spines,

with spines increasing in size from first to last (28-32 average 30.75). Three anal spines are close together. There are two externally visible anal spines. the first is smaller than the second. The second is the largest. The last additional anal spine is very short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. Origin of anal-fin ray is apparently situated anterior to the origin of the dorsal-fin ray [3.6-7.5 (mean 5.3) %L_S].

In all specimens the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on **two different vertebrae and are separated by 2-5 in-between vertebrae.** The vertebra with the neural spine supporting the pterygiophore of the last externally visible dorsal spine is **situated posterior** to the vertebrae whose haemal spine supports the first anal spine. First dorsal fin pterygiophore is inserted behind 4th or 5th neural spine. Pterygiophore of last dorsal fin spine is inserted behind 33rd, 34th, 35th or 36th neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 29th, 30th 31st or 32nd vertebra.

All materials have one preorbital spine (1L/1R), which is hidden under the skin in larger specimens. The tip of preorbital spine situated to reach to below anterior edge of eye. Preopercular spine number varies from 2L/2R to 3L/3R with the following frequencies: (2L/2R: 44); (2L/3R: 3); (3L/2R: 1); (3L/3R: 3).

Maximum observed L_S: 191.9 mm (CUM 2006.10.20:18: 228.5 mm L_T).

COLOURATION. — Coloration varies greatly in intensity, possibly depending on the clarity of the water inhabited.

FRESH SPECIMENS. — Colour live specimens at Sukhothai**,** Phrae and Uttaradit: overall usually drab yellowish; head and sometimes body with shiny yellowish reflection, abdomen pale, off-white or slightly cream-colored (not yellowish); spots along dorsal fin ray, forming imperfect ocelli (4-13 semi-ocelli) and varying in intensity from relatively faint too very dark (almost black). Base of dorsal fin sometimes is orangish (specimens from Prachinburi). Caudal and anal fin is dusky, without markings, sometimes anal fin with a thin black marginal stripe. Pectoral fin is clear.

DISTRIBUTIONS.

THAILAND. — It is distributed in the Chao Phraya basin from the north to the central Thailand, the Mekong and the Eastern basins.

OTHER REGIONS. — the Mekong basin in Laos, Cambodia and Vietnam **(Kottelat, 2001; Rainboth, 1996)**.

GENERIC STATUS. — Robert (1986) described *M. semiocellatus* as a new member of the genus *Macrognathus*. *M. semiocellatus* is most similar to *M. taeniagaster*.

BIOLOGY AND ECOLOGY.

- **STATUS. —** *M. semiocellatus* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**.
- **HABITATS. —** *M. semiocellatus* was found at the bottom depths of slow-flowing rivers or standing waters or floodplain areas.
- **DIETS. —** Earthworms and insect larvae.
- **FISHRIES. —** It was caught by bamboo trap and hook and line.

6. *Macrognathus siamensis* (Günther, 1861)

(FIGURE 4.3a-d, 4.7c and TABLE 4.9, 4.10)

SYNONYMS AND CITATIONS.

Rhynchobdella aculeata var. *siamensis* Günther, 1861 (type locality: "Pachebore, Siam", presumably Petchaburi).

Rhynchobdella aculeata (Bloch): Fowler, 1935.

Macrognathus ocellatus Hamilton-Buchanan, 1822: 29.

Mastacembelus pentopthalmus Gray, 1854: 172.

Mastacembelus paucispinis Fowler, 1939: 75; Smith, 1945: 66.

Macrognathus aculeatus Suvatti, 1950: 207.

Macrognathus aculeatus aculeatus Deraniyagala, 1952: 132.

Macrognathus siamensis: Roberts, 1980: 389.

COMMON NAME. — Siamese Spiny Eel**,** Peacock Eel**.**

LOCAL NAME. — Pla Lod**,** Pla Lod Siam (Sa-Yam) (Thailand).

TYPE LOCALITY. — Thailand**.**

TYPE SPECIMEN. — BMNH 1861.10.8.14**.**

MATERIALS EXAMINED.

TOTAL MATERIAL NUMBER. — 223 specimens.

***Chao Phraya Basin* —** 142 specimens.

CUMZ 2006.06.25:1-4, 4: 211.1-248 mm L_S, Yom River, Mueang, Sukhothai; **CUMZ 2006.11.20:5-20**, 16: 184.4-261.2 mm L_S, Tron, Uttaradit; **CUMZ 2006.11.20:21-30**, 10: 187-230 mm L_S, Tron, Uttaradit; **CUMZ 2006.11.20:31-50**, 10: 147.6-200.7 mm L_S, Tron, Uttaradit; **CUMZ 2006.11.21:51-56**, 6, Bang Rakam, Phitsanulok; **CUMZ 2006.11.19:57-61**, 5, Yom River, Mueang Phrae, Phrae; **CUMZ 2006.11.20:62-66**, 5, Nong Ta Ngu, Mueang Uthai Thani, Uthai Thani; **CUMZ 2006.11.18:67-72**, 5, Nan River, Mueang Nan, Nan; **CUMZ 2006.06.24:73-80**, 5, Mueang Sukhothai, Sukhothai; **CUMZ 1992.02.25:152-156**, 5,

Kamphaeng Phet; **CUMZ 2006.11.07:157-161**, 5, Chai Nat; **CUMZ 2006.11.18:162-178**, 17, Nakhon Sawan; **CUMZ 2007.07.14:179-189**, Phichit; **CUMZ 2007.08.22:190-204**, 15, Phichit; **CUMZ 2006.06.24:205-213**, 9, Nan River, Mueang Phitsanulok, Phitsanulok; **CUMZ 1990.11.24:214**, 1, Nonthaburi; **CUMZ 1997.10.19:215**, 1, Sing Buri.

KUMF 1290, 2: 133-149 mm L_S, Lop Buri (Fish market); **KUMF 2643**, 183 mm L_S, Nontaburi; **KUMF 6888**, 157 mm L_S, Huai Kra Siao, Ban Chao Wat, Ban Rai, Uthai Thani; **KUMF 6892**, 128 mm L_S, Bantha Plara, Dan Chang, Suphan Buri; **KUMF 6896**, 153 mm L_S, Pak Huai Dur, Dan Chang, Suphan Buri. **NIFI 00619**, Phra Nakhon Si Ayutthaya; **NIFI 01262**, Chao Phraya reservoir, Chai Nat.

***Mekong Basin* —** 76 specimens.

CUMZ 2006.09.11:81-83, 4, Si Songkhram, Nakhon Phanom; **CUMZ 2006.09.12:84-88**, 5, Mueang Mukdahan, Mukdahan; **CUMZ 2006.09.10:89-99**, 11, Kok Gong, Si Wilai, Nong Kai; **CUMZ 2006.09.09:100-103,** 4, Bueng Kan, Nong Kai; **CUMZ 2006.09.09:104-113,** 10, Mueang Nong Kai, Nong Kai; **CUMZ 2006.09.11:114-116**, 3, Nong Han**,** Sakon Nakhon; **CUMZ 2006.11.28:117-128**, Bamnet Narong, Chaiyaphum; **CUMZ 2006.11.28:129-149**, 20, Bamnet Narong, Chaiyaphum; **CUMZ 2006.11.28:150-151**, 2, Wang Nam Khiao, Nakhon Ratchasima.

NIFI 00616, Lam Pao reservoir, Kalasin; **NIFI 02131**, Lam Dome Noi, Ubon Rachathani; **NIFI 02006**, Huai Luang reservoir, Udonthani; **NIFI 02087**, Lam Dome Yai, Det Udom, Ubon Rachathani; **NIFI 00620**, Ubon Ratana Reservoir, Khon Kaen; **NIFI 3225**, None Kadam, Ubon Ratana Reservoir, Khon Kaen.

***Meklong Basin* —** 3 specimens.

KUMF 1285, **1286**, 3: 123-155 mm, Nong Bang Ngu, Ratchaburi.

***Eastern Basins* —** 1 specimen.

NIFI 00617, 1, Bang Phra Reservoir, Si Racha, Chon Buri.

ETYMOLOGY. — *Macrognathus siamensis* is named after Siam as a type locality.

DIAGNOSIS. — *Macrognathus siamensis* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XI-XVII 52-60; A. III 49-58; P. 19-23; C. 14-16;
- Predorsal vertebrae 18-23, abdominal vertebrae 32-34, caudal vertebrae 41-43, total vertebrae 74-77, in-between vertebrae 0 **(see TABLE 4.25-4.29)**;
- Relatively small snout with 7-14 rostral toothplates (compared with long snout in *M. aculeatus* and medium snout in *M. meklongensis*) **(see TABLE 4.33)**;
- Rim of anterior nostril with 6 fingerlike projections;
- Preorbital and preopercular spines absent **(see TABLE 4.34)**;
- Dorsal fin ray and anal fin ray separated with a distinct notch from round caudal fin;
- A series of 0 to 6 large ocelli with a white boundary situated along base of dorsal fin ray on both sides; Dorsal and caudal fins without striation or spots or dots.

M. siamensis is distinguished from species in *Macrognathus*, excluding *M. aculeatus* and *M. siamensis*, by fewer dorsal-fin spines (11-17 *vs*. 27-32). It differs from *M. aculeatus* in having fewer numerous rostral toothplates (10-13 *vs*. 32-50) **(see TABLE 4.32)**. It differs from *meklongensis* by distinctive colour pattern consisting of 0-6 ocelli along base of dorsal fin. It also has a caudal ocellus.

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, *M. siamensis* can be distinguished from all mastacembelid species by its rostral appendage length [15.0-20.8 (mean 18.2) %L_H], its distance from angle of jaws to eye [12.0-19.3 (mean 16.2) %L_H], its distance from snout to first dorsal spine [40.0-49.5 (mean 44.4) %L_H], its spinous dorsal-fin base length [18.0-24.7 (mean 21.6) %L_H], and its distance from dorsal-fin ray origin to anal-fin ray origin [21.2-29.7 (mean 25.8) %L_H].

The snout length and postjaw angle length can be employed for distinguishing *M. siamensis* from almost all species, excluding *Mastacembelus alboguttatus* [40.5-

48.5 (mean 44.1) %L_H and 70.2-77.0 (73.9) respectively]. The upper jaw length can be used for distinguishing *M. siamensis* from all mastacembelid in *Macrognathus*.

For distinguishing *M. siamensis* from *M. aculeatus* and *M. meklongensis*, pre –posterior external nare can be used [31.2-38.2 (mean 34.9) %L_H and 27.2-32.9 (29.9)]. For more details on other diagnoses of *M. siamensis*, see account under *M. aculeatus* and *M. meklongensis*.

DESCRIPTION. — Morphometric measurements and meristic counts are given respectively in **TABLE 4.7-4.8** and **TABLE 4.24-4.34**. For general appearance see **FIGURE 4.3a-d**.

Macrognathus siamensis has a medium snout and medium rostrum [40.5-48.5 (mean 44.1) %L_H and 15.0-20.8 (18.2) respectively]. A pair of tubular anterior nostrils is situated at subdistal tip of rostrum. Each aperture of rim tubular nostrils is guarded by six finger-like frimbrae.

Gape of mouth is small. Upper jaw length is longer than lower jaw [13.4-19.8 (mean 16.8) %L_H and 10.1-16.0 (12.8)]. Eyes are relatively small [6.3-11.7 (mean 8.9) %L_H]. There is no any gill rakers. Caudal fin is distinctly separated from the dorsal and anal fins. Preanal length is always greater than the postanal length [57.3-67.2 (mean 60.7) %L_S and 36.9-42.7 (39.4)]. Vent is nearer to base of caudal fin than to snout.

Scales are between and around eye and posterior nostril, and from the latter to the maxilla. Top of snout, internasal space, interorbital space and top of head as far as hind edge of preoperculum are naked.

Fleshy angle of jaws are situated apparently before anterior border of the posterior external nare and not extending to below the posterior nostril **(FIGURE 4.9b)**. Upper tip of gill slit and dorsal edge of the pectoral-fin base are at the same level and are anterior to the ventral edge of pectoral-fin base **(FIGURE 4.12e)**.

The first dorsal spine is situated apparently far behind posterior edge of pectoral-fin base and is originated at the middle of body. *M. siamensis* has a relatively

low number of dorsal-fin spines, with spines increasing in size from first to last (11-17 average 14.17). Three anal spines are close together. Two anal spines are externally visible. The first is smaller than the second. The second is the largest. The last additional anal spine is very short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. Anal-fin ray is slightly situated before the origin of dorsal-fin ray.

The neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated **on two different successive vertebrae** and in the others, they are situated **on the same vertebrae** with the following frequencies: 6 and 26 specimens respectively. First dorsal fin pterygiophore is inserted behind 18th, 19th, 20th or 21st (23rd in three specimens) neural spine. Pterygiophore of last dorsal fin spine is inserted behind 33rd, 34th, 35th or 36th neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 33rd, 34th or 35th vertebra.

All specimens lack preorbital and preopercular spines.

Maximum observed L_S: 262 mm (**CUMZ 2006.11.20:5-20**, 281 mm L_T).

COLOURATION.

FRESH SPECIMENS. — A series of 0 to 6 large ocelli with a white boundary situated along base of dorsal fin ray on both sides; Dorsal and caudal fins without striation or spots or dots.

DISTRIBUTION.

- **THAILAND. —** *M. siamensis* is distributed in the Mekong basin, the Chao Phraya basin and other rivers of Thailand southwards to the northern end of the Malay Peninsula, as well as in the Eastern basins such as Khao Soi Dao and Khao Kitchana Koot, Chanthaburi **(Yananan, 2001)**. Phetchaburi is southernmost locality for *M. siamensis*.

- **OTHER REGIONS. —** The Mekong Basin in Laos, Cambodia, Vietnam **(Rainboth, 1996)**. It is not known from Malaysia **(Roberts, 1980)**.

BIOLOGY AND ECOLOGY.

- **HABITATS. —** *M. siamensis* was found at the bottom depths of slow-flowing rivers or standing waters or floodplain areas.

- **STATUS. —** *M. siamensis* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**. It is widely distributed with a relatively high abundance of number.

- **DIETS. —** Earthworms.

7. *Macrognathus zebrinus* (Blyth, 1858)

(FIGURE 4.4a-c, 4.9c, 4.12f and 4.15c and TABLE 4.11, 4.12)

SYNONYMS AND CITATIONS.

Mastacembelus zebrinus Blyth, 1859: 281 (type locality: Moulmein).

Macrognathus zebrinus: Travers, 1984b: 144.

Mastacembelus zebrinus: Sufi, 1956: 124.

COMMON NAME. — Zebra Spiny Eel.

LOCAL NAME. — Pla Lod Ma Lai**.**

TYPE LOCALITY. — Moulmein, Myanmar.

TYPE MATERIAL. — Unknown, probably non-existent **(Sufi, 1956)**.

MATERIALS EXAMINED.

TOTAL SPECIMENS NUMBER — 21 specimens, 123.0-267.0 mm L_S.

***Salween Basin* —** 21 specimens, 123-267 mm L_S.

CUMZ 2006.12.16:1-9, 9: 224.5-257.3 mm L_S, Moei River, Tha Song Yang, Tak; **CUMZ 2006.12.16:10-18**, 9: 146.4-267 mm L_S, Moei River, Tha Song Yang, Tak.

NIFI 01672: 1, 123 mm L_S, Pegu Division, Kha Yein, Chaung, 4 miles NE of Hlegu, Burma; **NIFI 02408**: 1, 148 mm L_S, Rangoon River, Rangoon, Myanmar; **NIFI 12476**: 1, 246 mm L_S, Salween river, Mae Hong Son.

ETYMOLOGY. — The specific name "*zebrinus*" is derived from the word "*zebra*", meaning the Abyssinian name for the stripped equine of Africa. Therefore, it is interpreted that a fish that has a pattern of stripes like a zebra.

DIAGNOSIS. — *Macrognathus zebrinus* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XXVIII-XXX 48-54; A. III 50-58; P. 18-19; C. 18-19;
- Rostral toothplate absent;
- Rim of anterior nostril with 6 fingerlike projections;
- Predorsal vertebrae: 5, abdominal vertebrae: 29-32 (27 in one specimen), caudal vertebrae: 41-44, total vertebrae: 71-74, in-between vertebrae 3-5 **(see TABLE 4.25-4.29)**;
- One preorbital and two, three or four preopercular spines always present **(see TABLE 4.34)**;
- Dorsal and anal fins are free from caudal fin;
- Body with 17-22 dark brown vertical bars but not continued onto abdomen or across abdomen like *Macrognathus circumcinctus*.

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, rostral appendage length can be employed for distinguishing *M. zebrinus* from all other species in the genus *Macrognathus* [9.7-13.7 (mean 11.6) %L_H]. Only distance from angle of jaws to eye is a morphometric measurement which can be used for distinguishing *M. zebrinus* from both *M. circumcinctus* and *M. semiocellatus* [13.5-18.3 (mean 16.1) %L_H *vs*. 11.2-18.1 (14.9) *vs*. 10.9-16.1 (mean 13.3) respectively].

Additionally, *M. zebrinus* is distinguished from *M. circumcinctus* by its long postorbital length [53.9-60.1 %L_H (mean 56.8) *vs*. 51.7-57.6 (54.1)] and its distance from snout to first dorsal spine [19.8-23.3 %L_S (mean 21.4) *vs*. 20.9-28.6 (23.7)]. It is distinguished from *M. semiocellatus* by its short distance from angle of jaws to tip of rostral appendage [25.8-30.8 %L_H (mean 28.2) *vs*. 30.4-37.5 (33.0)], its short distance between base of tubular anterior nostril and posterior external nare [22.6-27.3 %L_H (mean 25.3) *vs*. 24.3-31.2 (28.6)], its distance from dorsal spine origin to anal-fin ray origin [41.1-47.4 %L_S (mean 44.3) *vs*. 39.1-45.5 (41.7)], its distance from anal-fin ray origin to dorsal-fin ray termination [31.6-37.9 %L_S (mean 34.7) *vs*. 34.2-40.6 (37.3)] and its distance from posterior edge of anus to anterior base of first anal-fin ray [46.3-53.2 %L_S (mean 50.5) *vs*. 45.4-54.1 (49.5)].

For the other diagnoses of *M. zebrinus*, see account under *M. circumcinctus* and *M. semiocellatus*.

DESCRIPTION. — Morphometric features and meristic counts are given respectively in **TABLE 4.11-4.12** and **TABLE 4.24-4.34**. For general appearance see **FIGURE 4.4a-c**.

Macrognathus zebrinus has a relatively small snout [36.9-43.6 (mean 40.0) %L_H] and small head [16.3-19.8 (mean 17.5) %L_H]. A pair of tubular anterior nostrils is originated at subdistal tip of rostrum. Teeth are in bands on both jaws. No gill rakers. Caudal fin is free from soft-dorsal and soft-anal fins. Upper jaw length is longer than lower jaw [15.2-20.5 (mean 17.6) %L_H *vs*. 11.4-15.7 (13.0)]. Eyes are small [7.6-12.3 (mean 9.4) %L_H]. Preanal length is always greater than the postanal length [56.0-60.1 (mean 58.0) %L_S *vs*. 39.9-44.0 (42.1)]. Vent is nearer to base of caudal fin than to snout.

Scales are minute and cycloid, occurring in the internasal space, interorbital space and between the eyes and posterior nostrils. Snout is entirely scaly. Top of the head as far as the hind edge of the preoperculum are naked.

Fleshy angle of jaws are situated apparently anterior to the anterior border of posterior external nare and not extending to below the posterior external nare **(FIGURE 4.9c)**. Upper tip of gill slit and the dorsal edge of the pectoral-fin base are at the different level. The upper tip of gill slit is higher than the dorsal edge of pectoral-fin base and is anterior to the ventral edge of pectoral-fin base **(FIGURE 4.12f)**.

The first dorsal spine is situated apparently posterior to the dorsal and ventral edge of pectoral-fin base and is originated over the middle of pectoral fin. *M. zebrinus* has a relatively high number of dorsal spines, with spines increasing in size from first to last [28-30 (average 29.2)]. Three anal spines are close together. Two anal spines are externally visible. The first is smaller than the second. The second is the largest anal spines. The last additional anal spine is very short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. Origin of anal-fin ray distinctly more anterior than origin of dorsal-fin ray [1.9-4.4 (mean 3.5) %L_S].

All materials have one preorbital spine (1L/1R), which is hidden under the skin in larger specimens. The tip of preorbital spine situated nearly below anterior edge of eye. Preopercular spine number varies from 2L/3R to 4L/4R with the following frequencies: (2L/3R: 1); (3L/2R: 1); (3L/3R: 12); (3L/4R: 5); (4L/4R: 1).

In all specimens the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on **two different vertebrae** and **are separated by one to three in-between vertebrae.** The vertebra with the neural spine supporting the pterygiophore of the last externally visible dorsal spine **is situated posterior** to the vertebrae whose haemal spine supports the first anal spine. First dorsal fin pterygiophore is inserted behind 5^{th} neural spine. Pterygiophore of last dorsal fin spine is inserted behind 32^{nd}, 33^{rd}, 34^{th}, 35^{th} or 36^{th} neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 29^{th}, 30^{th}, 31^{st}, 32^{nd} or 33^{rd} vertebra.

Scales situated between origin of soft dorsal and lateral line are ranged from 21 to 23 **(Sufi, 1956)**.

Maximum observed L_S: 267 mm (**CUMZ 2006.12.16:11**, 283 mm L_T).

COLOURATION.

FRESH SPECIMENS. — Background spirit brown, darker along the back and paler on the belly. Body with 17-22 dark brown vertical bars, edged with yellowish. In the caudal region the bars may be forked or curved. Dorsal and caudal fin yellowish and striated with minute brown spots; the anal with the body bars continued on it alternating with shorter dark bars.

DISTRIBUTION. — Irrawaddy to Salween basins (Boulenger, 1912; Vidthayanon *et al*., 2005)**.** *M. zebrinus* is probably endemic to Salween basin**.**

THAILAND. — *M. zebrinus* is distributed in the Salween basin only (the Moei and the Salween Rivers).

OTHER REGIONS. — Myanmar: Irrawaddy River in Rangoon to Mandalay; Sittang and Salween Rivers in Moulmein **(Sufi, 1956)**.

BIOLOGY AND ECOLOGY.

- **HABITAT. —** *M. zebrinus* habits in lowland rivers and marshland including streams. It also lives in slow-running rivers with fine sand substrate such as the Moei River.

- **STATUS. —** *M. zebrinus* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**. Even if it has not been considered as an endemic species, it is probably restricted to the Salween basin, Thailand.

Genus *Mastacembelus* Scopoli, 1777

Mastacembelus Gronovius, 1763 (non-binomial, not available for zoological nomenclature).

Mastocembelus Scopoli, 1777 (misspelling of *Mastacembelus* Gronovius; type species *Ophidium mastacembelus* Solander in Russell, 1794, by absolute tautonomy)

Pararhynchobdella Bleeker, 1874 (type species "*Rhynchobdella maculata* Rwdt." = *Mastacembelus maculatus* Cuvier in Cuvier and Valenciennes, 1831, but monotypy).

TYPE SPECIES. — *Mastacembelus mastacembelus*

DIAGNOSIS. — *Mastacembelus* differs from all other *Macrognathus* in having 1) snout with a relatively small and short fleshy appendage without rotral toothplate; 2) rostral toothplates absent; 3) rim of tubular anterior nostrils with two fimbriae and two broad-based flaps; 4) usually more numerous dorsal spines, dorsal fin rays and anal fin rays (dorsal fin spines 32-39, dorsal fin rays 68-85, anal fin rays 68-82); 5) preorbital and preopercular spines usually present; 6) upper corner of gill slit lying anterior to upper half of pectoral-fin base and situated lower than dorsal edge of pectoral fin except in one species; 7) usually more numerous abdominal vertebrae, caudal vertebrae and total vertebrae (predorsal vertebrae 4-5, abdominal vertebrae 34-42, caudal vertebrae 45-54, total vertebrae 81-94); 8) adults relatively large. Other characters are given by **Travers (1984b: 135, 143-144)** and **Roberts (1986)**.

REMARKS. — Based on all examined specimens in this study, all species in the genus *Mastacembelus* can reach at least 40 cm. (*vs*. a maximum length of 30 cm. or less in the genus *Macrognathus*). According to **Travers (1984a, 1984b)** and **Roberts (1989)**, adductor arcus palatine muscle of species belonging to the genus *Mastacembelus* is not inserted on first infraorbital bone.

Key to Species of *Mastacembelus* in Thailand

1a. Dorsal and anal fins broadly joined to caudal fin; position of fleshy angle of jaws situated behind anterior border of posterior external nare, usually extending to below the posterior external nare; snout broad and short; caudal fin ray 13-20; abdominal vertebrae 37-42; not endemic to any basin……...…**2**

1b. Dorsal and anal fins separate from caudal fin; position of fleshy angle of jaws situated apparently anterior to anterior border of posterior external nare, always never extending to below the posterior external nare; snout very narrow and more elongate; caudal fin ray 21-23; abdominal vertebrae 34-36, body and soft-dorsal fin with several pale spots forming rings around larger dusky spots; endemic to the Salween basin.…….***Mastacembelus alboguttatus***

2a. Anus nearer first anal spine, shorter distance between posterior edge of anus to anterior base of first anal spine 0.8-3.9 (mean 2.0) %L_S; total vertebrae 86-94 or more, in-between vertebrae 1-2; soft-rayed portions of dorsal, anal and caudal fins usually with relatively faint or indistinct marking or with white margin……**3**

2b. Anus more away from first anal spine, relatively long distance between posterior edge of anus to anterior base of first anal spine 2.2-3.7 (mean 2.8) %L_S; total vertebrae 81-86 or less, in-between vertebrae absent; soft-rayed portions of dorsal, anal and caudal fins with red margin; head and anterior part of body with longitudinal red and black bands, rest of body with red spots edged with black on dark background, abdomen with numerous yellowish or orange spots…….***Mastacembelus erythrotaenia***

3a. Body relatively more slender, body depth at first dorsal spine 6.3-8.8 (mean 7.4) %L_S, body depth at posterior edge of anus 7.3-12.3 (mean 9.5) %L_S; body with non-network pattern, sometimes connecting to form a network but not extending onto abdomen; caudal length shorter 3.8-6.9 (mean 5.0) %L_S; caudal fin outline incompletely merged with soft-rayed portions of dorsal and anal fins; caudal fin rays 16-20……..….....4

3b. Body relatively deep, body depth at first dorsal spine 7.0-12.4 (mean 8.5) %L_S, body depth at posterior edge of anus 9.2-14.8 (mean 11.1) %L_S; body with broadly connected dark network always extending onto abdomen; caudal length longer 4.2-8.5 (mean 6.6) %L_S; caudal fin outline completely merged with soft-rayed portions of dorsal and anal fins; caudal fin rays 13-15 …….....***Mastacembelus favus***

4a. soft-rayed portions of dorsal, anal and caudal fins usually with relatively faint; body usually with zig-zag lines, sometimes connecting to form a netwok, but almost never extending onto abdomen; abdominal vertebrae 38-40, caudal vertebrae 53-54, total vertebrae 92-94, in-between vertebrae 0-1……..……..***Mastacembelus armatus***

4b**.** Soft-rayed portions of dorsal, anal and caudal fins defined white margin; body usually with four-five regular and parallel, longitudinal dark bands along the body, expressed as series of interrupted lines or broken up into individual blocthes; abdominal vertebrae 41-42; caudal vertebrae 48-50, total vertebrae 90-91, in-between vertebrae 1-2……....***Mastacembelus tinwini***

8. *Mastacembelus alboguttatus* Boulenger, 1893

(FIGURE 4.5a, 4.10a, 4.13a and 4.16a and TABLE 4.13-4.14 and 4.23-4.34)

SYNONYMS AND CITATIONS.

Mastacembelus alboguttatus Boulenger, 1893: 200 (type locality: Sittang River, Myanmar).

Mastacembelus alboguttaus Roberts, 1986: 95-109 + figure 2a.

COMMON NAME. — White-Spotted Spiny Eel.

LOCAL NAME. — Pla Kra-Ting Jud Khao (Thailand).

TYPE LOCALITY. — Sittang River, Myanmar.

MATERIALS EXAMINED.

TOTAL MATERIAL NUMBER. — 23 specimens: 263.7-454 mm L_S.

***Salween Basin* —** 22 specimens: 118.8-454 mm L_S.

CUMZ 2006.12.17:1-3, 3: 275.7-338 mm L_S, Moei River, Mae Ramad, Tak; **CUMZ 2006.12.18:4-18**, 15: 263.7-454 mm L_S, Moei River, Tha Song Yang, Tak; **CUMZ uncat.**, 1 : 118.8 mm L_S, Huai Mae Saem Lap, the Salween River basin, Mae Hong Son.

NIFI 00972, 2: 288-351 mm L_S, Pai river, Mae Hong Son; **NIFI 00610**, 1: 286 mm L_S, Pai river, Nam Phieng Din, Mae Hong Son.

KUMF 1292, 1: 287 mm L_S, Pai River, Mae Hong Son.

ETYMOLOGY. — The specific name "*alboguttatus*" is derived from the Latin word "*alb*", meaning white and "*guttatus*" meaning to be dappled, speckle and spotted. They are translated together as a fish that has numerous white spots scattered on body.

DIAGNOSIS. — *Mastacembelus alboguttatus* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XXXIV-XXXVII 75-85; A. III 70-82; P. 22-24; C. 21-23.
- Predorsal vertebrae: 5 (4 in one specimen), abdominal vertebrae: 35-36 (34 in one specimen), caudal vertebrae: 46-50, total vertebrae: 81-86, in-between vertebrae 1-2 **(see TABLE 4.25-4.29)**;
- Rostral toothplate absent;
- Rim of anterior nostril with 2 fingerlike projections and 2 broad-based flaps;
- One preorbital spine and 3 or 4 preopercular spines on each side **(see TABLE 4.34)**;
- Caudal fin entirely separated from soft-dorsal and soft-anal fins;
- Body and soft-rayed portions of dorsal fin with numerous large dusky and small pale spots, several translucent spots on pectoral fin.

M. alboguttatus is distinguished from all other species in the genus *Mastacembelus* by its position of fleshy angle of jaws situated apparently anterior to the anterior border of posterior external nare and not extending to below the posterior external nare. It also differs from all other *Mastacembelus* in having fewer abdominal vertebrae (34-36 vs. 37-42) and very unique colouration.

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, many morphometric measurements in $\%L_H$ *viz.* distance from angle of jaws to tip of rostral appendage, postorbital length, postjaw angle length, upper jaw length, lower jaw length, pectoral fin length, pectoral-fin base length, distance from angle of jaws to eye, distance from posterior external nare to eye, pre-posterior external nare length, distance between base of tubular anterior and posterior external nare and some measurements in $\%L_S$ *viz.* distance from snout to first anal spine, preanal length, postanal length, soft dorsal-fin base length, anal-fin base length and dorsal-fin ray termination to anal-fin ray origin can be used for distinguishing *Mastacembelus alboguttatus* from all other species in the genus *Mastacembelus*.

Additionally, *M. alboguttatus* can be distinguished from *M. erythrotaenia* and *M. favus* by its distance from snout to last externally visible dorsal spine. It also differs from *M. armatus* and *M. favus* by its short distance from angle of jaws to posterior external nare [8.0-12.4 (mean 9.7) %L_H *vs*. 8.5-13.5 (11.2) *vs*. 7.1-13.7 (11.0) respectively]. Its head depth can be also used for distinguishing *M. alboguttaus* from *M. armatus*, *M. erythrotaenia* and *M. favus*.

DESCRIPTION. — Morphometric features and meristic counts are given respectively in **TABLE 4.13-4.14** and **TABLE 4.24-4.34**. For general appearance see **FIGURE 4.5**a.

Mastacembelus alboguttatus is very distinctive with unique colouration and morphology. Head is more elongate and slender [head depth 3.5-4.8 (mean 3.9) % L_H]. Snout is relatively very narrow and elongate. A pair of tubular anterior nostrils is originated at subdistal tip of rostrum. Sharp teeth are in bands on both jaws. No gill-rakers. A caudal fin is oval and also entirely free from its dorsal and anal fins. However the previously published illustration in **Sufi (1956: figure 24, plate 23)** showed an example of a specimen with a damaged tail that dorsal and anal fins are confluent with caudal fin. From all examined materials of *M. alboguttatus*, caudal fins are entirely separated from dorsal and anal fins. Upper jaw length is longer than lower jaw [18.1-23.0 (mean 20.8) %L_H *vs*. 14.5-19.6 (17.2)]. Preanal length is always greater than the postanal length [52.4-58.1(mean 54.3) %L_S *vs*. 44.2-47.6 (46.0)]. Vent is nearer to base of caudal fin than to snout.

Scales are small and cycloid and present around eyes and between eyes and posterior external nares, extending from the latter to gape of mouth. Top of snout, internasal space, interorbital space and top of head as far as the hind edge of preoperculum are naked.

Fleshy angle of jaws is situated apparently anterior to the anterior border of posterior external nare and not extending to below the posterior external nare **(FIGURE 4.10a)**. Upper tip of gill slit and dorsal edge of the pectoral-fin base are at different levels. The upper tip of gill slit is anterior to dorsal and ventral edges of the pectoral-fin base **(FIGURE 4.13a)**.

The first dorsal spine is situated apparently behind dorsal and ventral edges of pectoral-fin base and originated above the middle of appressed pectoral fin. *M. alboguttatus* has a relatively high number of dorsal spines, with spines increasing in size from first to last. One additional very short spine is hidden under skin and situated anterior to the base of the first dorsal-fin ray (33+1-36+1). Three anal spines are close together. There are two externally visible anal spines. The first anal spine is smaller than the second. The second is the largest anal spine. The last additional anal spine is very short and small, always hidden under its skin and situated anterior to the base of first anal-fin ray. The origin of anal-fin ray is distinctly anterior to the origin of dorsal-fin ray [1.0-3.2 (mean 2.1) %L_S].

In all specimens the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are **situated on two different vertebrae** and are **separated by one to two in-between vertebrae.** The vertebra with the neural spine supporting the pterygiophore of the last externally visible dorsal spine is **always situated posterior** to vertebra whose haemal spine supports the first anal spine. First dorsal-fin pterygiophore is inserted behind 5th (4th in one specimen) neural spine. Pterygiophore of last dorsal fin spine is inserted behind 37th, 38th, 39th or 40th neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 35th, 36th or 37th vertebra.

All materials have one preorbital spine (1L/1R), which is hidden under the skin in most specimens. The preorbital spine was well developed and the tip of preorbital spine is situated nearly below anterior edge of eye. Preopercular spine number varies from 3L/3R to 4L/4R with the following frequencies: 3L/3R (6); 3L/4R (1), 4L/3R (4) and 4L/4R (9).

Maximum observed standard length: 454 mm. (**CUMZ 2006.12.18:4-18**, MAS 0018: 480.5 mm L_T). However, **Sufi (1956)** examined one specimen of BMNH 1891.11.30.135-138 with a standard length of 493.5 mm.

COLOURATION.

FRESH SPECIMENS. — Body brown, darker along the back and lighter underneath. The fresh specimens with numerous larger dark yellow and round spots edged with dark brown (dusky spots) and small light yellow spots (pale spots) covering head, body, abdomen, median fins and sometimes base of pectoral fin. On body pale spots form rings around larger dusky spots (usually 8-10 pale spots around each dusky spot). The body with vertical and pectoral fins marked with numerous roundish white spots. Similarly, caudal fin marked with white round spots.

PRESERVED SPECIMENS. — Numerous yellow spots scattered over the body became pale or white spots.

DISTRIBUTION. — *M. alboguttatus* is distributed from the Sittang River in Myanmar to the Salween basin in Thailand. *M. alboguttatus* is probably endemic to the Salween basin**.**

THAILAND. — It is distributed in the Salween Basin including Moei, Salween and Pai River basins.

OTHER REGIONS. — Myanmar: Sittang River **(Sufi, 1956)**.

BIOLOGY AND ECOLOGY.

- **HABITAT. —** *M. alboguttatus* habits in slow-running rivers with fine sand substrate such as the Moei, the Salween and the Pai Rivers.

- **DIET. —** Earth worms and small prawns**.**

- **STATUS. —** *M. alboguttatus* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**. Even if it has not been considered as an endemic species, it is probably restricted to the Salween basin both in Thailand and Myanmar.

- **FISHERIES. —** *M. alboguttatus* is caught using hook and line and electro-fishing (the Moei and the Pai Rivers) to serve as a special food in large restaurants.

9. *Mastacembelus armatus* (Lacepède, 1800)

(FIGURE 4.5b and c, 4.10b, 4.13b and 4.17b and TABLE 4.15-4.16 and 4.23-4.34)

SYNONYMS AND CITATIONS.

Macrognathus armatus Lacepède, 1800: 286 (type locality unknown).
Mastacembelus armatus Valenciennes in Cuvier and Valenciennes, 1832: 456.
Mastacembelus favus Fowler, 1937: 222.
Mastacembelus armatus armatus Smith, 1945: 63.
Mastacembelus armatus Roberts, 1986: 104-106 + figure 2b-c.
For additional synonymy see Sufi (1956).

COMMON NAME. — Zig-Zag Eel, Tire Track Eel, Arm Spiny Eel

LOCAL NAME. — Pla Kra-thing, Pla Kra-thing Dam (Thailand)**,** Trey kchoeung (Cambodia) **(Rainboth, 1996)**.

MATERIAL EXAMINED.

TOTAL SPECIMEN NUMBER. — 37 specimens: 89.6-308.5 mm L_S.

***Chao Phraya Basin* —** 16 specimens: 114.5-230.3 mm L_S.

UMMZ 2743, 3: 184.2-196 mm L_S, Nam Wa Basin, Nan; **UMMZ 2755**, 2: 160-162.5 mm L_S, Mae Sa-Nga, Mae Hong Son; **UMMZ 2756**, 2: 141.8-230.3 mm L_S, Sob Mang, Bor Klur, Nan.

KUMF uncat., 2: 114.5-203.8 mm L_S, Huai Kha Khaeng Wildlife Sanctuary, 200 m. above Pong Kra-Tao, Kaen Makut, Ban rai, Uthai Thani; **KUMF uncat.**, 1: 148.3 mm L_S, St. C Huai Kha Khaeng Wildlife Sanctuary, Pong Kra-Tao, Kaen Makut, Ban Rai, Uthai Thani; **KUMF uncat.**, 1: 178.8 mm L_S, Huai Kha Khaeng Wildlife Sanctuary, Taling Sung, Kaen Makut, Ban Rai, Uthai Thani; **KUMF uncat.**, 1: 138.4 mm L_S, Huai Kha Khaeng Wildlife Sanctuary, Huai Mae Dee, Kaen Makut, Ban Rai, Uthai Thani; **KUMF uncat.**, 2: 116.3-178.6 mm L_S, Huai Kha Khaeng Wildlife Sanctuary, Huai Kha Khaeng, Kaen Makut, Ban Rai, Uthai Thani; **KUMF uncat.**, 2: 124-167.3 mm L_S, Huai Kha Khaeng Wildlife Sanctuary, Huai Kha Khaeng, Kaen Makut, Ban Rai, Uthai Thani.

***Salween Basin* —** 15 specimens: 89.6-256.3 mm L_S.

CUMZ 2006.11.16:1-4, 4: 89.6-121.5 mm L_S, Pai River, Pai, Mae Hong Son; **CUMZ 20061.1.15:5-10**, 6: 164.5-256.3 mm L_S, Huai Sue Thao, Mueang Mae Hong Son, Mae Hong Son; **CUMZ 2007.09.26:11-14**, 4: 129.6-216 mm L_S, Pai River, Mueang Mae Hong Son, Mae Hong Son.

UMMZ 2755, 1, Mae Sa-Nga, Mueang Mae Hong Son, Mae Hong Son.

***Mekong Basin* —** 2 specimens: 176-308.5 mm L_S.

NIFI 00610, 1: 176 mm L_S, Mekong River, Bueng Kan, Nong Khai; **NIFI 00614**, 1: 308.5 mm L_S, Mae Chan, Chiang Rai.

***Southern Basins* —** 4 specimens: 214.4-231 mm L_S.

NIFI 01129, 1: 219 mm L_S, Lansaka Waterfall, Nakhon Si Thammarat; **NIFI 02162**, 2: 205.7-231 mm L_S, Chiao Lam Reservoir, Suurathani; **NIFI 3226**, 1: 214.4 mm L_S, Bok Krai Waterfall, Ranong.

ETYMOLOGY. — The specific name "*armatus*" is derived from the Latin word "*arma*", meaning arms or armed.

DIAGNOSIS. — *Mastacembelus armatus* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XXXV-XXXVI 68-82; A. III 68-80; C. 16-18; P. 24-26;
- Predorsal vertebrae 4, abdominal vertebrae 38-40, caudal vertebrae 53-54, total vertebrae 92-94, in-between vertebrae 0 or 1 **(see TABLE 4.25-4.29)**;
- Rostral toothplate absent;
- Rim of anterior nostril with 2 fingerlike projections and 2 broad-based flaps;
- One preorbital spine and 2 or 3 preopercular spines on each side **(see TABLE 4.34)**;
- Caudal fin broadly confluent with dorsal and anal fins but caudal fin outline incompletely merged with soft-rayed portions of dorsal and anal fins;
- Body light to dark brown with 1-3 darker and longitudinal zigzag lines or reticulated patterns of dark markings restricted to upper two thirds of body and disappearing dorsally and ventrally.

M. armatus differs from all other species in the genus *Mastacembelus* in having more caudal vertebrae and total vertebrae **(TABLE 4.26-4.27)**. It can be distinguished from *M. favus* by its more dorsal spines. It can be distinguished from *M. tinwini* by its colour pattern with 1-3 darker and longitudinal zigzag lines or a reticulated pattern of dark markings.

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, *M. armatus* can be distinguished from *M. erythrotaenia* by its short distance from posterior external nare to eye [4.5-7.1 (mean 6.1) *vs*. 5.4-8.6 (7.6)]. It also differs from *M. favus* by its distance from snout to first anal spine, its preanal length, its postanal length, its body depth at first dorsal spine and at origin of anal fin ray, its anal fin base length, its soft dorsal fin base length and its distance from anal-fin ray origin to dorsal-fin ray termination.

For other diagnoses of *M. armatus* see accounts under *M. favus* and *M. tinwini.*

DESCRIPTION. — Morphometric measurements and meristic counts are respectively given in **TABLE 4.15-4.16** and **TABLE 4.24-4.34.** For general appearance see **FIGURE 4.5b-c.**

Mastacembelus armatus has a realatively small and pointed snout [33.1-41.1 (mean 37.7) %L_H]. Body is very elongate and slender than *M. favus*, oval in cross section, but strongly compressed in its caudal area. Head is relatively pointed with median fleshy rostrum projecting from upper jaw. A pair of tubular anterior nostrils is originated at subdistal tip of rostrum. Both upper and lower lips are fleshy and developed well. No gill raker. Upper jaw length is longer than lower jaw [23.9-29.0 (mean 26.6) %L_H *vs*. 20.5-25.8 (23.2)]. Eyes are relatively large [8.8-13.7 (mean 11.0) %L_H]. Preanal length is always greater than the postanal length [54.5-60.8 (mean 57.7) %L_S *vs*. 39.3-45.4 (42.3)]. Vent is nearer to base of caudal fin than to snout.

Scales are minute and cycloid. Scales are between and around eye and posterior external nare, and from the latter to the maxilla. Top of snout, internasal

space, interorbital space and top of head as far as hind edge of preoperculum are naked.

Fleshy angle of jaws are situated slightly behind the anterior border of posterior external nare. Mouth nearly extends to below the posterior external nare **(FIGURE 4.10b)**. Upper tip of gill slit and dorsal edge of the pectoral-fin base are at the different level. The upper tip of gill slit is anterior to the dorsal and ventral edges of pectoral-fin base **(FIGURE 4.13b)**.

The first dorsal spine is situated in various position expressed as 1) on the dorsal edge of its pectoral fin, or 2) on the ventral edge of its pectoral fin, or 3) behind the dorsal and ventral edges of its pectoral fin and above the middle of pectoral fin. Its distance between dorsal edge of pectoral fin base and anterior base of first dorsal spine is 0.0-16.4 (mean 10.3) %L_H.

M. armatus has a relatively high number of dorsal spines, with spines increasing in size from first to last [34+1-38+1 (average 36.69)]. One additional dorsal spine is very short and small. It is always hidden under skin and situated anterior to the base of the first dorsal-fin ray. Three anal spines are close together. There are two externally visible anal spines. The first anal spine is smaller than the second. The second is the largest anal spine. The last additional anal spine is very short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. Anal fin ray is originated slightly in advance of dorsal fin ray [approximately 0.4-2.7 %L_S (mean 1.6)].

The neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated **on two different, successive vertebrae.** In the others, they are situated **on two different vertebrae and are separated by one in-between vertebra**. The vertebra with the neural spine supporting the pterygiophore of the last externally visible dorsal spine **is situated posterior** to the successive vertebrae whose haemal spine supports the first anal spine. First dorsal-fin pterygiophore is inserted behind 4th neural spine. Pterygiophore of last dorsal fin spine is inserted behind 41st, 42nd or 43rd neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 39th, 40th or 41st vertebra.

All materials have one preorbital spine (1L/1R), which is hidden under the skin in most specimens. The preorbital spine was well developed and the tip of preorbital spine is situated nearly below anterior edge of eye. Preopercular spine number varies from 2L/2R to 3L/3R with the following frequencies: 2L/2R (5); 3L/2R (1), 3L/3R (29).

Maximum observed standard length: 256.3 mm. (**CUMZ 2006.11.15:5-10**: 269.5 mm L_T).

COLOURATION. — As with many mastacembelid species, colour pattern in *Mastacembelus armatus* is highly variable.

FRESH SPECIMENS. — Backgrounds of body are light to dark brown with 1-3 darker and longitudinal zigzag lines or reticulated patterns of dark markings restricted to upper two thirds of body and disappearing dorsally and ventrally. Abdomen coulour is lighter. A series of rounded black spots is along the base of its dorsal fin.

DISTRIBUTION.

THAILAND. — *M. armatus* is distributed in the Chao Phraya, the Salween, the Mekong, the southern and the eastern basins of Thailand.

OTHER REGIONS. — Myanmar, India, Sri Lanka **(Roberts, 1986; Britz, 2007)**.

BIOLOGY AND ECOLOGY.

- **HABITAT. —** It habitats in several types of wetlands, from hill streams to lowland swamps **(Vidthayanon *et al*., 2005)**.

  It also lives in streams with rocky bottom covered by moss or sand substrate at Prague Nam Daeng Waterfall, Nakhon Si Thammarat. The water is clear and has a pH of 7.6 **(Lertsuttichawan *et al*., 2001)**.

- **STATUS. —** *M. armatus* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**.

- **FISHERIES. —** It was caught by setting pole and line, hook and line, gill net, ornamental fish trap and bamboo trap.

10. *Mastacembelus erythrotaenia* Bleeker, 1850

(FIGURE 4.6a, 4.10c, 4.13c and 4.16b and TABLE 4.17-4.18 and 4.23-4.34)

SYNONYMS AND CITATIONS.

Mastacembelus erythrotaenia: Bleeker, 1850: 6 (type locality: Banjermassing Borneo).

Mastacembelus argus: Günther, 1861: 542 (type locality: freshwaters of Siam). See Sufi (1956): 130-131.

Mastacembelus argus: Fowler, 1936: 47.

COMMON NAME. — Fire Spiny Eel**,** Fire eel (trade name).

LOCAL NAME. — Pla Kra-thing Fai, Pla Kra-thing Sane (in Pathum Thani province) (Thailand); Trey Kchoeung phka (Cambodia) **(Rainboth, 1996)**.

TYPE LOCALITY. — Banjermassing, Borneo**.**

MATERIALS EXAMINED.

TOTAL SPECIMEN NUMBER. — 28 specimens**:** 171.5-504.2 mm L_S**.**

***Chao Phraya Basin* —** 2 specimens: 299.4-348.8 mm L_S**.**

NIFI 01256, 1: 299.4 mm L_S, Phra Nakhon Si Ayutthaya; **NIFI 01143**, 1: 348.8 mm L_S Nakhon Chai Si River, Nakhon Phathom**.**

***Southern Basins* —** 20 specimens: 356-515.8 mm L_S**.**

CUMZ 2006.12.26:7-18, 12, 426-504.2 mm L_S, Tapi River, Phunphin, Surat Thani.

KUMF 1305, 1: 356 mm L_S, Lampam, Phatthalung; **KUMF 1306**, 1: 381 mm L_S, Surat Thani.

***Eastern basins* —** 6 specimens: 171.5-432.4 mm L_S**.**

CUMZ 2006.11.12:1-6, 6: 171.5-432.4 mm L_S, Bang Pakong River, Bang Khla, Chachoengsao.

ETYMOLOGY. — The specific name "*erythrotaenia*" is derived from the Greek word "erythros", meaning red and "taenia", meaning ribbon, fillet or tapeworm. They are translated together as a fish that has a body with irregular red spots and horizontal markings, sometimes prolonged as stripes.

DIAGNOSIS. — *Mastacembelus erythrotaenia* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XXXII-XXXIV 72-78; A. III 72-80; P. 22-24; C. 15-17;
- Predorsal vertebrae 4-5, abdominal vertebrae 37-40, caudal vertebrae 45-48, total vertebrae 83-86, in-between vertebrae 0 **(see TABLE 4.25-4.29)**;
- Rim of anterior nostril with 2 fingerlike projections and 2 broad-based flaps;
- Rostral toothplate absent;
- Two or three spines on each preopercular and one strong preorbital spine piercing the skin or hidden **(see TABLE 4.34)**;
- Caudal fin completely united with caudal;
- Body with irregular red spots and horizontal markings, sometimes prolonged as stripes.

M. erythrotaenia is distinguished from all other species in the genus *Mastacembelus* by its very unique colouration and its very long distance from posterior edge of anus to anterior base of fisrt dorsal spine [2.2-3.7 (mean 2.8) %L_H].

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, *Mastacembelus erythrotaenia* can be distinguished from all other species in the genus *Mastacembelus* by its rostral appendage length [8.6-14.4 (mean 11.7) %L_H], its distance from posterior edge of anus to anterior base of fisrt dorsal spine. Additionally, the distance from posterior external nare to eye can be employed for distinguishing *M. erythroatenia* from *M. armatus* and *M. favus* [5.4-8.6 (mean 7.6) %L_H *vs*. 4.5-7.7 (6.1) *vs*. 4.7-7.5 (6.1) respectively]. Moreover, it differs from *M. favus* by its pre-posterior external nare length [31.1-36.1 (mean 33.1) %L_H]. It can be distinguished from *M. alboguttatus* and *M. armatus* by its distance from dorsal edge of pectoral-fin base to dorsal-fin ray origin.

DESCRIPTION. — Morphometric measurements and meristic counts are respectively given in **TABLE 4.17-4.18 and 4.24-4.34**. For general appearance see **FIGURE 4.6**a.

Mastacembelus erythrotaenia has a head pointed with median fleshy rostrum projecting from upper jaw. A pair of tubular anterior nostrils is originated at subdistal tip of rostrum, whereas posterior external nares are on the head and are situated anterior to its eyes with distance ranging of 5.4-8.6 (mean 7.6) %L_H. Both upper and lower lips are fleshy and developed well. Upper jaw length is longer than lower jaw [23.9-27.9 (mean 26.0) %L_H *vs*. 20.0-24.3 (mean 22.1)]. No gill raker. Eyes are relatively small [6.6-11.2 (mean 7.9) %L_H]. Preanal length is always greater than the postanal length [55.2-61.7 (mean 58.4) %L_S *vs*. 38.3-44.8 (41.6)]. Vent is nearer to base of caudal fin than to snout. Teeth are in bands of both jaws.

Scales are minute and cycloid. They occur between eye and posterior external nare and from the latter to the maxilla. Both eyes and posterior external nare may be surrounded by scales, or eyes may be completely surrounded but posterior external nare may be surrounded only the lower half circumference. A few scales may be present in its internasal space and interorbital space, or not. Top of snout and top of head as far as hind edge of preoperculum are naked.

Fleshy angle of jaws are situated apparently behind anterior border of the posterior external nare and extending to below its posterior external nare **(FIGURE 4.10c)**. Upper tip of gill slit and dorsal edge of the pectoral-fin base are at the different level. The upper tip of gill slit is anterior to dorsal and ventral edges of the pectoral-fin base **(FIGURE 4.13c)**.

The first dorsal spine is situated slightly behind posterior edge of pectoral-fin base [roughly 9.0-19.4 (mean 13.8) %L_H] and is originated above middle of pectoral fin. *M. erythrotaenia* has a relatively high number of dorsal spines, with spines increasing in size from first to last [31+1-33+1 average 32.48]. One additional dorsal spine is very short and small. It is always hidden under skin and situated anterior to the base of the first dorsal-fin ray. Three anal spines are close together and covered by its thick skin. There are two externally visible anal spines. The first is smaller than the second. The second is the largest anal spine. The last additional anal spine is very

short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. Anal fin ray is originated slightly in advance of dorsal fin ray.

The neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated **on the same vertebra or on two different, successive** with the following frequencies: 9 and 3 specimens respectively. However, the vertebra with the neural spine supporting the pterygiophore of the last externally visible dorsal spine is sometimes situated posterior to the successive vertebra whose haemal spine supports the first anal spine. First dorsal-fin pterygiophore is inserted behind 4^{th} or 5^{th} neural spine. Pterygiophore of last dorsal fin spine is inserted behind 38^{th}, 39^{th}, 40^{th} or 41^{st} neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 38^{th}, 39^{th}, 40^{th} or 41^{st} vertebra.

All materials have one strong preorbital spine (1L/1R), which is hidden under the skin in larger specimens or pierce the skin in some specimens. The tip of preorbital spine situated nearly below anterior edge of eye. Preopercular spine number varies from 2L/2R to 3L/3R with the following frequencies: 2L/2R (1); 2L/3R (2); 3L/2R (3) and 3L/3R (15).

Maximum observed L_S: 515.8 mm (CUMZ 2006.12.26: 7-18, 547.5 mm L_T). However *Mastacemeblus erythrotaenia* can attain up to 100 cm. in length **(Atack, 2006)**.

COLOURATION.

FRESH SPECIMENS. — *M. erythrotaenia* is one of the most striking of the spiny eels. General background colour nearly black or dark brown on the back and paler on the belly. Body with usually one or more bright red lateral lines along the dark brown body and spots along the tail, while the anal, pectoral and dorsal fins frequently have a red margin and white distal margin. The pattern of red stripes, or bars, or spots, or reticulations vary individually or even on the left and right side of one fish. These marking vary among individuals depending on health and age **(Atack, 2006)**. Moreover, the markings tend to be a yellow or orange colour in juveniles, changing to red in larger adults **(Atack, 2006)**.

PRESERVED SPECIMENS. — Red marginal bands and spots become to white or dirty white.

DISTRIBUTION. — Found throughout Souteast Asia excluding Myanmar **(Sufi, 1956; Roberts, 1986; Roberts, 1989; Rainboth, 1996; Atack, 2006)**.

THAILAND. — It is known from the Chao Phraya basin (Nakhon Pathom, Phra Nakhon Si Ayutthaya, Pathum Thani), the Southern basins (Surat Thani, Phatthalung, Krabi) and the Eastern basins (Chachoengsao, Prachin Buri).

OTHER REGIONS. — Malay Peninsula (Penang, Perak). **Sumatra** (Deli, Palembang, Muara Kompeh, Batang Hari, Sungei mahi, Laut Tador, Indragiri, Lower Langkat). **Borneo** (Baram, Kuching, Sambas, Kapuas, Bandjermasin, Balungan) **(Roberts, 1989; Atack, 2006)**. **Cambodia** (Mekong River) **(Rainboth, 1996)**. However it has not been reported from Myanmar **(Roberts, 1986)**.

BIOLOGY AND ECOLOGY.

- **HABITAT. —** *M. erythrotaenia* generally inhabits slow-running rivers and floodplain areas, hiding amongst plants and objects or burying in the river mud.
- **DIET. —** Feeds on small prawns, earthworms and benthic insect larvae. Additionally, they feed on some plant materials **(Atack, 2006)**. When they want to search a food, they always ambush small prawns and then attack directly to their preys.
- **STATUS. —** Although *M. erthrotaenia* is not listed on the IUCN Red List **(IUCN, 2007)**, it has been considered as a vulnerable species (VU) which is likely to become endangered unless the circumstances threatening its survival and reproduction improve **(Vidthayanon, 2005)**.
- **FISHERIES. —** *Mastacembelus erythrotaenia* is caught with seines, traps and hook-and-line. *M. erythrotaenia* is commonly utilized for recreation and aquarium trades; however, it is apparently becoming scarce in its natural habitats.

11. *Mastacembelus favus* Hora, 1923

(FIGURE 4.6b and c, 4.11a, 4.13d and 4.16c and TABLE 4.19-4.20 and 4.23-4.34)

SYNONYMS AND CITATIONS.

Mastacembelus armatus var. *favus* Hora, 1923: 180 (type locality: Nonthaburi = Chao Phraya near Bangkok).

Mastacembelus favus: Fowler, 1937: 222.

Mastacemeblus armatus favus: Smith, 1945: 64.

Mastacembelus armatus: Sufi, 1956: 134-138 (in part).

COMMON NAME. — Tire Track Eel**.**

LOCAL NAME. — Pla Kra-thing (bull fish), Pla Kra-thing Lai (Thailand), Pla Lat (northeastern Thailand); Pla Lat (Laos); Nga-thinbawmo (Myanmar); Trey khchung or Trey kchoeung (Cambodia); Cá chạch lấu (Vietnam); Tilan (Malay) **(Rainboth, 1996; Davidson, 1975)**.

TYPE LOCALITY. — Nonthaburi (the Chao Phraya River near Bangkok).

MATERIALS EXAMINED.

TOTAL MATERIAL NUMBER. — 180 specimens.

***Chao Phraya Basin* —** 90 specimens.

CUMZ 2006.11.19:1-2, 2: 208.7-209.7 mm L_S, Yom River, Mueang Phrae, Phrae; **CUMZ 2006.06.24:3-7**, 5: 229-237 mm L_S, Yom River basin, Mueang Sukhothai, Sukhothai; **CUMZ 2006.11.20:8-17**, 10, Nan River basin, Tron, Uttaradit; **CUMZ 2006.11.20:18-20**, 5, Bang Rakam, Phitsanulok; **CUMZ 2006.11.18:21-34**, 14: 164.2-288.4 mm L_S, Bueng Boraphet, Nakhon Sawan; **CUMZ 1997.08.25:35-36**, 2: 203.3-258 mm L_S, Phra Nakhon Si Ayutthaya; **CUMZ 2006.11.17**:**37-38**, 2, Nan River, Nan; **CUMZ 2006.11.14:39-40,** 2, Doi Tao Lake, Chiang Mai; **CUMZ 2006.11.14:41-43**, 3, Ping River, Hod, Chiang Mai; **CUMZ 1997.03.09:44**, 1, Sakae Krang River, Uthai Thani; **CUMZ 2006.11.20:45-56**, 12, Nong Bon, Nakhon Sawan;

CUMZ 1990.11.05:57-63, 7, Nonthaburi; **CUMZ 2007.06.14:64-67**, 4, Pond, Taphan Hin, Phichit.

NIFI 00609, 3, Chao Phraya basin; **NIFI 01763**, Bueng Boraphet, Nakhon Sawan.

KUMF 1294, 1295, 1298, 4: 86-144 mm L_S, Nong Bang Ngu, Ratchaburi; **KUMF 1297**, 2: 111-124 mm L_S, Lop Buri market; **KUMF 2674**, 2: 175-252 mm L_S, Sukhothai; **KUMF 2703**, 2: 149-158 mm L_S, Nan River, Phichit; **KUMF 2730**, 1: 163 mm L_S, Phitsanulok; **KUMF 6902**, 1: 318 mm L_S, Huai Hang, Dan Chang, Suphan Buri; **KUMF 6906**, 1, 41 mm L_S, Huai Krasiao, Ban Rai, Uthai Thani; **KUMF 6907**, 1: 109 mm L_S, Dan Chang, Suphan Buri; **KUMF uncat.**, 3: 102.6-146 mm L_S, Huai Kha Khaeng Wildlife Sanctuary, Kaen Makut, Ban Rai, Uthai Thani; **KUMF uncat.**, 2: 159.3-174.9 mm L_S, Huai Kha Khaeng Wildlife Sanctuary, Kaen Makut, Ban Rai, Uthai Thani.

***Mekong Basin* —** 44 specimens.

CUMZ 2006.11.17:67-82, 16, Kok River, Muaeng Chaing Rai, Chaing Rai; **CUMZ 2006.09.10:83-86**, 4, Mekong River, Bueng Kan, Nong Khai; **CUMZ 2006.09.10:87-89**, 3, Kud Thing, Si Wilai, Nong Khai; **CUMZ 2006.09.11:90-97**, 8, Songkhram River, Si Songkhram, Nakhon Phanom; **CUMZ 2006.09.12:98-102,** 5, Nam Oon Reservoir, Kudbak, Sakon Nakhon.

NIFI 02112, 1, Ubon Ratana reservoir, Khon Kaen; **NIFI 01915**, 1, Chi River; **NIFI 01529**, 1, Ubon Ratana reservoir, Khon Kaen; **NIFI 00607**, 2, Lam Pao Reservoir, Kalasin; **NIFI 02088** Lam Dome Yai, Ubon Ratchathani; **NIFI 01784**, 1, Lam Takhlong reservoir, Nakhon Ratchasima.

KUMF 1293, 3: 103-160 mm L_S, Nam Pong Reservoir, Nong Wai, 32 km from Khon Kaen to Udon Thani.

***Meklong Basin* —** 11 specimens.

CUMZ 2007.07.22:104-105, 2, Sangkla Buri, Kanchanaburi; **CUMZ 2007.08.17:106-107,** 2**,** Srinakharin reservoir, Kanchanaburi.

NIFI 00621, Kwae Yai River, Kanchanaburi; **NIFI 01044**, 6, Kwae Noi, Kanchanaburi; **NIFI 3227**, Chao Nane Reservoir, Kanchanaburi

***Southern Basins* —** 9 specimens.

CUMZ 2006.10.18:131-132, 2, Khlong Ro, Phunphin, Surat Thani. **CUMZ 2006.10.19:133**, 1, Mueang Phatthalung, Phatthalung.

NIFI 01482, 3, Bang Lang Reservoir, Patthani River, Bannang Sata, Yala; **NIFI 00178**, 2, Surat Thani; **NIFI 3228**, 1, Narathiwat.

***Eastern Basins* —** 26 specimens.

CUMZ 2007.01.06:108-126, 19, Pond, Phanat Nikhom, Chonburi; **CUMZ 2007.02.24:130**, 1, Khao Rakam Reservoir, Mueang Trat, Trat; **CUMZ 1997.11.11:127-129**, 3, Khao Soi Dao, Chanthaburi.

NIFI 00608, 1, Chanthaburi River, Chanthaburi.

KUMF uncat., 1: 115.3 mm L_S, St. 50(4) Khlong Tap Mon, Khao Chamao National Park, Rayong; **KUMF uncat.**, 1: 128.5 mm L_S, St. 54 Khlong Phawa-habatara, Khao Chamao National Park, Rayong.

ETYMOLOGY. — The specific name "*favus*" is derived from the Latin word "*favus*", meaning a honeycomb. It is translated as a fish that have a colour pattern like honeycomb.

DIAGNOSIS. — *Mastacembelus favus* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XXXII-XXXVII 74-80; A. III 72-80; P. 13-15; C. 24-28.
- Predorsal vertebrae 4-5, abdominal vertebrae 37-39, caudal vertebrae 45-48 and total vertebrae 86-89 (91 in one specimen), in-between vertebrae 0 or 1 **(see TABLE 4.25-4.29)**;
- Rim of anterior nostril with 2 fingerlike projections and 2 broad-based flaps;
- Rostral toothplate absent;
- One preorbital spine and 2 or 3 preopercular spines on each side **(see TABLE 4.34)**;

- Dorsal and anal fins broadly joined to caudal fin;
- Whole body with a reticulated pattern of dark markings that completely encircle the abdomen.

M. favus is distinguished from *M. armatus* and *M. tinwini* by its deeper body and fewer total vertebrae and caudal fin ray [13-15 (average 14.44) *vs*. 16-18 (17.71) *vs*. 18-20 (19.11)]. It also differs from both *M. armatus* and *M. tinwini* by its distinctive colouration.

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, *M. favus* can be distinguished from *M. alboguttatus*, *M. erythrotaenia* and *M. tinwini* by its head length. It differs from *M. armatus* and *M. tinwini* by its body depth at dorsal-fin ray and caudal fin length. The distance from dorsal spine origin to anal fin origin can be also employed for distinguishing *M. favus* from *M. armatus* and *M. alboguttatus*.

For other diagnoses of *M. favus* see accounts under *M. armatus* and *M. tinwini.*

DESCRIPTION. — Morphometric features and meristic counts are given respectively in **TABLE 4.19-4.20 and 4.24-4.34**. For general appearance see **FIGURE 4.6b-c**.

Mastacembelus favus has a relatively small and blunted snout [34.4-40.8 (mean 37.6) %L_H]. Based on body depth at oigin of first dorsal spine and at anus [7.0-12.4 (mean 8.5) %L_S and 9.2-14.8 (11.1)], its body is deeper than that of *M. armatus* and *M. tinwini*. Head is relatively small with median fleshy rostrum projecting from upper jaw [17.2-23.6 (mean 19.3) %L_H]. A pair of tubular anterior nostrils is situated at subdistal tip of rostrum, whereas the posterior external nares are on the head and are situated anterior its eyes [roughly 4.7-7.5 (mean 6.1) %L_H]. No gill raker. Both upper and lower lips are fleshy and developed well. Upper jaw length is longer than lower jaw [23.1-32.6 (mean 27.6) %L_H *vs*. 20.2-27.3 (mean 23.1)]. Eyes are relatively large [7.8-13.0 (mean 10.5) %L_H]. Preanal length is always greater than the postanal length [54.9-65.2 (mean 59.6) %L_S *vs*. 34.3-44.8 (38.0)]. Vent is nearer to base of caudal fin than to snout.

Scales are minute and cycloid and occur between and around eye and posterior external nare, and from the latter to the maxilla. Top of snout, internasal space, interorbital space and top of head as far as hind edge of preoperculum are naked.

Fleshy angle of jaws are situated behind the border of posterior external nare. Mouth extends to below the posterior external nare **(FIGURE 4.11a)**. Upper tip of gill slit and dorsal edge of the pectoral-fin base are at nearly the same level. The upper tip of gill slit is anterior to dorsal and ventral edges of the pectoral-fin base **(FIGURE 4.13d)**.

The first dorsal spine is situated in various position expressed as 1) on the dorsal edge of pectoral fin, or 2) on the ventral edge od pectoral fin, or 3) behind the dorsal and ventral edge of pectoral fin. The value in percentage of head length of its distance between dorsal edge of pectoral fin base and anterior base of first dorsal spine is 0.0-16.4 (mean 9.7).

M. favus has a relatively high number of dorsal spines, with spines increasing in size from first to last [31+1-36+1 (average 34.27)]. One additional dorsal spine is very short and small. It is hidden under skin and situated anterior to the base of the first dorsal-fin ray. Three anal spines are close together. Two anal spines are externally visible. The first is smaller than the second. The second is the largest anal spine. The last additional anal spine is very short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. Anal fin ray is very slighthly originated in advance of dorsal fin ray.

The neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated **on the same vertebra or on two different, successive vertebrae** with the following frequencies: 7 and 21 specimens respectively. In the others, they are situated on **two different vertebrae and are separated by one in-between vertebra** (4 specimens). First dorsal-fin pterygiophore is inserted behind 4^{th} or 5^{th} neural spine with the following frequencies: 28 and 4 respectively. Pterygiophore of last dorsal fin spine is inserted behind 38^{th}, 39^{th}, 40^{th}, 41^{st}, or 42^{nd} neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 38^{th}, 39^{th} or 40^{th} vertebra.

All materials have one preorbital spine (1L/1R), which is hidden under the skin in larger specimens. The tip of preorbital spine situated nearly below anterior edge of eye. Preopercular spine number varies from 2L/3R to 4L/4R with the following frequencies: (2L/3R: 1); (3L/2R: 1); (3L/3R: 12); (3L/4R: 5); (4L/4R: 1).

Maximum observed standard length: 359 mm. (**CUMZ 2006.11.17**:**37-38**, **MAS 0037**: 374 mm L_T). However, *Mastacembelus favus* can attain up to 70 cm in length **(Rainboth, 2006)**.

COLOURATION.

PRESERVED SPECIMENS. — Back ground colour is very dark to black. Body with a well developed netwoerk. The network usually extends over the entire abdomen as well as the entire length of the body. In live or fresh fish the pale areas within the network are bright yellow, particularly on the abdomen. Dark longitudinal stripe passed over eyes.

DISTRIBUTION.

THAILAND. — It is widely distributed throughout Thailand particularly in Mekong and Chao Phraya basins.

OTHER REGIONS. — It was commonly found in Cambodia, Laos and Malay Peninsula **(Rainboth, 1996; Roberts, 1980, 1986, 1989)**.

BIOLOGY AND ECOLOGY.

- **HABITAT. —** It was found along the bottom in running waters such as rivers, streams. It also inhabits small streams with sand and gravel substrates at Yong Waterfall, Nakhon Si Thammarat. The water is clear and has a pH of 5.7. It was captured in shallow water **(Lertsuttichawan *et al.*, 2001)**.

- **DIET. —** Feed on worms, benthic larvae, small crustaceans and small fish especially small prawns. According to **Inger (1962)**, stomach of *M. favus* also contained Plecoptera and Odonata nymphs and larvae of Neuroptera and Tricoptera. Based on observation in a tank, hunting occurs at night and is done

by ambush, waiting until a fish comes close enough to where the eel is buried then shooting out to grab the prey.

- **FEEDING. —** It is very easy to train *Mastacembelus favus* to be fed by hand, which can be useful when kept in a tank with larger fish that also appreciate the same kinds of food. They are very curious and friendly once they get used to their surroundings, and have been known to come out and sit in their owner's hand to be fed. They do not need to be fed on a daily basis, even when small, as they do not waste their energy doing a lot of swimming.

- **REPRODUCTION. —** It is less known about its breeding habits in the wild. To date, there have been no reports of Tiretracks being bred in aquariums.

- **STATUS. —** *M. favus* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**. It is can be found throughout Thailand with a relatively high abundance of number.

- **FISHERIES. —** It was caught using seines, hook-and-line, bamboo traps and electrofishing.

12. *Mastacembelus tinwini* Britz, 2007

(FIGURE 4.7a-c, 4.11b, 4.13e and 4.17a and TABLE 4.21-4.22 and 4.23-4.34)

SYNONYMS AND CITATIONS.

Mastacemblus tinwini Britz, 2007: 258 (new species, type locality: "Mon State, Myanmar").

COMMON NAME. — Spiny eel.

LOCAL NAME. — Pla Kra-thing (Thailand).

TYPE LOCALITY. — Mon State, Myanmar **(Britz, 2007)**.

TYPE MATERIAL.

HOLOTYPE. — NRM 55468, 356 mm L_S; Myanmar: Mon State: Thaton market; T. Roberts, 7 July 2000 **(Britz, 2007)**.

PARATYPES. — NRM 48646, 12, 214-377 mm L_S; same data as holotype; **BMNH 2007.1.10.1**; **USNM 385951**, 4, 107.1-252 mm L_S; Myanmar: Kayin State: Kawkareik; Tin Win, 5 Jan 2002; **CMK 19715**, 6, 105.9-156 mm L_S; Myanmar: Kayin State: Chon Son stream between Kyondaw and Phadaw, about 20 km northwest of Payathouzu, at border with Thailand; K. Kubota, December 2002 **(Britz, 2007)**.

MATERIAL EXAMINED.

TOTAL MATERIALS NUMBER. — 10 specimens: 153.4-384 mm L_S.

***Chao Phraya Basin* —** 6 specimens: 153.4-340.6 mm L_S.

CUMZ 2006.11.17:1-2, 2: 199.2-276 mm L_S, Nan River, Mueang Nan, Nan.

NIFI 00614, 1: 308.5 mm L_S, Pangsa, Mae Chan, Chiang Rai**.**

UMMZ 2744, 3: 220-340.6 mm L_S, Nam Wa River basin, Nan; **UMMZ 2782**, 2: 153.4-155.6 mm L_S, Nam Wa River basin, Nan.

***Southern Basins* —** 2 specimens: 368.9-384 mm L_S**.**

NIFI 02162, 2: 368.9-384 mm L_S, Ratchaprapha Reservoir, Surat Thani.

ETYMOLOGY. — *Mastacembelus tinwini* is named after U Tin Win, in appreciation of his help in the field and the gift of specimens **(Britz, 2007)**.

DIAGNOSIS. — *Mastacembelus tinwini* is distinguished from all other Asian mastacembelid species by the following combination of characters:

- D. XXXVI-XXXIX 68-74; A. III 65-76; P. 24-25; C. 18-20.
- Predorsal vertebrae 4-5, abdominal vertebrae 40-42, caudal vertebrae 48-52, total vertebrae 88-93, in-between vertebrae 1-2 **(see TABLE 4.25-4.29)**;
- Rim of anterior nostril with 2 fingerlike projections and 2 broad-based flaps;
- Rostral toothplate absent;
- One preorbital spine and 2 or 3 preopercular spines on each side **(see TABLE 4.34)**;
- Caudal fin broadly confluent with soft dorsal and soft anal fins; however, caudal fin outline incompletely merged with soft-rayed portions of dorsal and anal fins;
- Body with four-five regular and parallel, dark, longitudinal bands along the body, expressed as series of interrupted lines or broken up into individual blotches; soft-rayed potions of dorsal, anal and caudal fins edged with white margin.

M. tinwini can be distinguished from *M. armatus* by its more abdominal and caudal vertebrae and distinctive colouration. It also differs from *M. favus* in having fewer caudal fin rays. According to **Britz (2007)**, it differs from other species in the *M. armatus* group by a count of 41-43 + 47-51 = 89-92 vertebrae.

Based on forty-two morphometric measurements analyzed using multiple comparisons with Scheffe, *M. tinwini* can be distinguished from *M. armatus* by its long distance from dorsal spine origin to anal-fin ray origin [44.5-50.5 (mean 50.5) %L_S *vs*. 41.0-46.9 (43.9)]. It differs from *M. favus* by its short head depth [4.0-4.9 (mean 4.3) %L_S *vs*. 4.1-7.2 (5.0)]. Moreover, its distance from dorsal edge of

pectoral-fin base to dorsal-fin ray origin can be employed for distinguishing *M. tinwini* from *M. armatus* and *M. favus* [49.8-54.3 (mean 51.3) %L_S *vs*. 45.0-50.6 (47.7) *vs*. 45.5-52.7 (48.1) respectively].

For other diagnoses of *M. tinwini* see accounts under *M. armatus* and *M. favus.*

DESCRIPTIONS. — Morphometric features and meristic counts are given respectively in **TABLE 4.21-4.22** and **4.24-4.34**. For general appearance see **FIGURE 4.7a-c.**

Mastacembelus tinwini has a relatively small snout [37.3-40.1 (mean 38.5) %L_H]. Body is very elongate and slender than *M. favus*, oval in cross section, but its caudal area is strongly compressed. Head is relatively small and pointed with median fleshy rostrum projecting from upper jaw. A pair of tubular anterior nostrils is situated at subdistal tip of its rostrum. No gill raker. Both upper and lower lips are fleshy and developed well. Upper jaw length is slightly longer than lower jaw [24.6-29.6 (mean 27.0) %L_H *vs*. 21.1-24.2 (22.9)]. Eyes are relatively small [7.5-11.3 (mean 9.3) %L_H]. Preanal length is always greater than the postanal length [54.8-60.2 (mean 57.9) %L_S *vs*. 39.8-45.0 (42.2)]. Vent is nearer to base of caudal fin than to snout.

Scales are minute and cycloid. Scales present between and around eye and posterior external nare, and from the latter to the maxilla. Top of snout, internasal and interorbital spaces and top of head as far as hind edge of preoperculum are naked.

Fleshy angle of jaws are situated behind anterior border of the posterior external nare. Mouth extends to below the posterior eaxternal nare **(FIGURE 4.11b).** Upper tip of gill slit and dorsal edge of the pectoral-fin base are at different level and anterior to the ventral edge of the pectoral-fin base **(FIGURE 4.13e)**.

The first dorsal spine is situated slightly behind posterior edge of pectoral-fin base [roughly 7.5-15.7 (mean 11.6) %L_H] and is originated above middle of pectoral fin. *M. tinwini* has a relatively high number of dorsal spines, with spines increasing in size from first to last [35+1-38+1 average 37.88 (35+1 in one specimens)]. One additional dorsal spine is very short and small. It is hidden under skin and situated anterior to the base of the first dorsal-fin ray. Three anal spines are close together and covered by its thick skin. Two anal spines are externally visible. The first is smaller

than the second. The second is the largest anal spine. The last additional anal spine is very short and small, hidden under the skin and situated anterior to the base of the first anal-fin ray. The soft-portion of anal fin is originated in advance of soft dorsal fin [approximately 1.0-2.5 (mean 1.9) %L_S].

The neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on **two different, successive vertebrae** (2 specimens). In the others, they are situated on **two different vertebrae and are separated by one or two in-between vertebrae** with the following frequencies: 6 and 3 specimens respectively. The vertebra with the neural spine supporting the pterygiophore of the last externally visible dorsal spine is always situated posterior to the vertebrae whose haemal spine supports the first anal spine. First dorsal-fin pterygiophore is inserted behind 4th (5th in two specimens) neural spine. Pterygiophore of last dorsal fin spine is inserted behind 42nd, 43rd or 44th neural spine. First anal-fin pterygiophore is inserted behind haemal spine of 40th, 41st or 42nd vertebra.

All materials have one preorbital spine (1L/1R), which is hidden under the skin. The tip of preorbital spine is situated nearly below anterior edge of eye. The number of preopercular spine varies from 2L/2R to 3L/3R with the following frequencies: 2L/2R (3); 2L/3R (1); 3L/2R (1); 3L/3R (5).

Maximum observed standard length: 384 mm. (**NIFI 02162**: 400.5 mm L_T). However, **Britz (2007)** examined one additional materials of BMNH 1891.11.30.125-133 with a standard length of 523 mm.

COLOURATION.

PRESERVED SPECIMENS. — Background colour is light brown. The ventral side is lighter than the body. Its Body has dark markings arranged in parallel series. The series can be shown as 1) uninterrupted longitudinal bands, or 2) interrupted longitudinal bands or short longitudinal bands, or 3) longitudinal bands broken up into individual blotches from head to caudal. In addition to these markings on body, parallel and middorsal stripe appears on the top of body from snout across eyes and continued along the base of spinous and soft dorasal fins and ends of caudal area.

Head has numerous dark blotches. Pectoral fin also has varying number of black spots.

DISTRIBUTIONS.

THAILAND. — It was reported in the Chao Phraya basin (Nan river basin) and the Southern basins (Nakhon Si Thammarat and Surat Thani). However it is possibly found in parts of Thailand drained by the Salween River because *M. tinwini* was discovered in the Salween basin in Myanmar where is adjacent to Thailand.

OTHER REGIONS. — Myanmar: it is known from the Chon son stream (the Salween basin) adjacent to the border between Thailand and Myanmar and possibly from the Sittang **(Britz, 2007)**.

GENERIC STATUS. — *M. tinwini* is classified as a new species by **Britz (2007)**. It was distinguished from the *Mastacembelus armatus* species-complex. The taxonomy of the *Mastacembelus armatus* species-complex is less known due to its wide distribution and high intrasepecifically variability both in meristic characters and colour patterns **(Sufi, 1956; Roberts, 1986, 1989)**. *M. tinwini* differs from other members in the *Mastacembelus armatus* species-group by its unique colouration and number of vertebrae.

BIOLOGY AND ECOLOGY.

- **HABITAT. —** *M. tinwini* lives in from small streams to large river. Two specimens were captured from Nan River with sand and gravel substrates in Nan province. Additionally**,** a previous study reported that it habits in small streams with sand and gravel substrates at Yong Waterfall, Nakhon Si Thammarat. The water is clear and has a pH of 5.7. It was captured in shallow water **(Lertsuttichawan *et al.*, 2001)**.

- **STATUS. —** *M. tinwini* is not listed on both the IUCN Red List and Thailand Red data **(IUCN, 2007; Vidthayanon, 2005)**. The present status is not known.

- **FISHERIES. —** It was caught by hook and line and sold together with other spiny eels in local fish market.

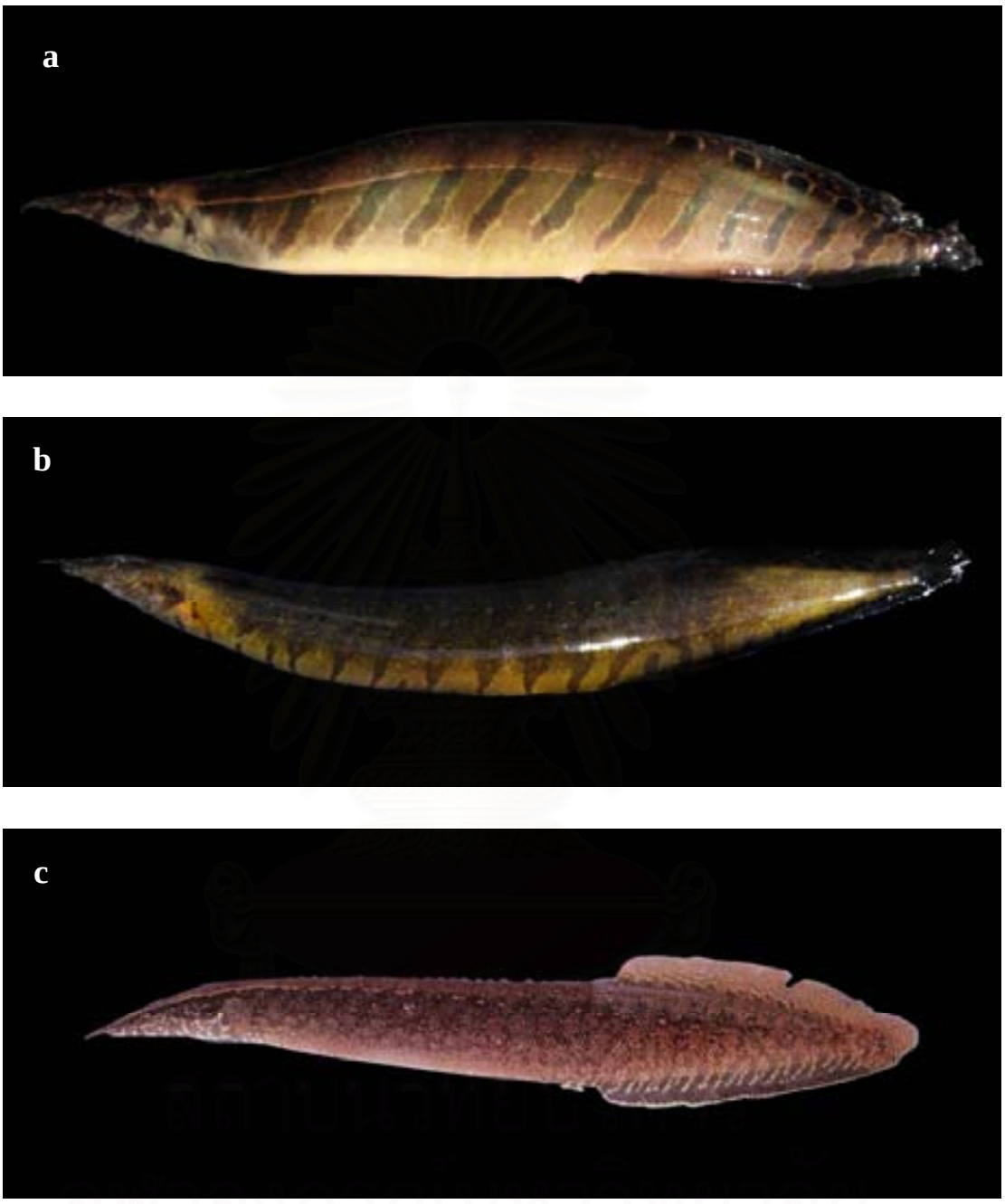

FIGURE 4.1. *Macrognathus* of Thailand. a, *M. aculeatus*, 267.4 mm L_S from Khlong Cha-uat, Cha-uat, Nakhon Si Thammarat; b, *M. circumcinctus*, 198 mm L_S from Thale Noi, Khuan Khanun, Phatthalung; and c, *M. maculatus* (picture of *M. maculatus* from Vidthayanon, 2002).

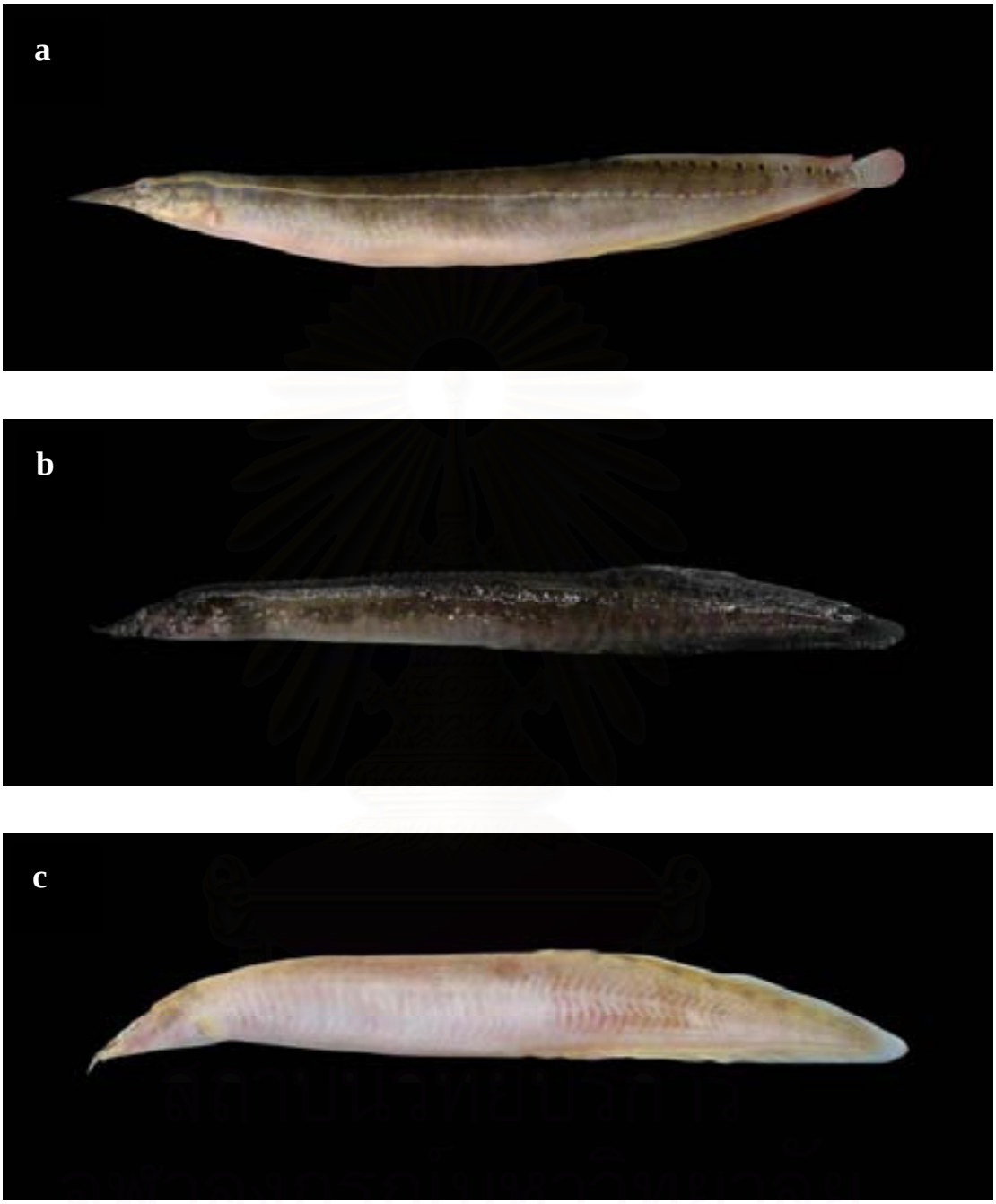

FIGURE 4.2. *Macrognathus* of Thailand. a, *M. meklongensis*, 186.8 mm L_S from Kwae Noi River, Sangkhla Buri, Kanchanaburi; b, *M. semiocellatus*, 145.3 mm L_S from Kabinburi, Prachinburi; and c, *M. semiocellatus*, 183.4 mm L_S from Mueang Prachinburi, Prachinburi.

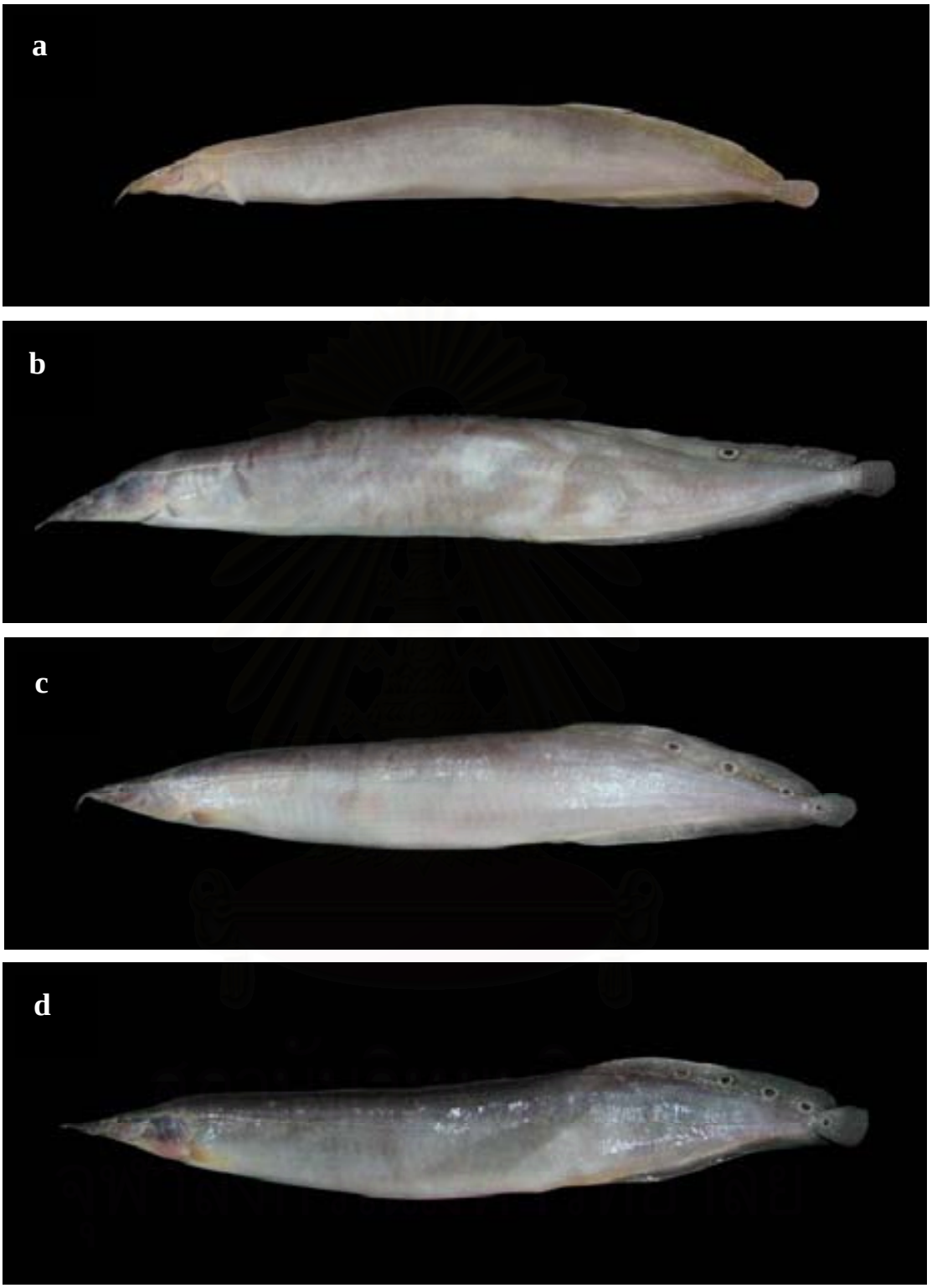

FIGURE 4.3a-d. *Macrognathus siamensis* in Thailand. a, 193 mm L_S from Nan River basin, Tron, Uttaradit; b, 214.8 mm L_S from Nan River basin, Tron, Uttaradit; c, 239.8 mm L_S from Yom River basin, Mueang, Phrae and d, 225.4 mm L_S from Nan River basin, Tron, Uttaradit.

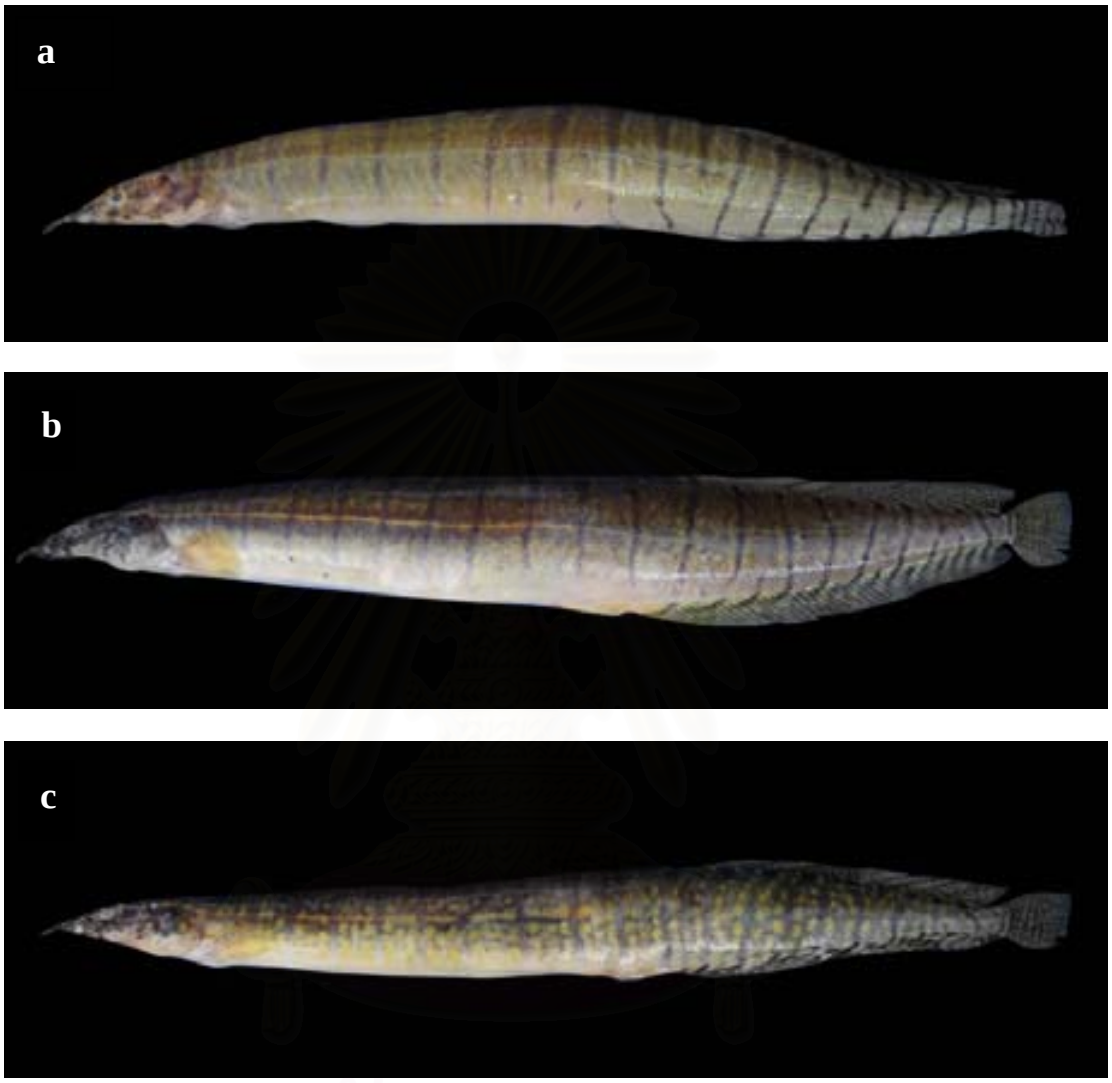

FIGURE 4.4. *Macrognthus zebrinus* of Thailand. a, *M. zebrinus*, 142 mm L_S from Huai Sam Laep, Mae Hong Son; b, *M. zebrinus*, 247.2 mm L_S from Moei River, Tha Song Yang, Tak; and c, *M. zebrinus*, 240.2 from Moei River, Tha Song Yang, Tak.

FIGURE 4.5. *Mastacembelus* of Thailand. a, *M. alboguttatus*, 321.5 mm L_S from Moei River, Tha Song Yang, Tak; b, *M. armatus*, 196 mm L_S, from Nam Wa River basin, Nan; c, *M. armatus*, 194.2 mm L_S, from Nam Wa River basin, Nan.

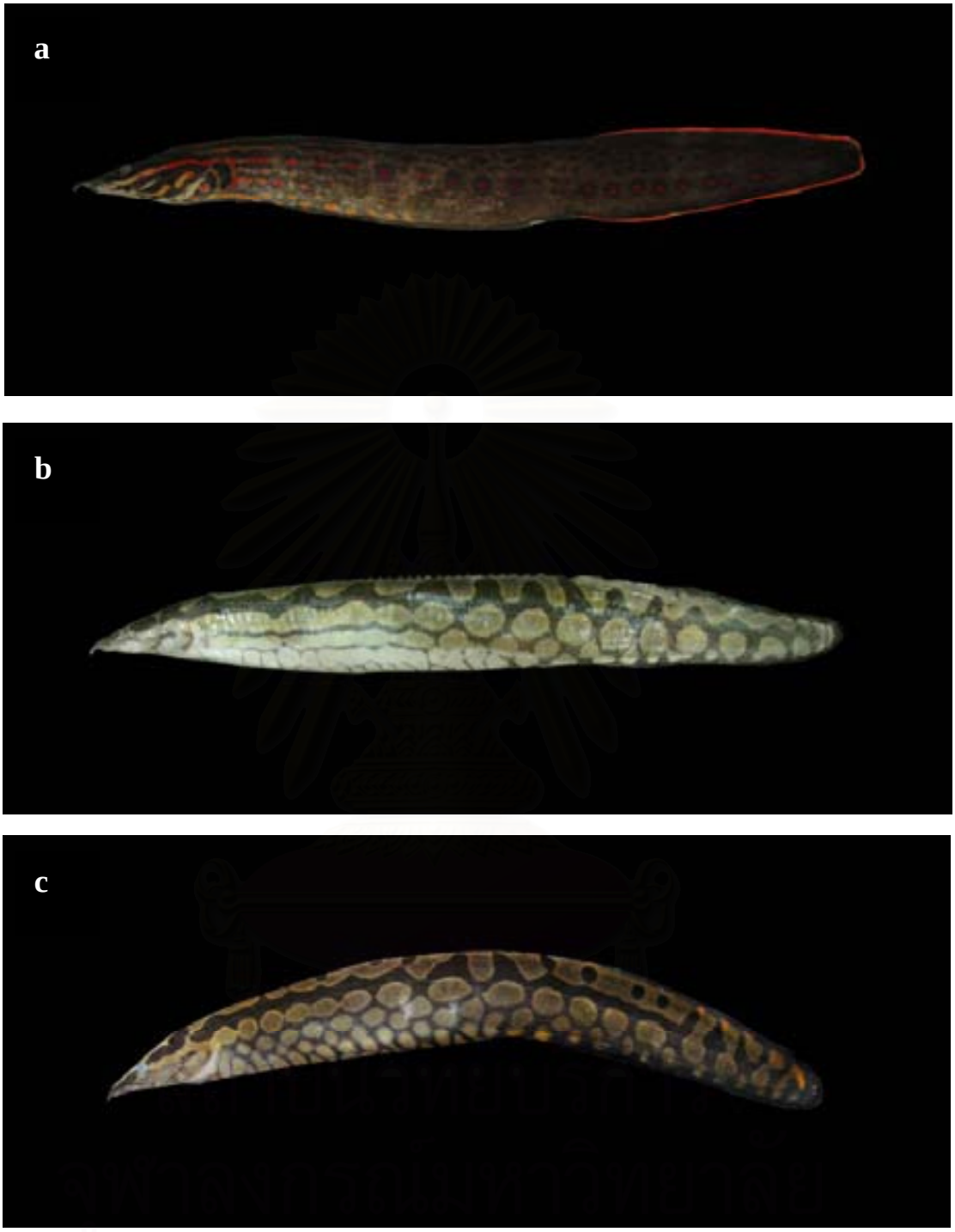

FIGURE 4.6. *Mastacembelus* of Thailand. a, *M. erythroatenia*, 409.4 mm L_S from Tapi River, Phunphin, Surat Thani; b, *M. favus*, 188.5 mm L_S from Nan river, Tron, Uttaradit; c, *M. favus*, 178 mm L_S from Nan river, Tron, Uttaradit;

FIGURE 4.7. *Mastacembelus tinwini* of Thailand. a, 163.8 mm L_S from Nam Wa River basin, Nan; b, 160.8 mm L_S from Nam Wa River basin, Nan; c, *M. tinwini* (picture c. from Vidthayanon, 2004).

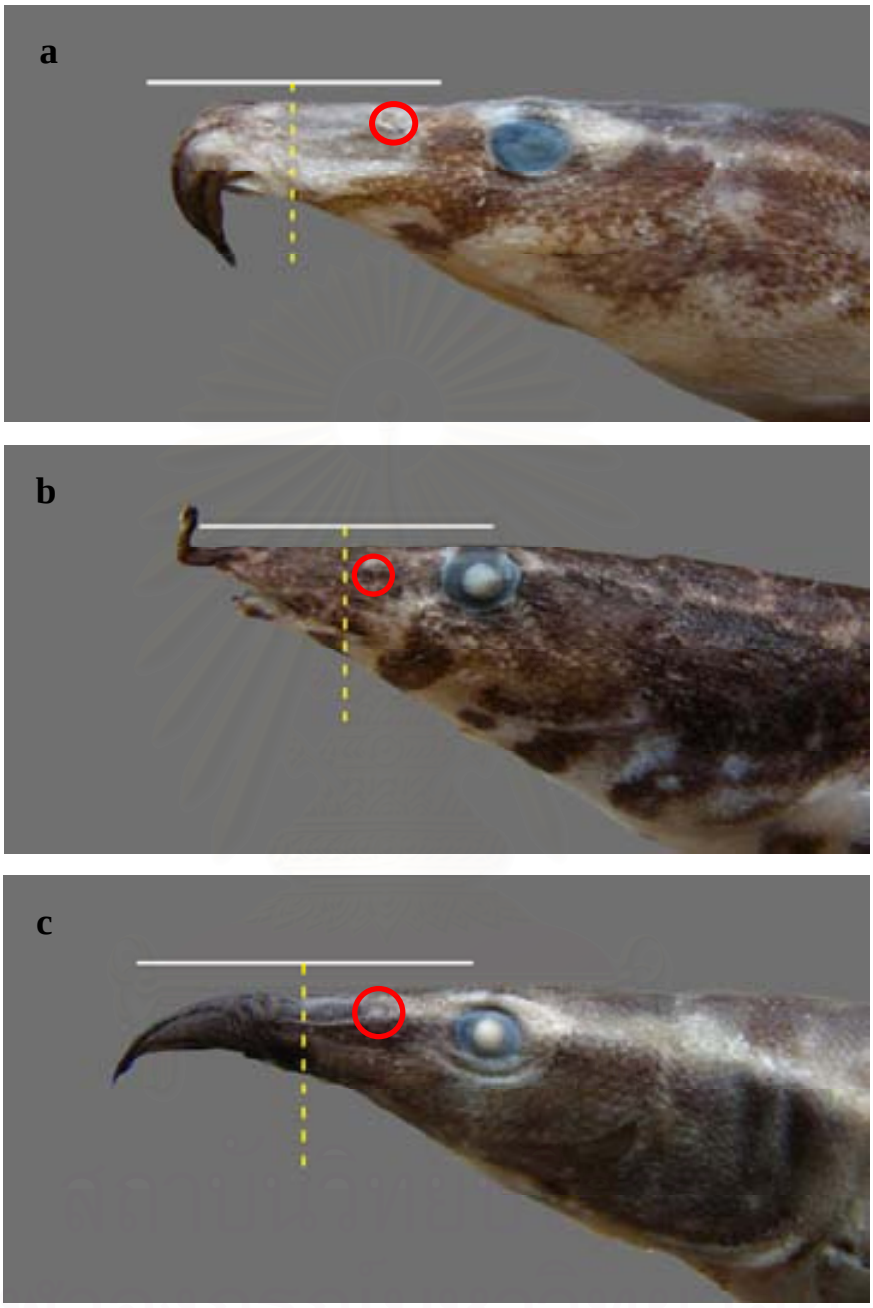

FIGURE 4.8. Showing a position of posterior angle of lips in relation to posterior external nare and eye (vertical line is perpendicular to a horizontal line parallel with the upper surface of the snout; a small circle indicates the position of posterior external nare). a, *Macrognathus aculeatus*; b, *Macrognathus circumcinctus*; and c, *Macrognathus meklongensis*.

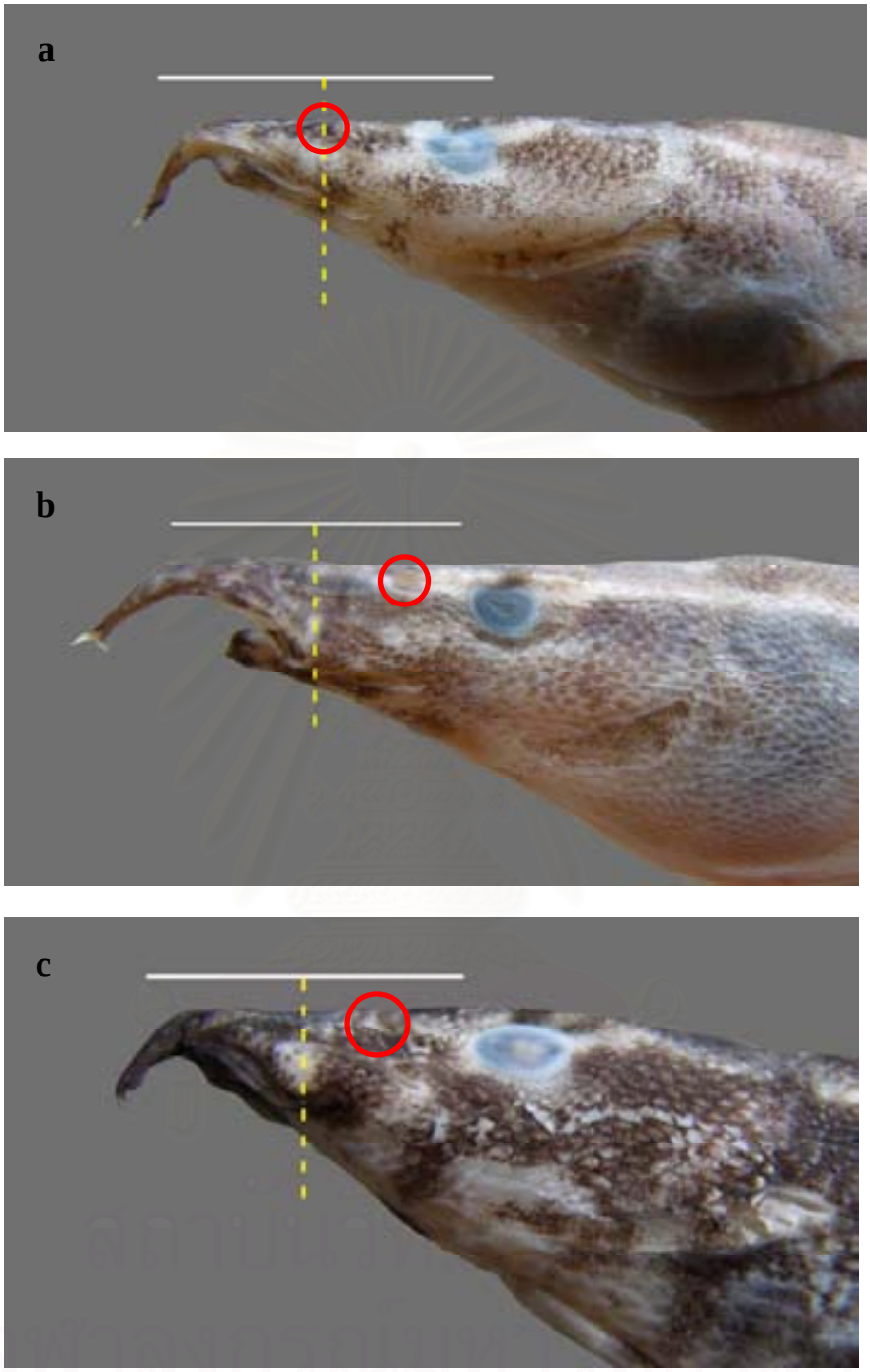

FIGURE 4.9. Showing a position of posterior angle of lips in relation to posterior external nare and eye (vertical line is perpendicular to a horizontal line parallel with the upper surface of the snout; a small circle indicates the position of posterior external nare). a, *Macrognathus semiocellatus*; b, *Macrognathus siamensis*; and c, *Macrognathus zebrinus*.

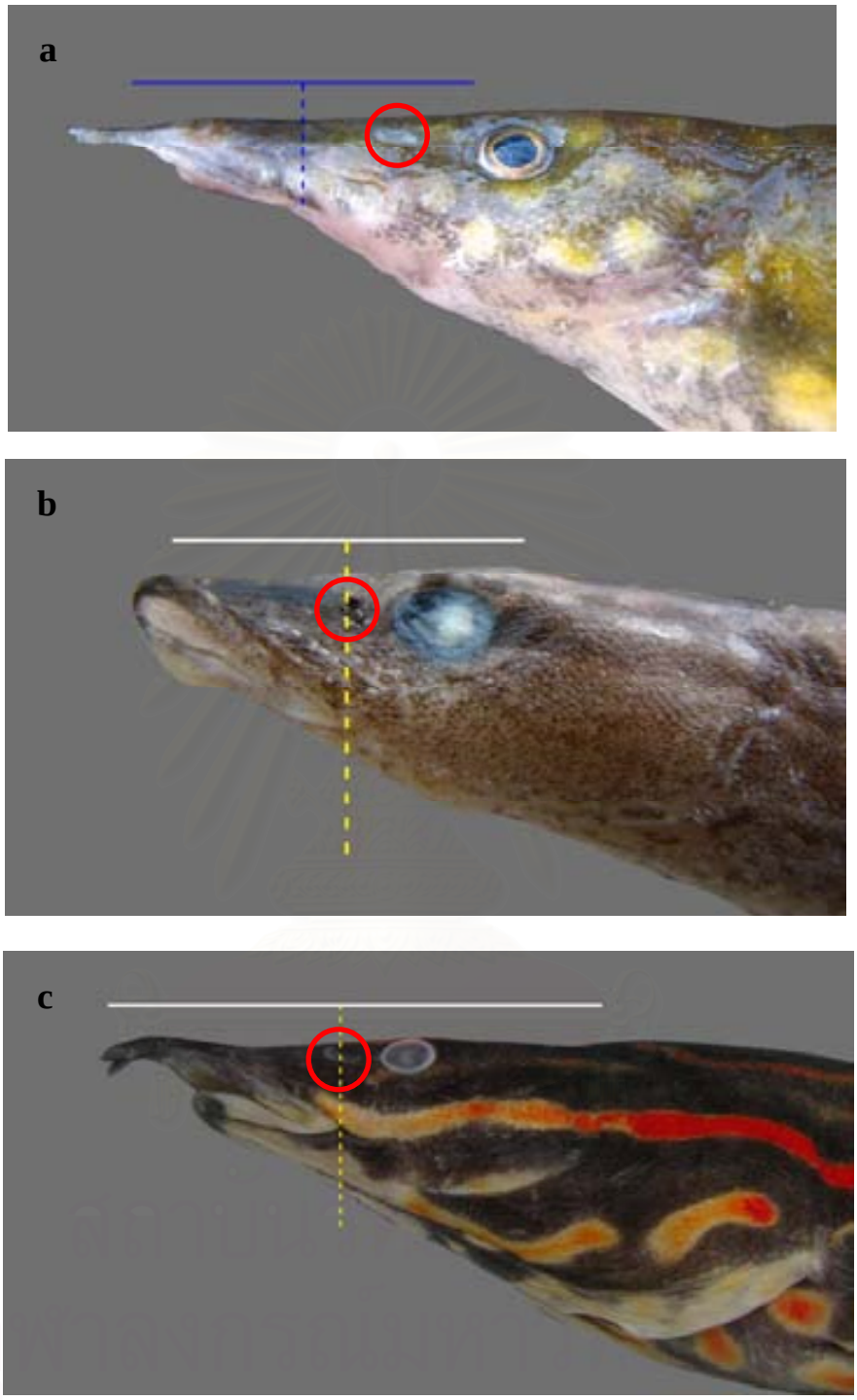

FIGURE 4.10. Showing a position of posterior angle of lips in relation to posterior external nare and eye (vertical line is perpendicular to a horizontal line parallel with the upper surface of the snout; a small circle indicates the position of posterior external nare). a, *Mastacembelus alboguttatus*; b, *Mastacembelus armatus*; and c, *Mastacembelus erythrotaenia*.

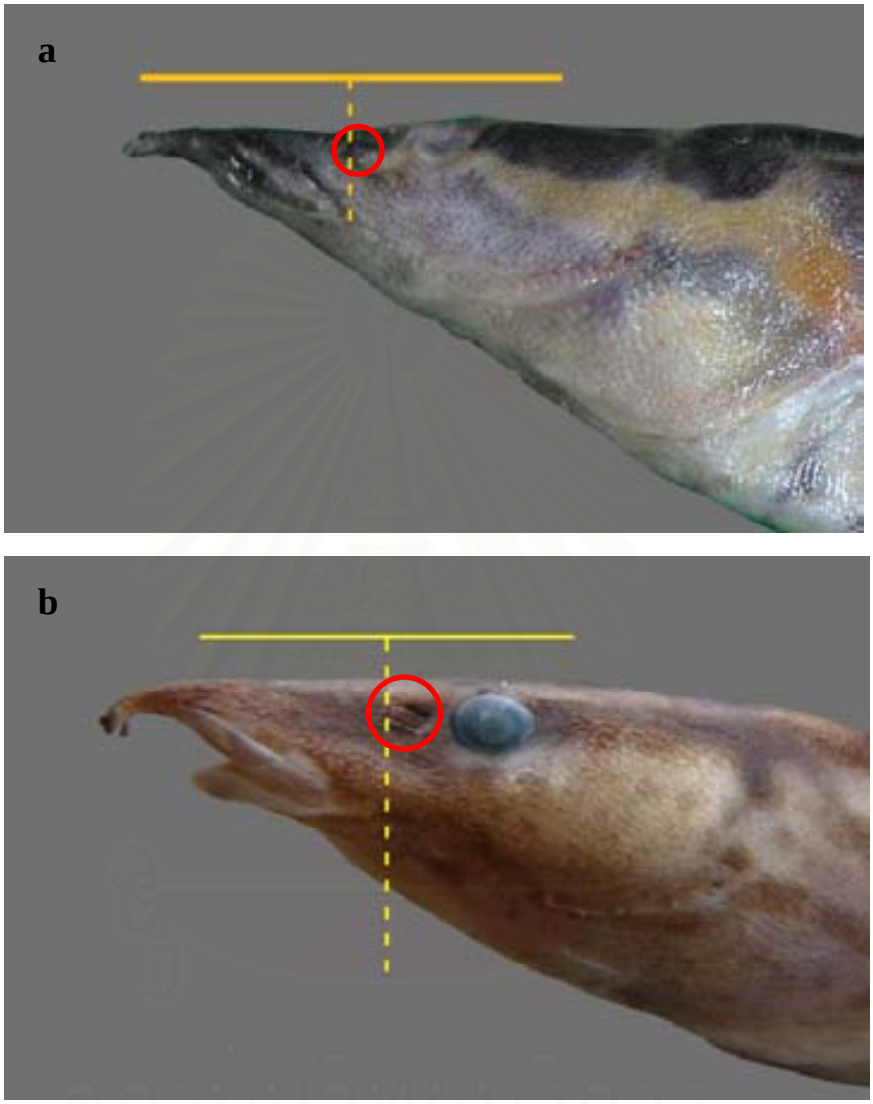

FIGURE 4.11. Showing a position of posterior angle of lips in relation to posterior external nare and eye (vertical line is perpendicular to a horizontal line parallel with the upper surface of the snout; a small circle indicates the position of posterior external nare). a, *Mastacembelus favus* and b, *Mastacembelus tinwini*.

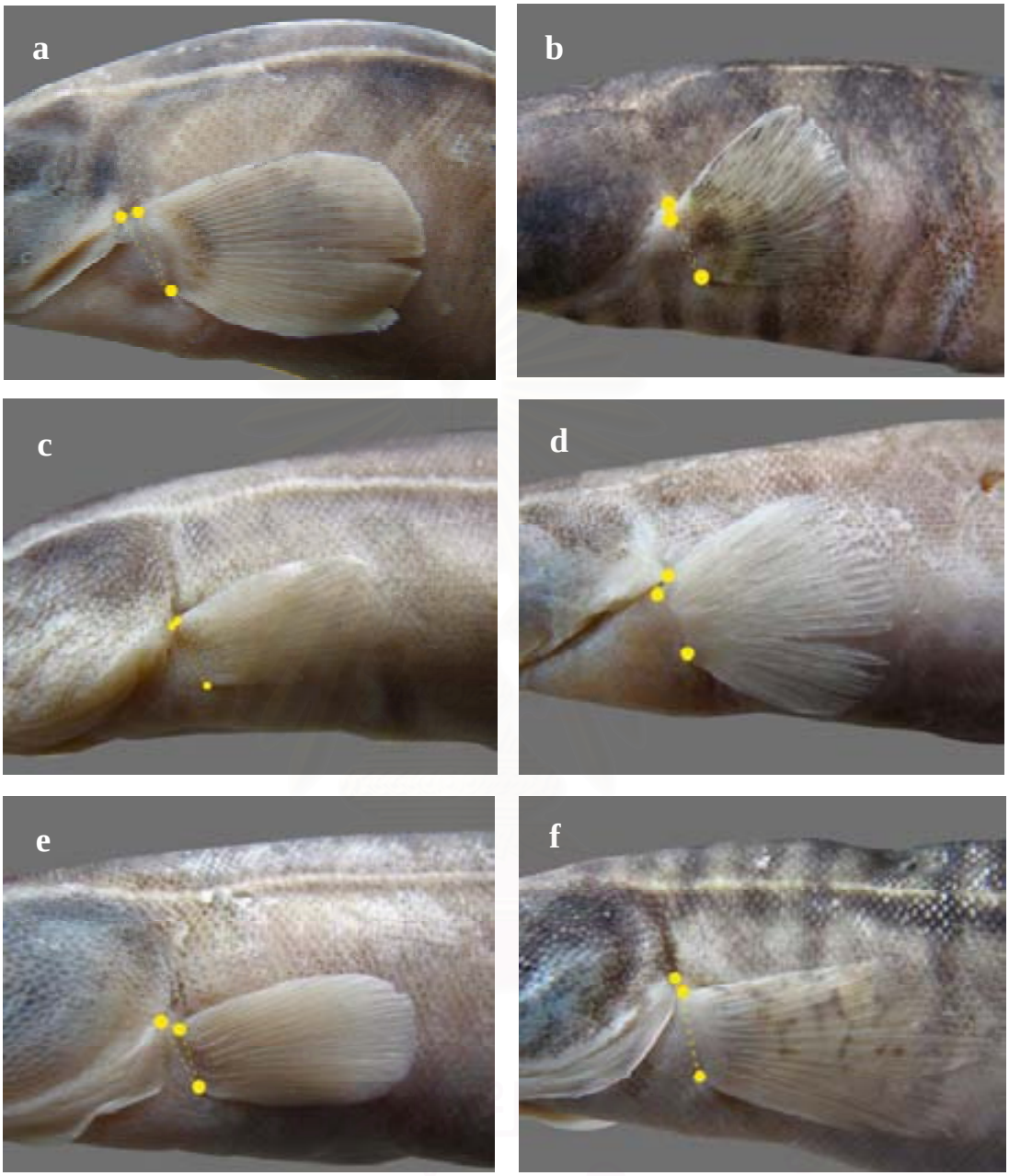

FIGURE 4.12. Showing a detail of pectoral-fin region of *Macrognathus*. Upper tip of gill slit, dorsal edge of pectoral-fin base and ventral edge of pectoral-fin base are connected by dashed lines. a, *M. aculeatus*; b, *M. circumcinctus*; c, *M. meklongensis*; d, *M. semiocellatus*; e, *M. siamensis* and f, *M. zebrinus*.

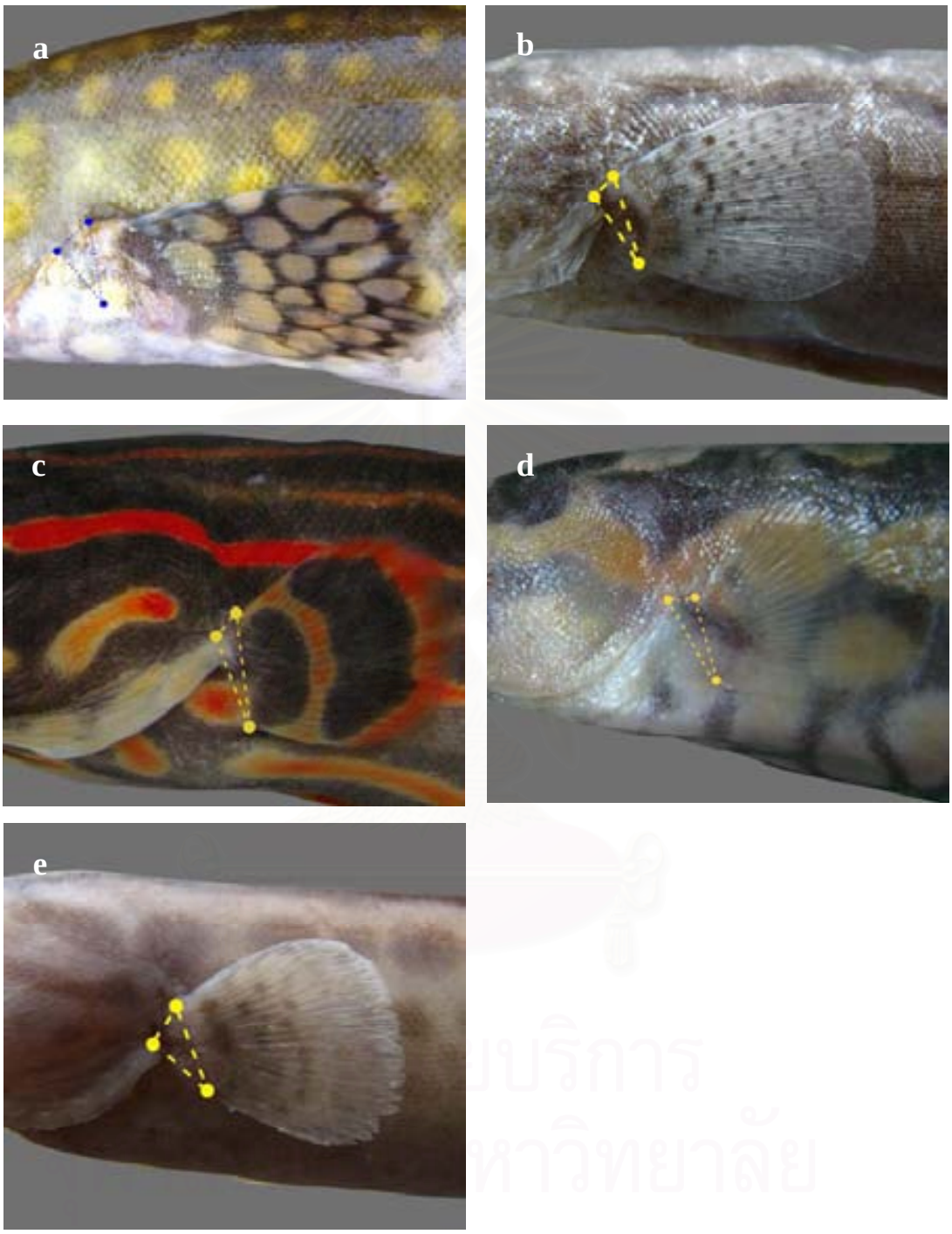

FIGURE 4.13. Showing a detail of pectoral-fin region of *Mastacembelus*. Upper tip of gill slit, dorsal edge of pectoral-fin base and ventral edge of pectoral-fin base are connected by dashed lines. a, *M. alboguttatus*; b, *M. armatus*; c, *M. erythrotaenia*; d, *M. favus*; and e, *M. tinwini*.

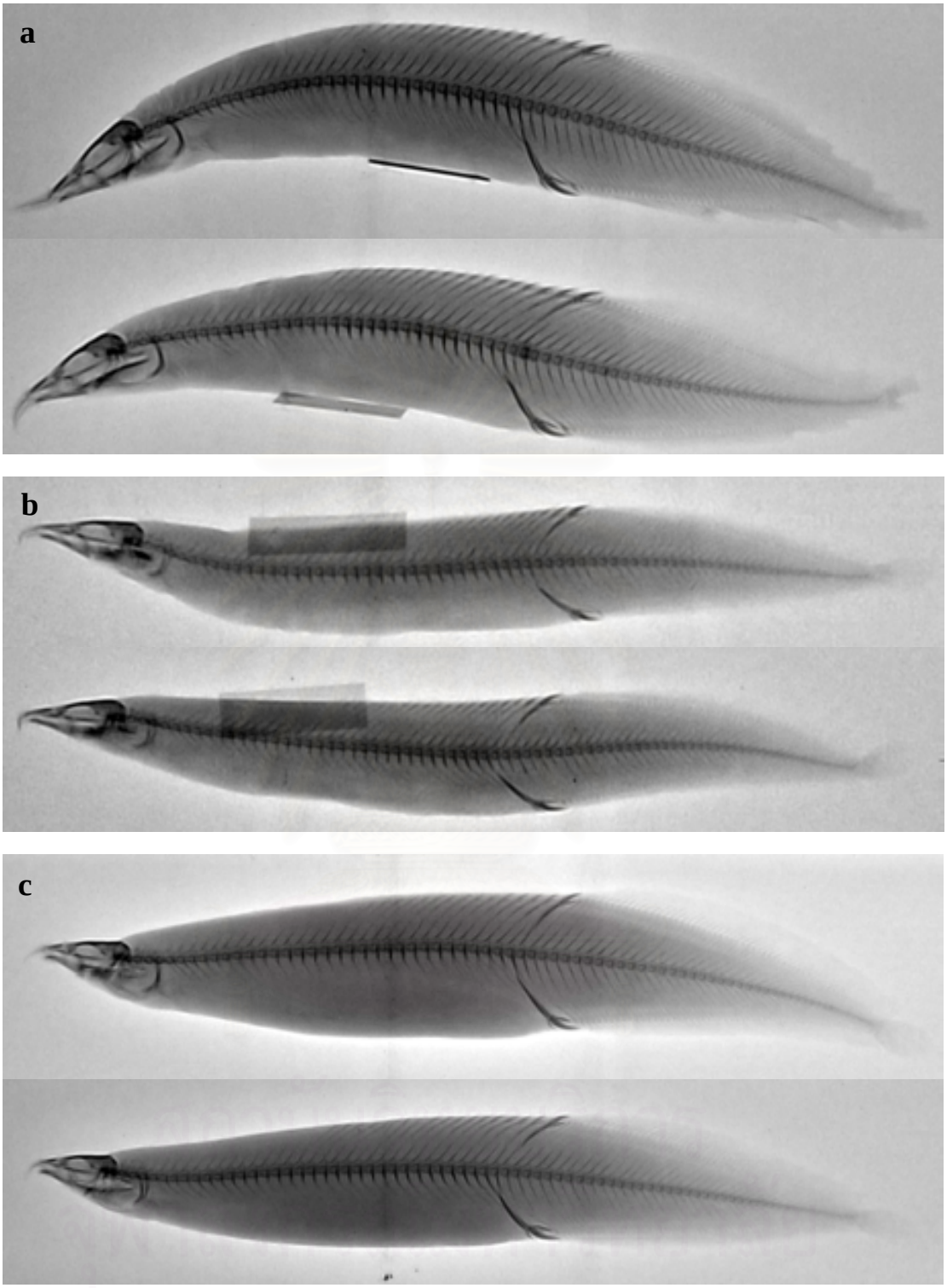

FIGURE 4.14. Radiographs of *Macrognathus* in Thailand. a, *M. aculeatus*; b, *M. meklongensis* and c, *M. siamensis*: the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on the same vertebra (above) or on two different, successive vertebrae (below) in each species.

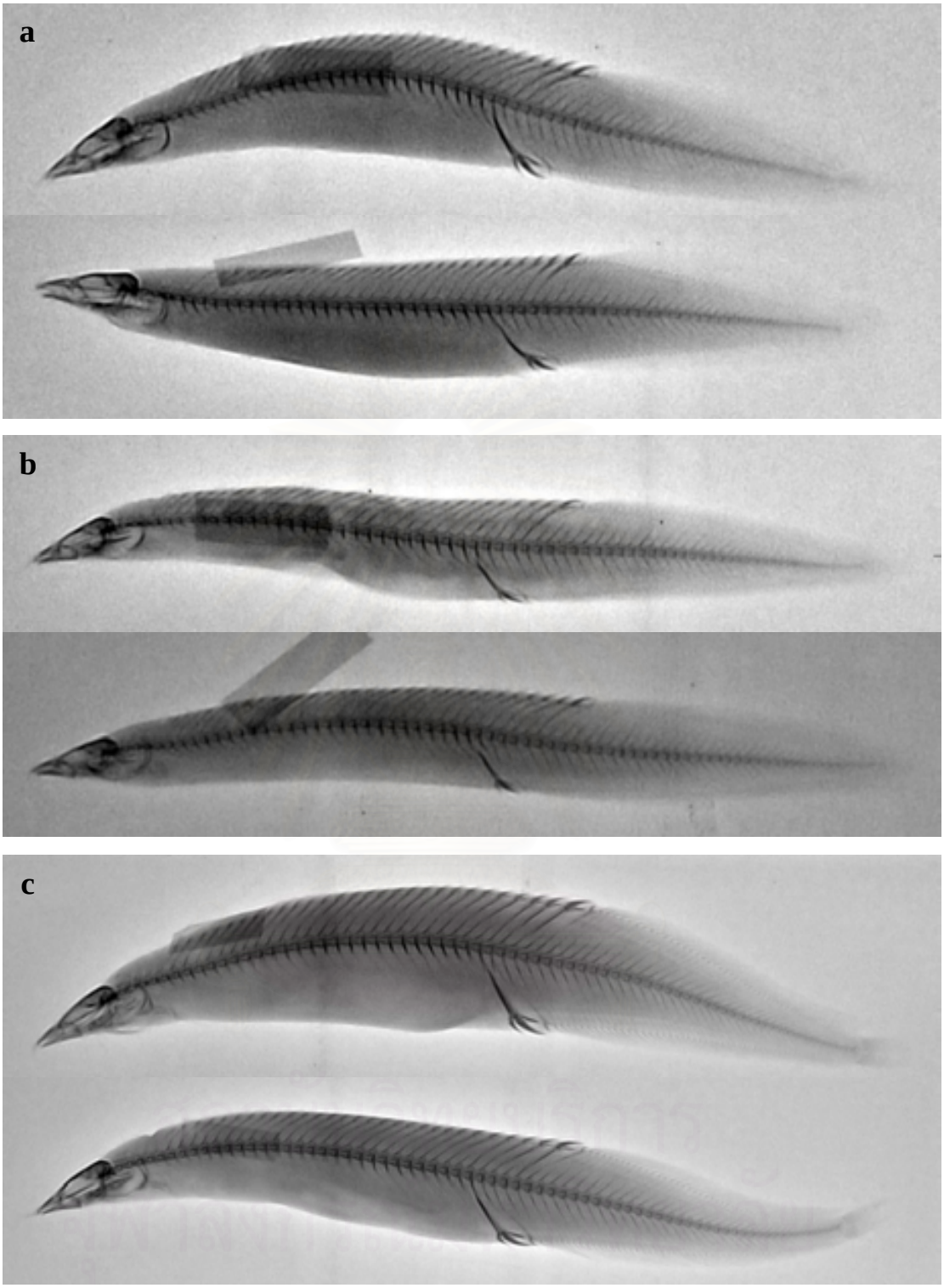

FIGURE 4.15. Radiographs of *Macrognathus* in Thailand. a, *M. circumcinctus*; b, *M. semiocellatus*; and c, *M. zebrinus*: the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on two different vertebrae. Both a and c, they are separated by one (above) and two (below) in-between vertebrae. b, *M. semiocellatus*: they are separated by three (above) and four (below) in-between vertebrae.

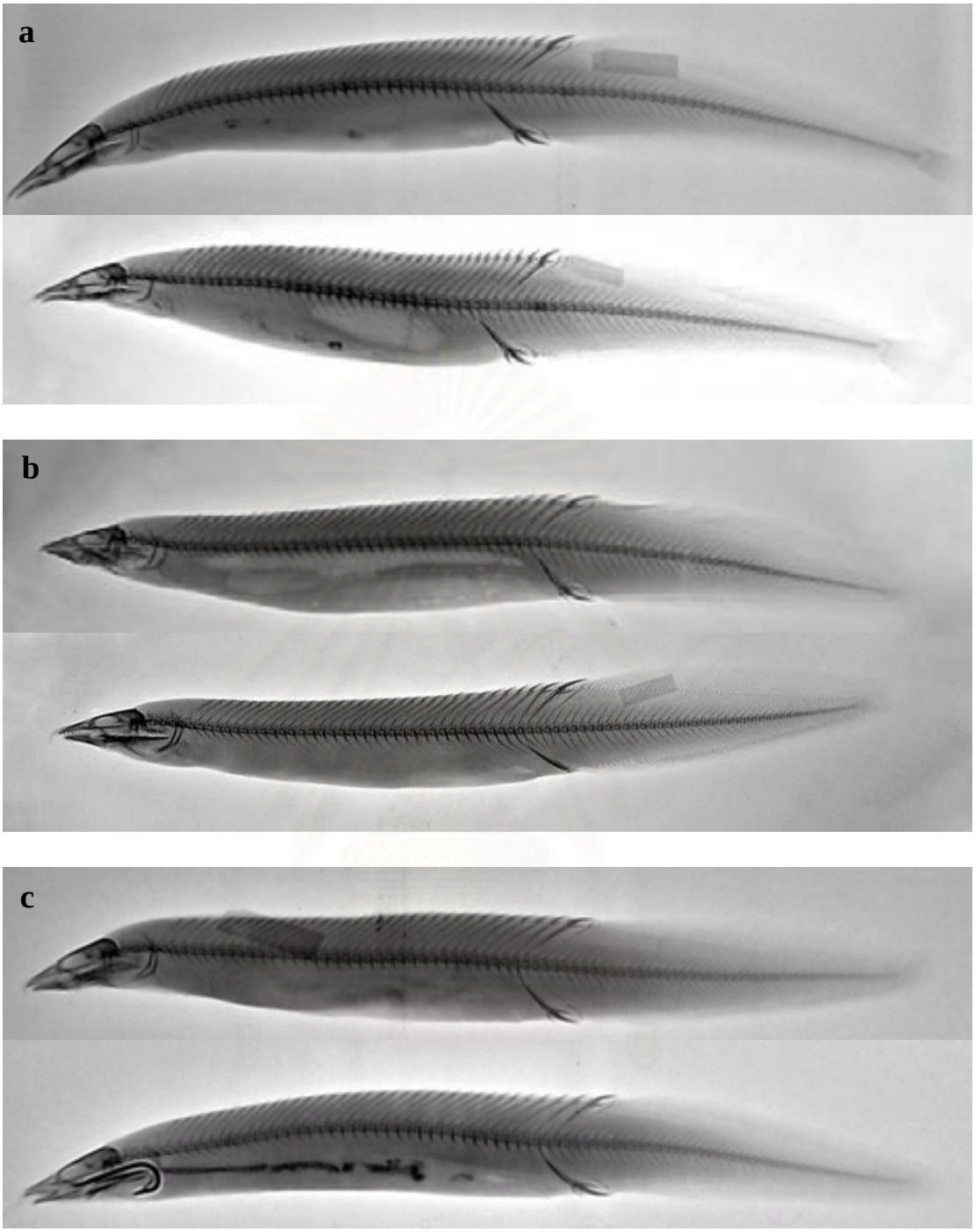

FIGURE 4.16. Radiographs of *Mastacembelus* in Thailand. a**,** *M. alboguttatus*: the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on two different vertebrae and are separated by one in-between vertebrae. b, *M. erythrotaenia* and c, *M. favus*: the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on the same vertebra (above) or on two different, successive vertebrae (below).

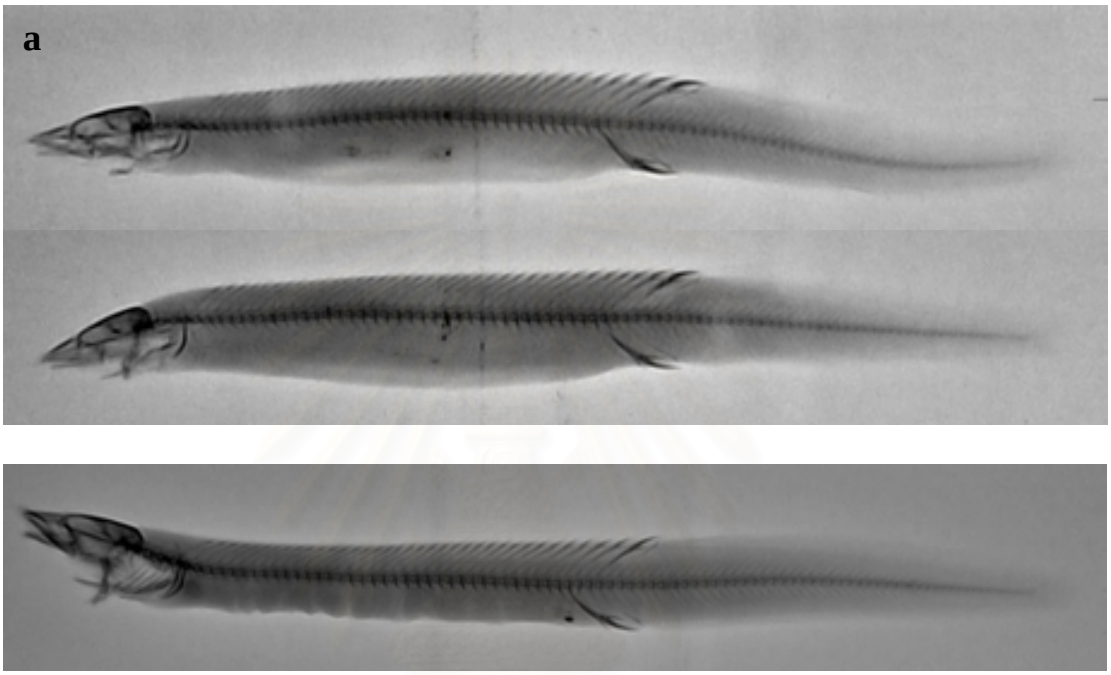

FIGURE 4.17. Radiographs of *Mastacembelus* in Thailand. a, *M. tinwini*: the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on two different vertebrae and are separated by one and two in-between vertebrae. b, *M. armatus*: the neural spine-supporting pterygiophore of the last externally visible dorsal spine and the haemal spine-supporting pterygiophore of the first anal spine are situated on two different vertebrae and are separated by one in-between vertebrae

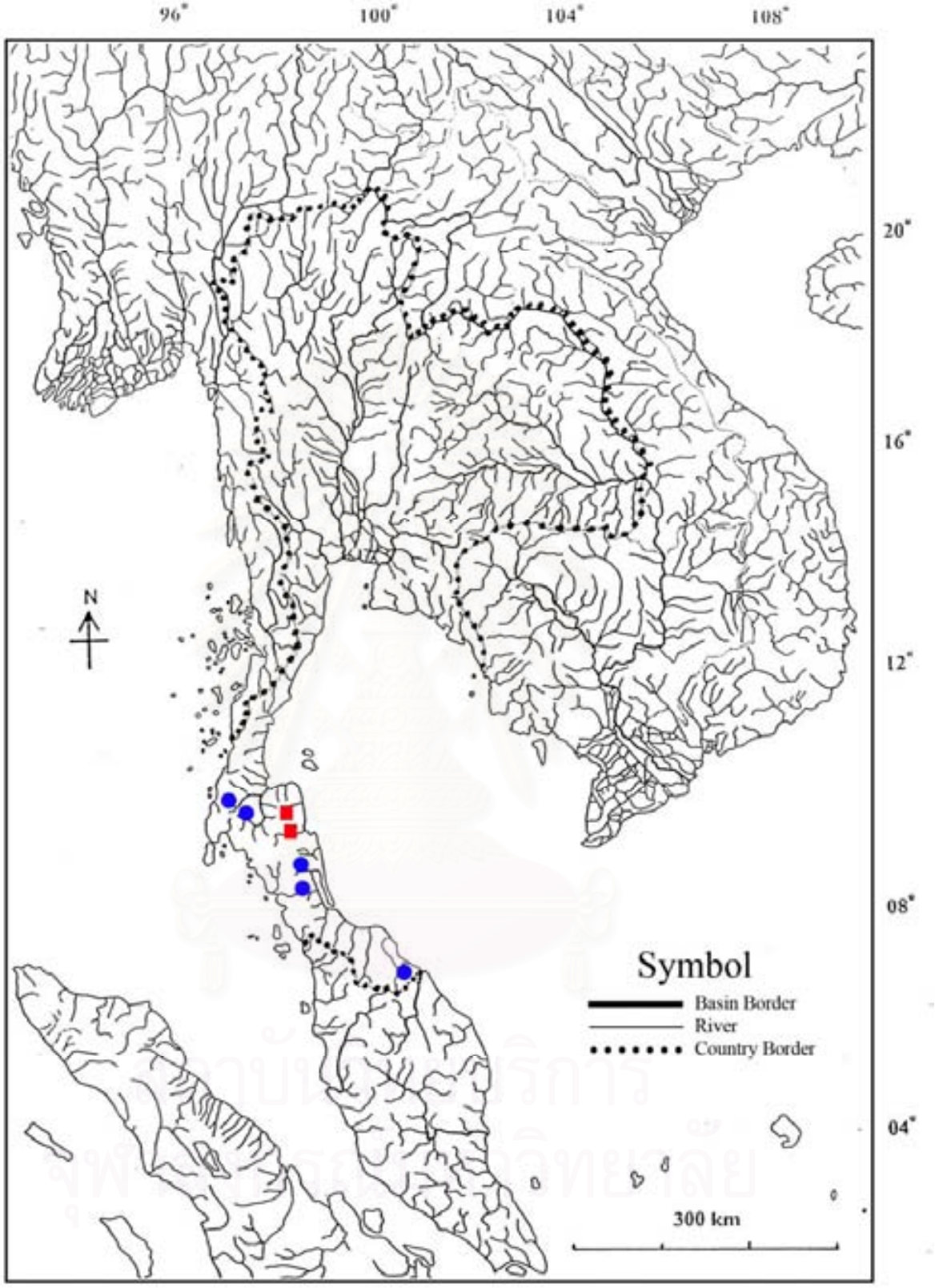

FIGURE 4.18. Distribution Map of *Macrognathus aculeatus* (● = material examined, ■ = previous report).

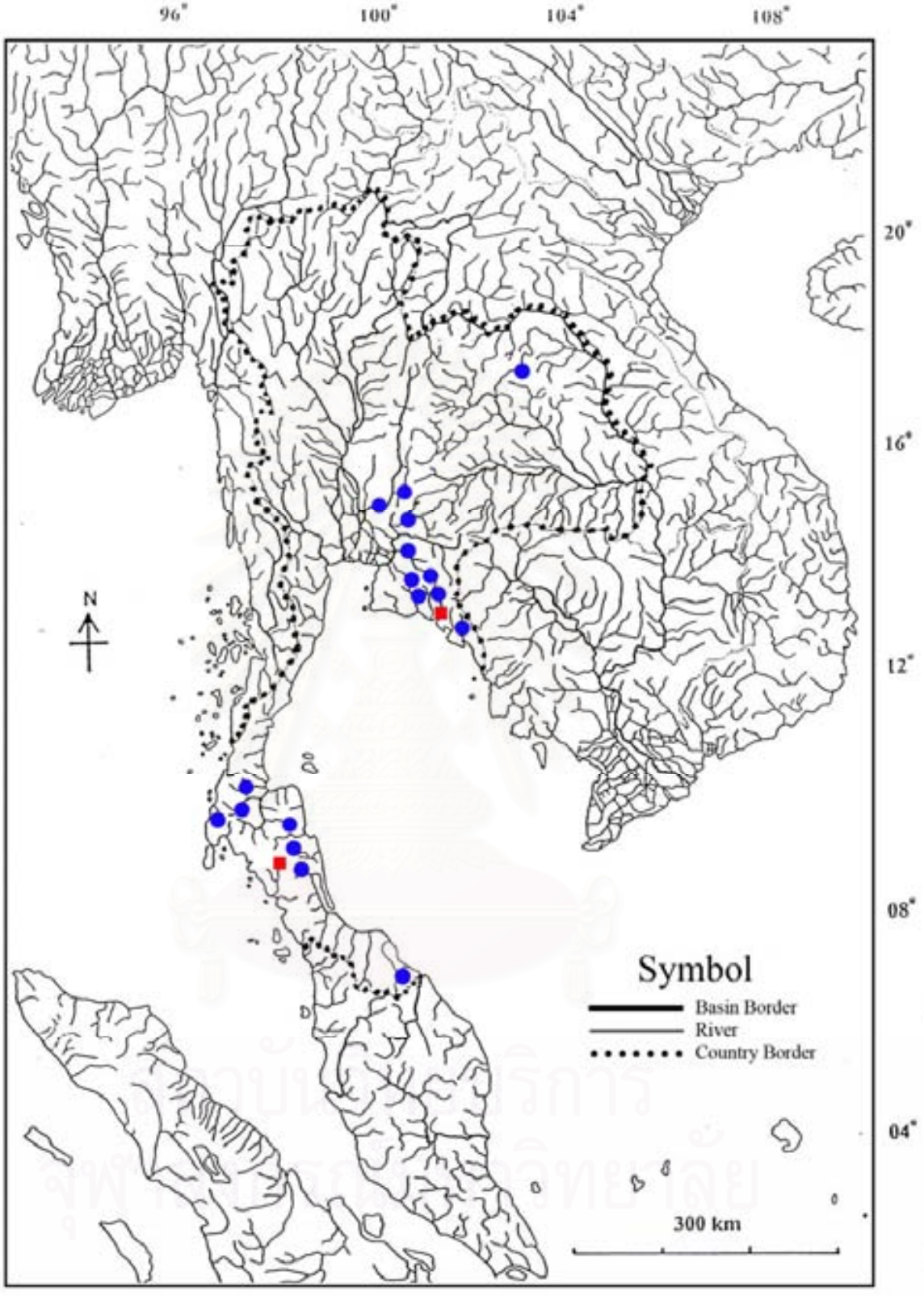

FIGURE 4.19. Distribution Map of *Macrognathus circumcinctus* (● = material examined, ■ = previous report).

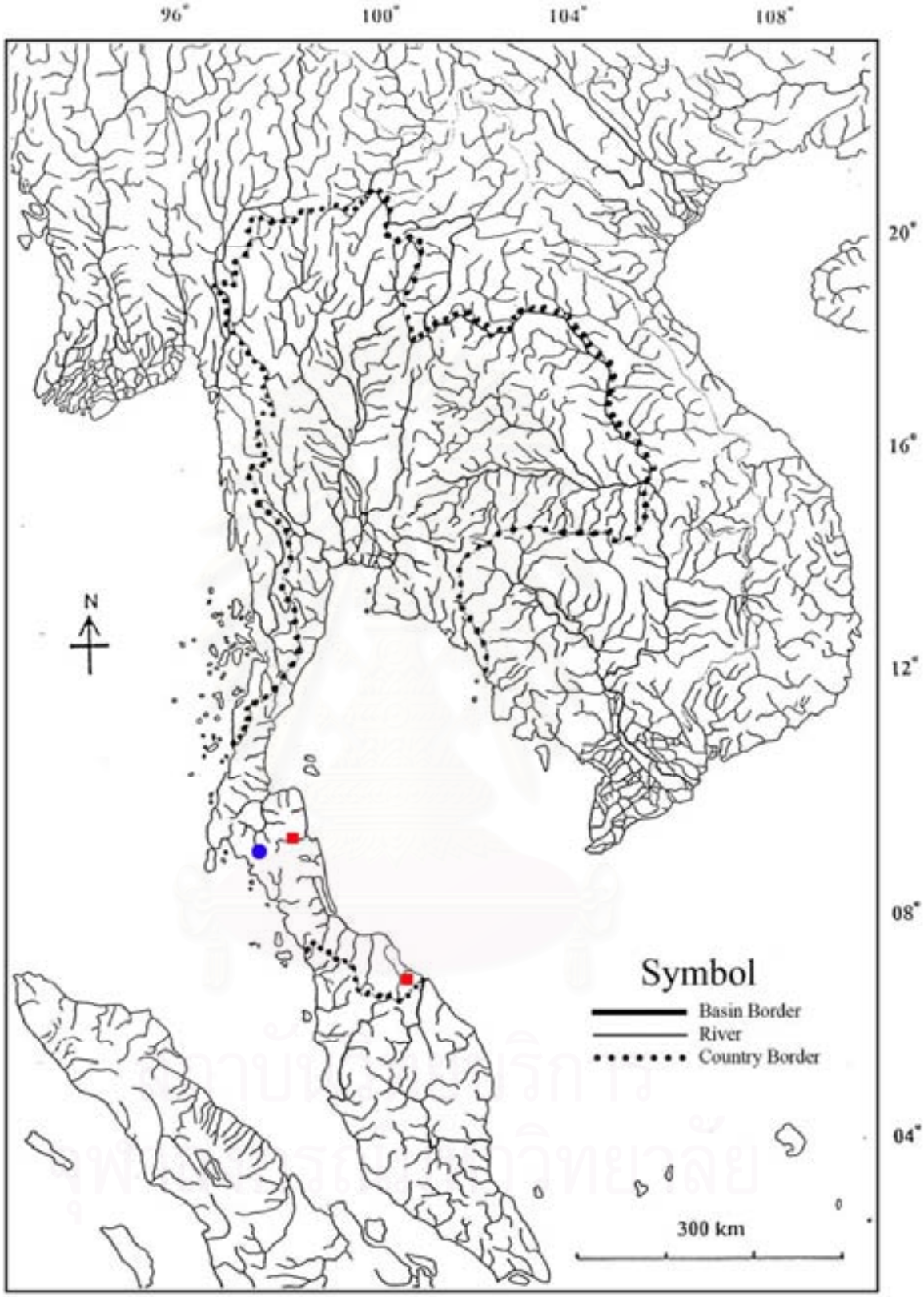

FIGURE 4.20. Distribution Map of *Macrognathus maculatus* (● = material examined, ■ = previous report).

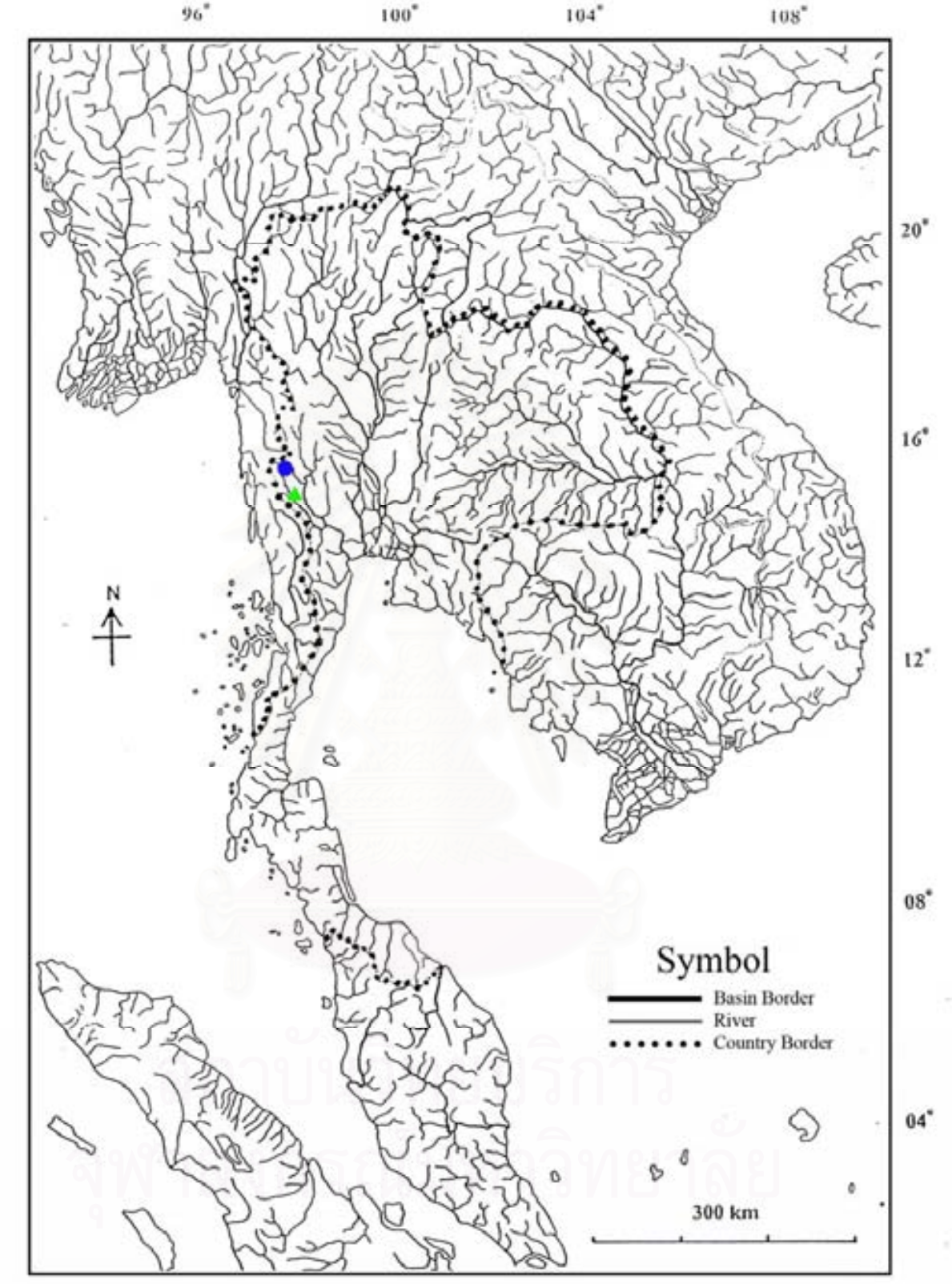

FIGURE 4.21. Distribution Map of *Macrognathus meklongensis* (● = material examined, ▲ = Holotype).

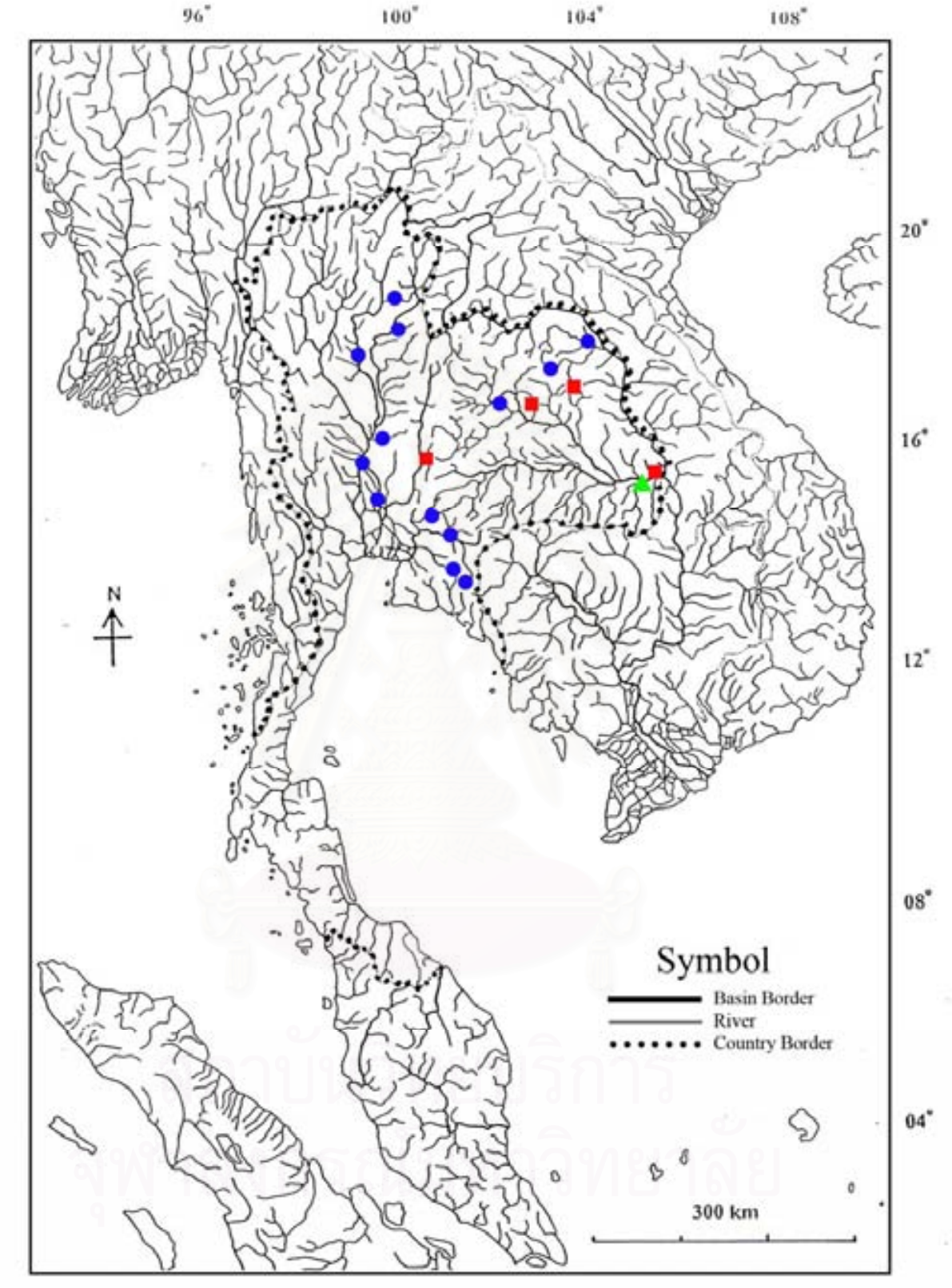

FIGURE 4.22. Distribution Map of *Macrognathus semiocellatus* (● = material examined, ■ = previous report, ▲ = Holotype).

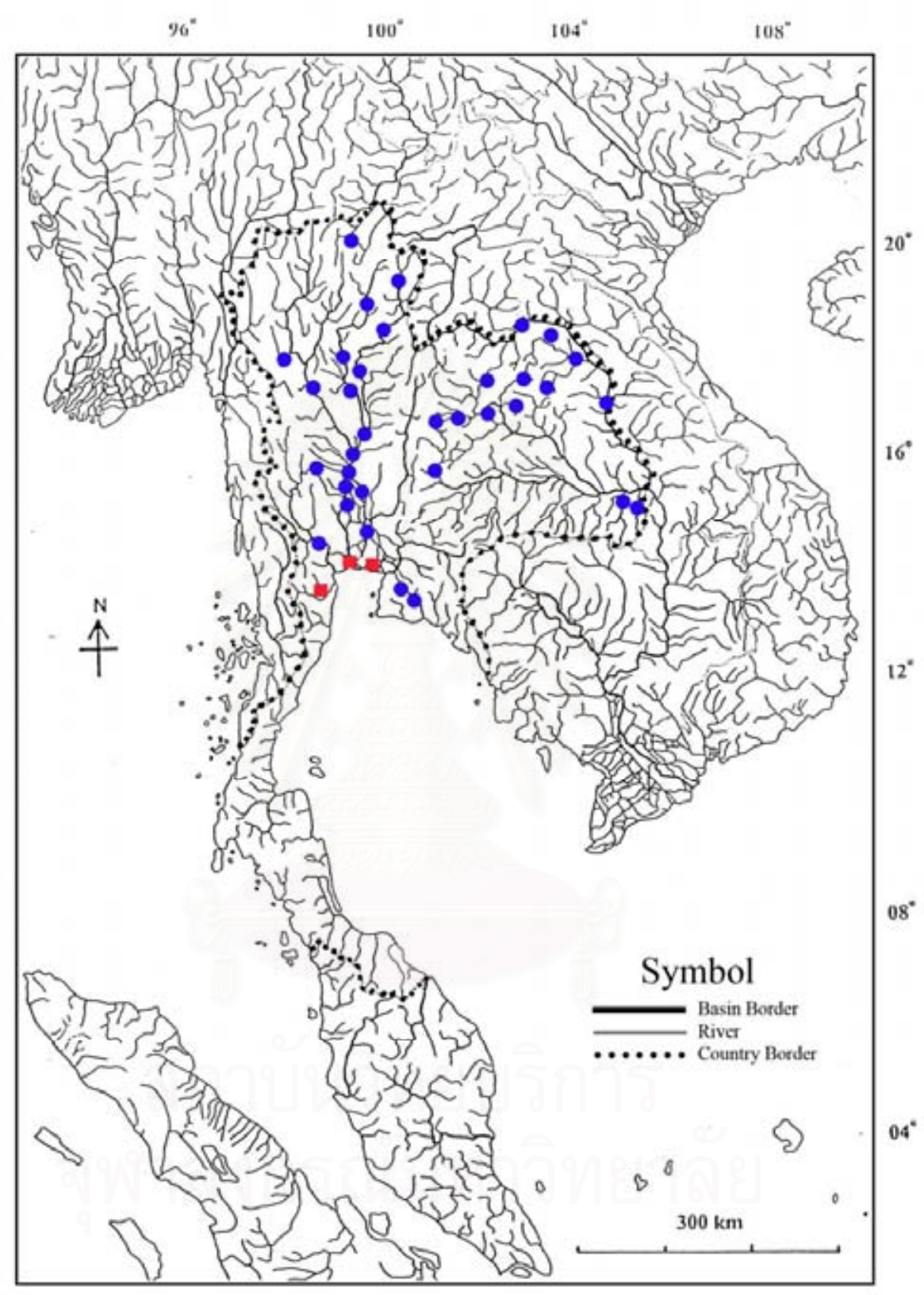

FIGURE 4.23. Distribution Map of *Macrognathus siamenis* (● = material examined, ■ = previous report).

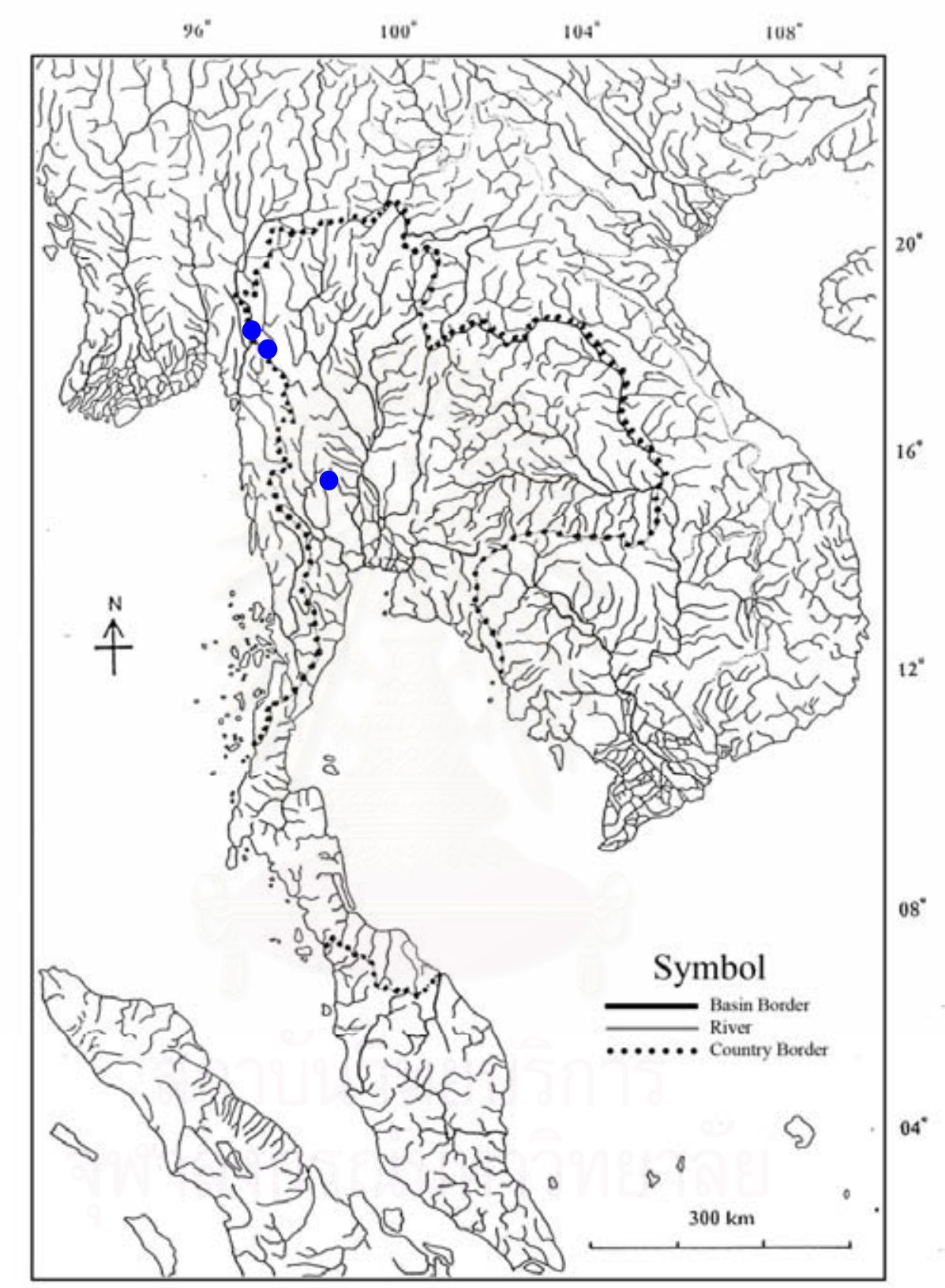

FIGURE 4.24. Distribution Map of *Macrognathus zebrinus* (● = material examined).

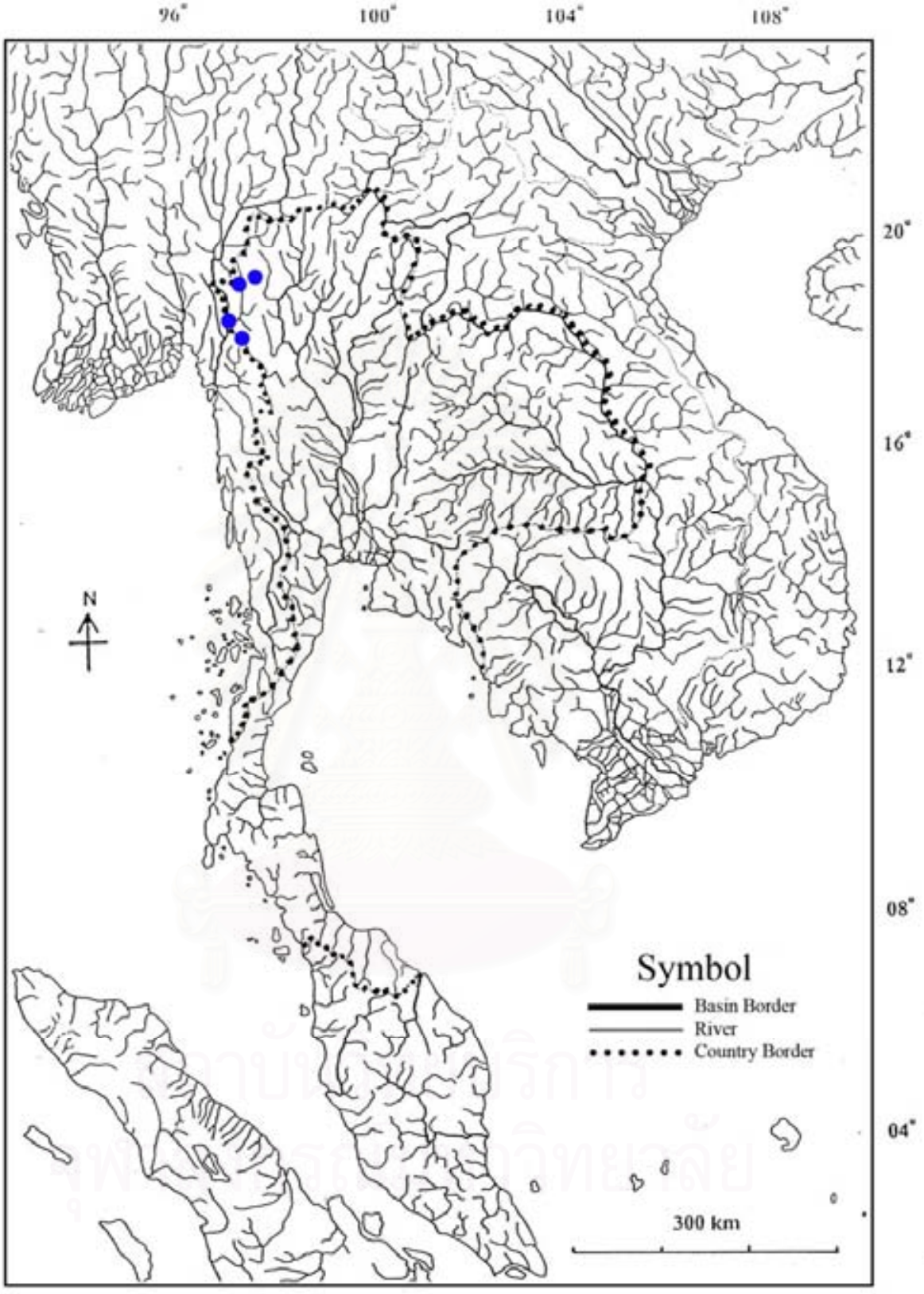

FIGURE 4.25. Distribution Map of *Mastacembelus alboguttatus* (● = material examined).

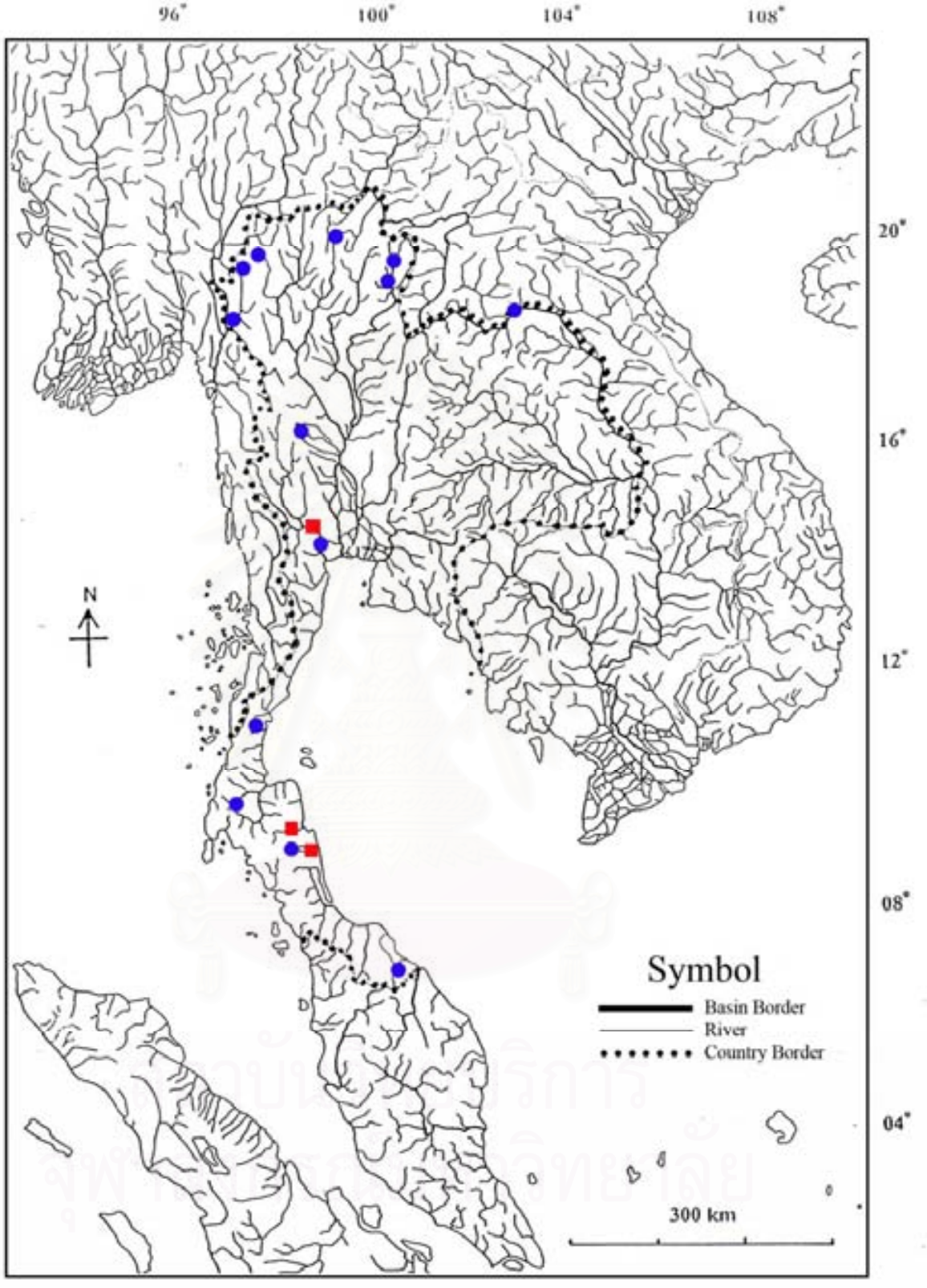

FIGURE 4.26. Distribution Map of *Mastacembelus armatus* (● = material examined, ■ = previous report).

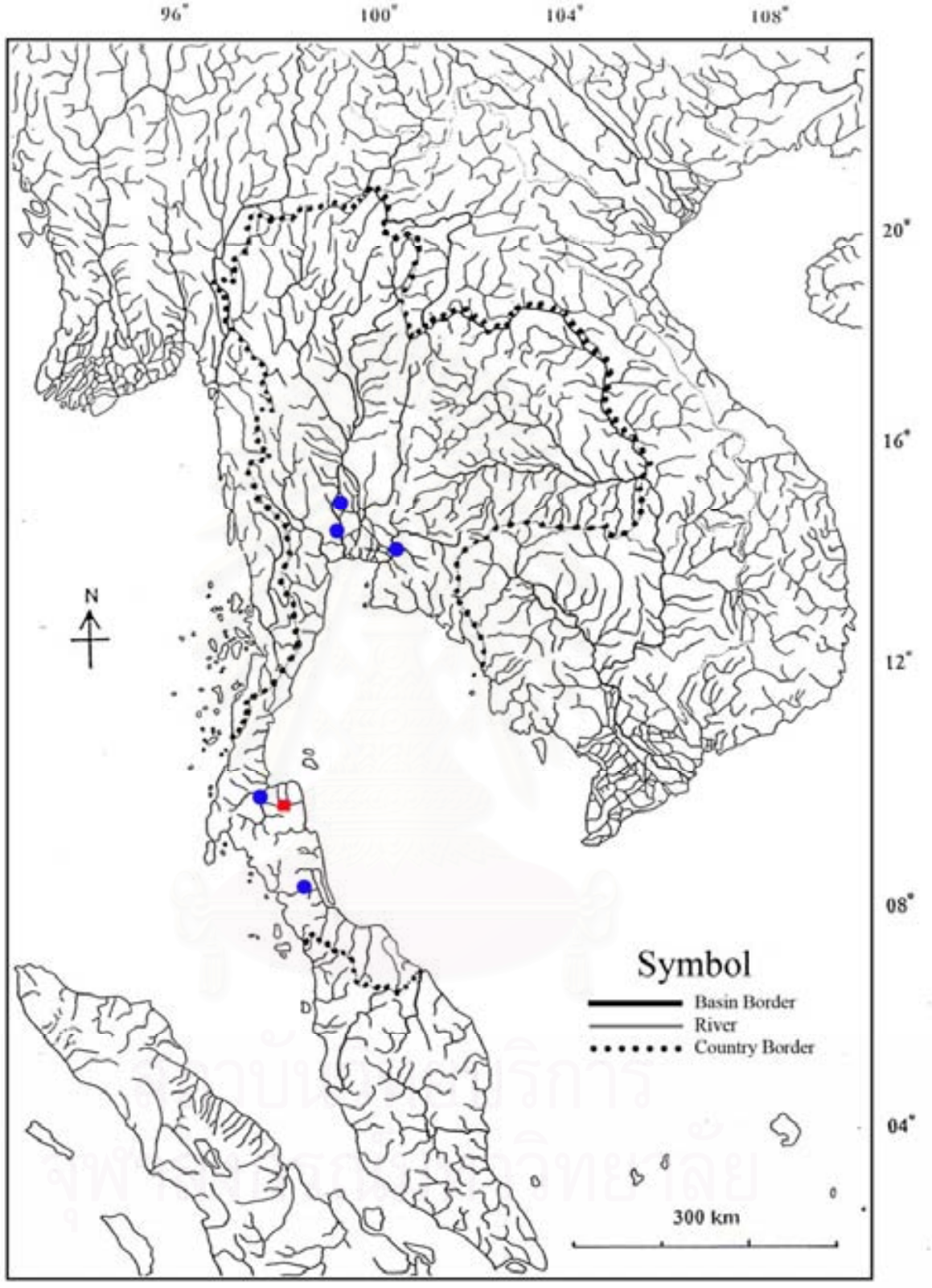

FIGURE 4.27. Distribution Map of *Mastacembelus erythrotaenia* (● = material examined, ■ = previous report).

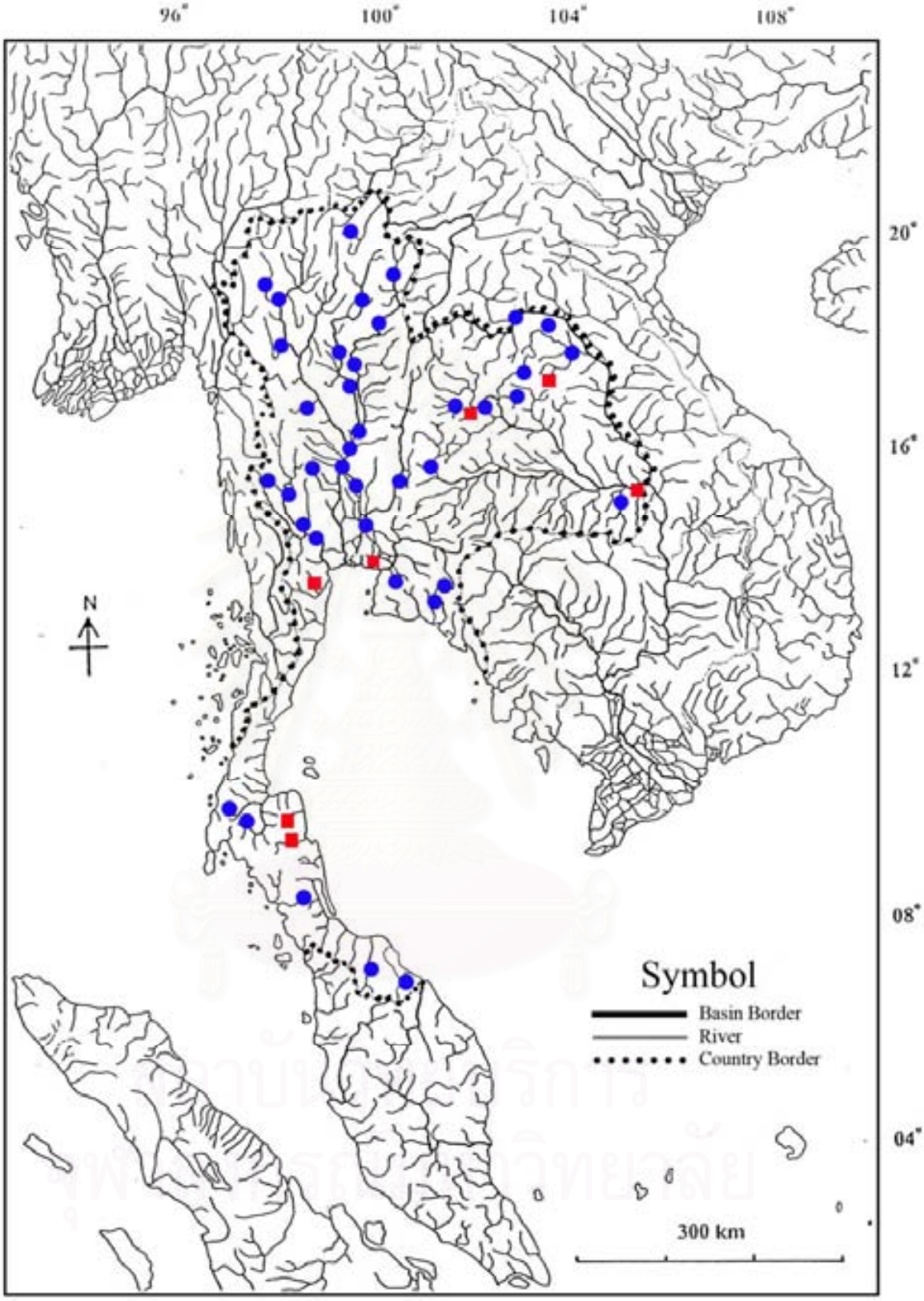

FIGURE 4.28. Distribution Map of *Mastacembelus favus* (● = material examined, ■ = previous report).

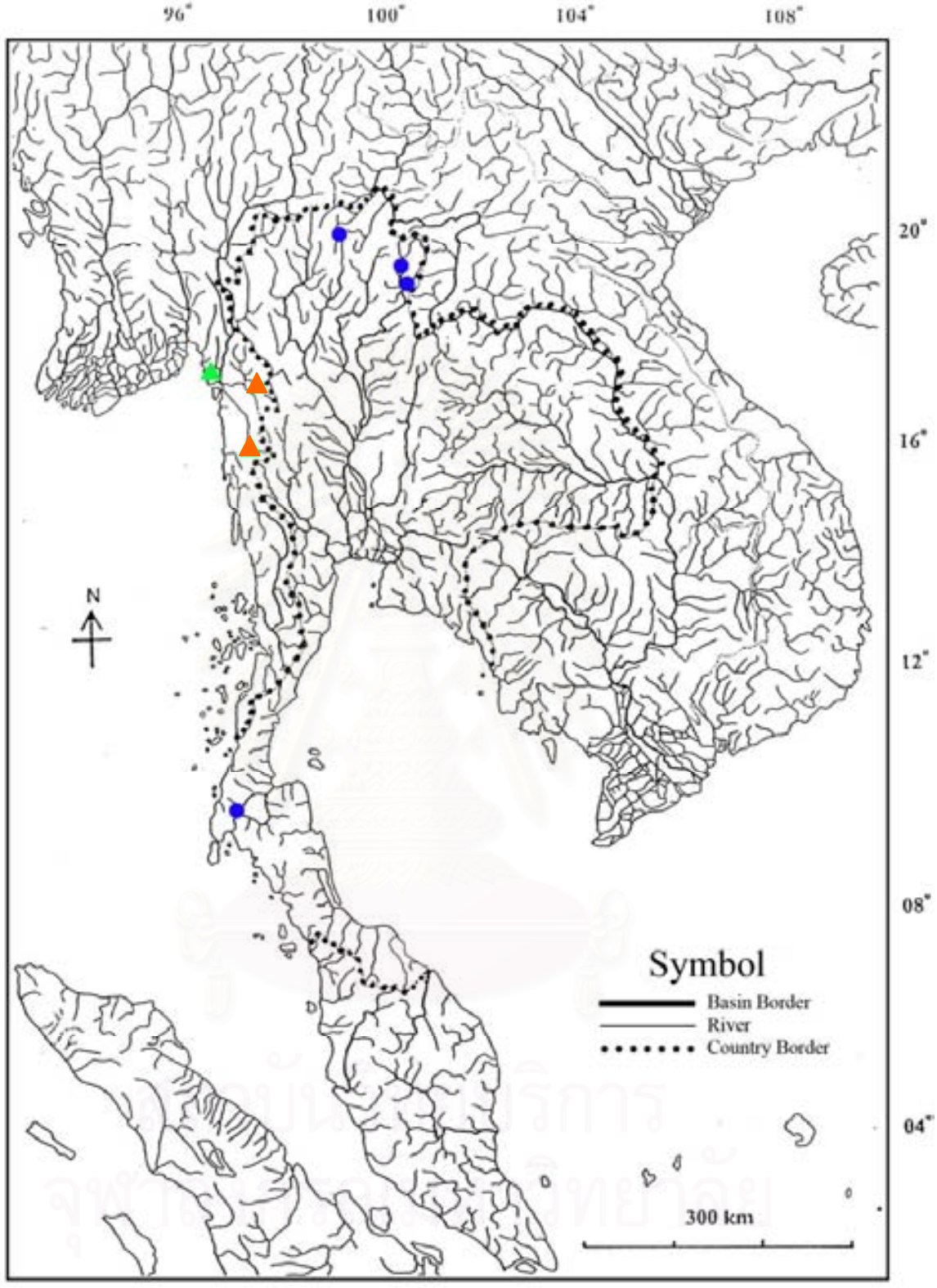

FIGURE 4.29. Distribution Map of *Mastacembelus tinwini* (● = material examined, ▲ = Holotype, ▲ = Paratype).

FIGURE 4.30. Localities of the Chao Phraya Basin. a, Chao Phraya River, Pathum Thani; b, Nan River, Pichit; c, Rice field, Phra Nakhon Si Ayutthaya; d, Chao Phraya River, Phra Nakhon Si Ayutthaya; e, Phayao Swamp, Phayao; f, Yom river, Phayao; g, Nan River, Nan; h, Doi Tao Lake, Chiang Mai.

FIGURE 4.31. Localities of the Salween Basin. a, Pai River, Pai, Mae Hong Son; b, Mae Hong Son; c, Huai Suew Thao, Mae Hong Son; d & e, Moei River, Tha Song Yang, Tak.

FIGURE 4.32. Localities of the Mekong Basin. a, Mekong River, Nong Khai; b, Mekong River, Mukdahan; c, Ubonratana Reservoir, Khon Kaen; d, Song Khram River, Nakhon Phanom; e, Khong Chiam, Ubon Ratchathani; f, Khlong Ngu Laeum, Nakhon Ratchasima.

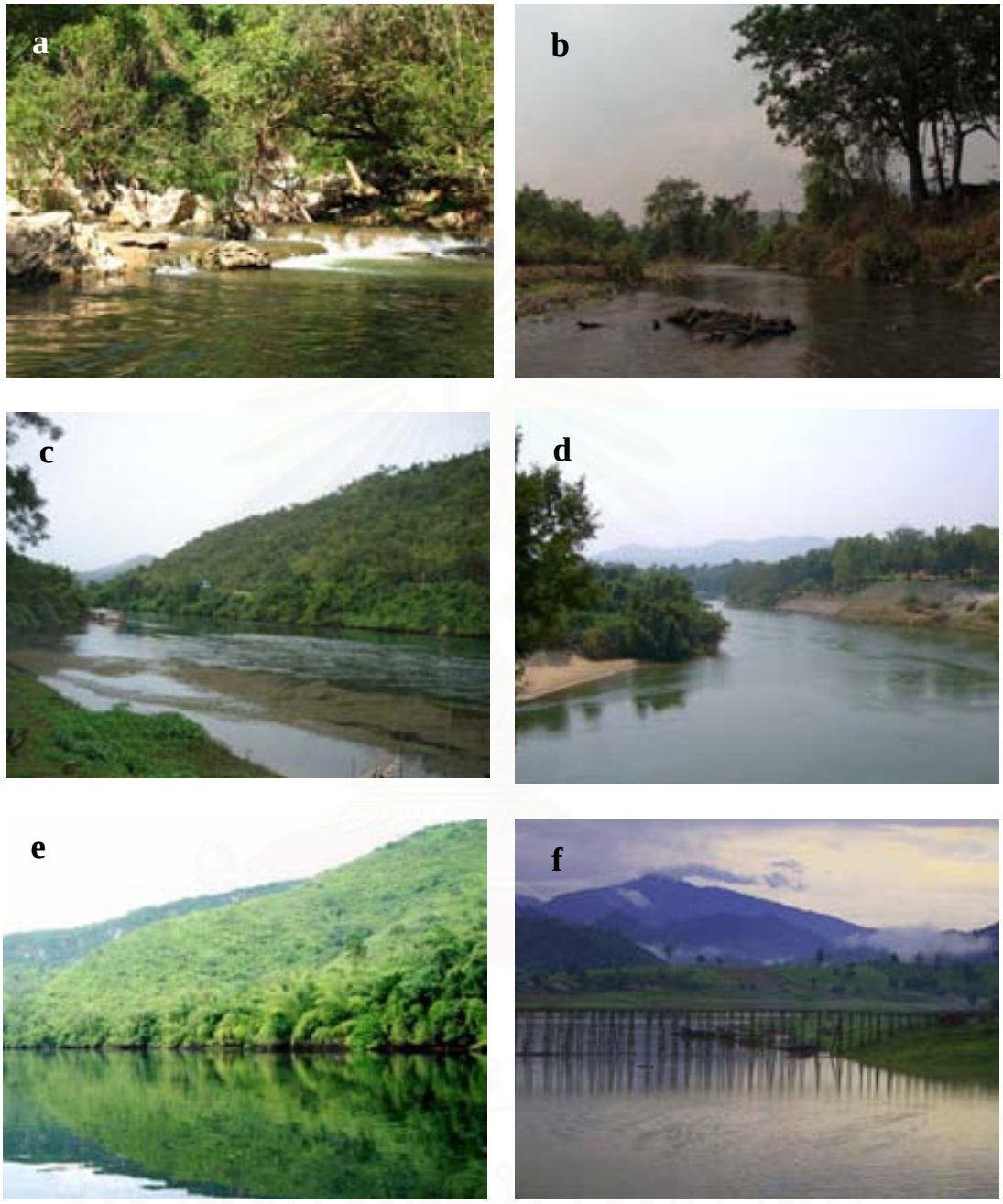

FIGURE 4.33. Localities of the Meklong Basin. a and b, Meklong Yai River, Umphang, Tak; c, Kwae Noi River, Kanchanaburi; d, Kwae Yai River, Kanchanaburi; e, Phetchaburi River, Phetchaburi; f, Kwae Noi River, Sangkhla Buri, Kanchanaburi.

FIGURE 4.34. Localities of the Southern Basins. a & b, Khlong Ro, Khian Sa, Surat Thani; c, Tapi River, Phunphin, Surat Thani; d, Thale Noi, Khuan Khanun, Phatthalung; e, Yong Waterfall, Nakhon Si Thammarat; f, Pru Toh Daeng, Narathiwat.

FIGURE 4.35. Localities of the Eastern Basins. a, Bang Pakong River, Bang Kla, Chachoengsao; b, Bang Pakong Reservoir, Chachoengsao; c, Chanthaburi River, Chanthaburi; d, stream at Khao Soi Dao Sanctuary, Chanthaburi; e & f, Khao Rakam Reservoir, Trat.

TABLE 4.1. Morphometric data in percentage of head length for examined materials of *Macrognathus aculeatus*. (SD = standard deviation).

	Macrognathus aculeatus **N = 27**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	118.1	287.0		
Standard Length (SL) in mm.	111.4	278.0		
Head Length (HL) in mm.	29.8	63.3		
In percentage of Head Length				
Snout Length	50.0	54.9	52.0	1.3
Eye diameter	8.2	11.8	9.6	1.1
Interorbital distance	10.5	16.3	12.9	1.6
Rostral appendage Length	25.0	30.0	27.0	1.5
Angle of jaws to tip of rostral appendage	36.0	41.4	38.0	1.9
Postorbital Length of Head	41.8	47.1	44.1	1.8
Post-preorbital spine Length	-	-	-	-
Postjaw angle Length	62.5	68.3	65.3	1.9
Upper jaw Length	12.1	16.8	14.1	1.6
Lower jaw Length	8.4	15.2	10.7	1.7
Pectoral-fin Length	26.1	31.7	29.2	1.9
Pectoral fin base Length	8.7	11.9	10.3	0.8
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	-	-	-	-
Ventral edge of pectoral fin base to anterior base of first dorsal spine	-	-	-	-
Posterior edge of pectoral fin base to anterior base of first dorsal spine	-	-	-	-
Angle of jaws to eye	15.0	20.4	17.9	1.8
Angle of jaws to posterior eaxternal nare	7.1	12.3	9.5	1.5
Posterior external nare to eye	9.4	12.9	11.6	0.8
Pre-posterior external nare Length	38.6	44.0	41.1	1.6
Distance between base of tubular anterior nostril and posterior external nare	32.6	38.4	35.5	1.7

TABLE 4.2. Morphometric data in percentage of standard length for examined materials of *Macrognathus aculeatus*. (SD = standard deviation).

	Macrognathus aculeatus **N = 27**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	118.1	287.0		
Standard Length (SL) in mm.	111.4	278.0		
Head Length (HL) in mm.	29.8	63.3		
In percentage of standard Length				
Head Length	21.0	26.8	23.1	1.5
Snout to first dorsal spine	40.1	46.5	42.8	1.8
Snout to last externally visible dorsal spine	66.8	72.0	69.4	1.6
Snout to first anal spine	61.7	64.8	63.5	0.9
Preanal Length	60.2	64.6	62.2	1.0
Postanal Length	36.1	40.3	38.0	1.0
Head depth at posterior eye margin	5.0	6.1	5.4	0.2
Body depth at the origin of dorsal fin spine	9.7	14.4	12.5	1.2
Body depth at the origin of dorsal fin ray	9.4	14.9	13.1	1.2
Body depth at anus	11.2	15.8	14.2	1.1
Body depth at the origin of anal fin ray	9.4	15.5	13.4	1.3
Caudal fin Length	5.2	8.4	7.2	0.9
Anal fin base Length	27.8	34.1	31.6	1.6
The spinous dorsal-fin base Length	23.7	30.9	26.9	1.8
The soft dorsal-fin base Length	29.2	34.7	31.5	1.7
Distance from posterior edge of anus to anterior base of first anal-fin spine	0.8	1.9	1.5	0.3
Distance from posterior edge of anus to anterior base of first anal-fin ray	5.2	7.2	6.3	0.6
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	-	-	-	-
Dorsal spine origin to anal fin origin	25.1	31.8	28.9	1.6
Dorsal spine termination to anal fin termination	29.6	33.7	31.6	1.1
Anal fin origin to dorsal fin termination	29.1	32.9	31.1	1.1
Dorsal edge of pectoral-fin base to Dorsal fin origin	42.3	50.0	46.3	1.8
Ratios				
SL/HL	3.7	4.4		

TABLE 4.3. Morphometric data in percentage of head length for examined materials of *Macrognathus circumcinctus*. (SD = standard deviation).

	Macrognathus circumcinctus **N = 52**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (SL) in mm.	75.7	228.0		
Standard Length (SL) in mm.	69.3	210.5		
Head Length (SL) in mm.	16.6	38.8		
In percentage of Head Length				
Snout Length	40.0	46.0	42.6	1.7
Eye diameter	8.2	13.3	10.1	1.1
Interorbital distance	9.8	17.8	13.0	1.6
Rostral appendage Length	10.5	17.2	14.1	1.5
Angle of jaws to tip of rostral appendage	30.4	37.5	33.0	1.7
Postorbital Length of Head	51.7	57.6	54.1	1.7
Post-preorbital spine Length	60.3	66.6	63.0	1.8
Postjaw angle Length	68.5	74.2	71.4	1.8
Upper jaw Length	16.8	23.4	19.7	1.9
Lower jaw Length	11.0	18.7	15.2	1.7
Pectoral-fin Length	26.0	34.0	30.1	2.4
Pectoral fin base Length	9.3	14.0	11.8	1.2
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	13.8	34.2	21.6	4.2
Ventral edge of pectoral fin base to anterior base of first dorsal spine	10.0	27.6	16.9	4.1
Posterior edge of pectoral fin base to anterior base of first dorsal spine	3.8	20.8	13.1	4.2
Angle of jaws to eye	11.2	18.1	14.9	1.3
Angle of jaws to posterior eaxternal nare	8.3	11.5	9.6	0.6
Posterior external nare to eye	6.0	11.9	9.8	1.1
Pre-posterior external nare Length	30.7	36.9	33.8	1.7
Distance between base of tubular anterior nostril and posterior external nare	24.3	31.2	28.6	1.5

TABLE 4.4. Morphometric data in percentage of standard length for examined materials of *Macrognathus circumcinctus*. (SD = standard deviation).

	Macrognathus circumcinctus **N = 52**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	75.7	228.0		
Standard Length (SL) in mm.	69.3	210.5		
Head Length (HL) in mm.	16.6	38.8		
In percentage of standard Length				
Head Length	16.6	24.0	18.7	1.4
Snout to first dorsal spine	20.9	28.6	23.7	1.5
Snout to last externally visible dorsal spine	65.3	73.0	69.1	1.8
Snout to first anal spine	58.6	66.3	61.8	1.7
Preanal Length	57.2	63.2	59.3	1.6
Postanal Length	36.4	44.4	40.7	1.7
Head depth at posterior eye margin	4.1	6.2	4.7	0.4
Body depth at the origin of dorsal fin spine	7.9	10.8	9.1	0.5
Body depth at the origin of dorsal fin ray	10.0	14.9	12.7	1.1
Body depth at anus	11.3	16.0	14.0	1.2
Body depth at the origin of anal fin ray	11.0	15.4	13.4	1.1
Caudal fin Length	5.3	10.2	7.8	1.0
Anal fin base Length	28.5	35.9	33.1	1.7
The spinous dorsal-fin base Length	41.7	49.1	45.5	1.9
The soft dorsal-fin base Length	27.1	35.1	30.7	1.7
Distance from posterior edge of anus to anterior base of first anal-fin spine	1.2	3.5	2.4	0.6
Distance from posterior edge of anus to anterior base of first anal-fin ray	5.8	9.3	7.4	0.9
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	1.6	4.2	2.6	0.8
Dorsal spine origin to anal fin origin	39.7	46.9	44.0	2.0
Dorsal spine termination to anal fin termination	28.3	35.9	32.0	1.5
Anal fin origin to dorsal fin termination	29.0	37.7	33.5	1.6
Dorsal edge of pectoral-fin base to Dorsal fin origin	45.9	53.8	50.2	1.8
Ratios				
SL/HL	4.2	5.4		

TABLE 4.5. Morphometric data in percentage of head length for examined materials of *Macrognathus meklongensis*. (SD = standard deviation).

	Macrognathus meklongensis **N = 30**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	162.0	228.5		
Standard Length (SL) in mm.	151.0	213.0		
Head Length (HL) in mm.	31.0	42.5		
In percentage of Head Length				
Snout Length	46.2	52.0	48.6	1.4
Eye diameter	8.2	10.0	9.0	0.5
Interorbital distance	9.2	13.4	11.0	1.3
Rostral appendage Length	21.0	24.2	22.8	0.9
Angle of jaw to tip of rostral appendage	31.6	37.5	33.6	1.8
Postorbital Length of Head	43.2	49.5	46.5	1.5
Post-preorbital spine Length	0.0	0.0	0.0	0.0
Postjaw angle Length	64.8	71.6	67.6	1.8
Upper jaw Length	13.0	16.8	14.9	1.2
Lower jaw Length	9.1	14.7	11.5	1.7
Pectoral-fin Length	25.7	32.7	29.1	1.7
Pectoral fin base Length	7.8	11.3	9.9	0.8
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	-	-	-	-
Ventral edge of pectoral fin base to anterior base of first dorsal spine	-	-	-	-
Posterior edge of pectoral fin base to anterior base of first dorsal spine	-	-	-	-
Angle of jaws to eye	16.0	20.0	18.2	1.0
Angle of jaws to posterior eaxternal nare	8.4	11.6	9.9	0.8
Posterior external nare to eye	9.8	13.1	10.9	0.7
Pre-posterior external nare Length	35.5	41.1	38.3	1.3
Distance between base of tubular anterior nostril and posterior external nare	30.5	35.3	32.9	1.1

TABLE 4.6. Morphometric data in percentage of standard length for examined materials of *Macrognathus meklongensis*. (SD = standard deviation).

	Macrognathus meklongensis **N = 30**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	162.0	228.5		
Standard Length (SL) in mm.	151.0	213.0		
Head Length (HL) in mm.	31.0	42.5		
In percentage of standard Length				
Head Length	19.4	21.9	20.5	0.6
Snout to first dorsal spine	37.5	45.7	41.6	1.8
Snout to last externally visible dorsal spine	65.0	68.3	67.2	0.9
Snout to first anal spine	61.5	65.7	63.4	1.0
Preanal Length	60.0	63.8	61.6	1.0
Postanal Length	36.2	40.0	38.4	1.0
Head depth at posterior eye margin	4.4	5.1	4.7	0.1
Body depth at the origin of dorsal fin spine	10.3	12.9	11.9	0.7
Body depth at the origin of dorsal fin ray	10.7	13.4	11.9	0.7
Body depth at anus	11.5	13.9	12.9	0.6
Body depth at the origin of anal fin ray	10.8	13.4	12.2	0.7
Caudal fin Length	6.5	8.0	7.3	0.4
Anal fin base Length	29.6	33.6	31.5	0.8
The spinous dorsal-fin base Length	21.1	28.4	25.6	1.6
The soft dorsal-fin base Length	29.4	33.1	31.1	1.0
Distance from posterior edge of anus to anterior base of first anal-fin spine	1.2	2.2	1.8	0.3
Distance from posterior edge of anus to anterior base of first anal-fin ray	5.7	7.3	6.3	0.3
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	-	-	-	-
Dorsal spine origin to anal fin origin	24.5	31.2	27.9	1.6
Dorsal spine termination to anal fin termination	30.7	35.2	32.5	1.0
Anal fin origin to dorsal fin termination	29.8	33.5	31.7	0.7
Dorsal edge of pectoral-fin base to Dorsal fin origin	45.8	49.4	47.5	1.0
Ratios				
SL/HL	4.9	5.0		

TABLE 4.7. Morphometric data in percentage of head length for examined materials of *Macrognathus semiocellatus*. (SD = standard deviation).

	Macrognathus semiocellatus **N = 51**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	97.0	204.2		
Standard Length (SL) in mm.	90.0	191.9		
Head Length (HL) in mm.	18.4	33.3		
In percentage of Head Length				
Snout Length	38.7	44.4	41.3	1.4
Eye diameter	7.5	12.8	9.5	1.2
Interorbital distance	10.0	13.8	11.6	1.1
Rostral appendage Length	11.3	17.0	14.4	1.5
Angle of jaw to tip of rostral appendage	17.0	30.0	33.6	1.6
Postorbital Length of Head	50.7	58.5	55.0	1.6
Post-preorbital spine Length	60.4	66.7	63.7	1.6
Postjaw angle Length	68.7	74.5	71.3	1.6
Upper jaw Length	15.5	22.0	19.2	1.7
Lower jaw Length	12.2	17.4	15.0	1.4
Pectoral-fin Length	30.0	38.2	34.0	2.4
Pectoral fin base Length	9.6	14.0	11.7	1.1
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	22.3	3.8	13.9	4.2
Ventral edge of pectoral fin base to anterior base of first dorsal spine	18.1	1.4	10.2	4.1
Posterior edge of pectoral fin base to anterior base of first dorsal spine	15.2	34.1	22.9	4.9
Angle of jaws to eye	10.9	16.1	13.3	1.3
Angle of jaws to posterior eaxternal nare	7.4	12.5	9.2	1.3
Posterior external nare to eye	7.3	12.3	10.3	0.9
Pre-posterior external nare Length	29.6	34.5	32.0	1.4
Distance between base of tubular anterior nostril and posterior external nare	22.5	28.2	24.8	1.3

TABLE 4.8. Morphometric data in percentage of standard length for examined materials of *Macrognathus semiocellatus*. (SD = standard deviation).

	Macrognathus semiocellatus **N = 51**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	97.0	204.2		
Standard Length (SL) in mm.	90.0	191.9		
Head Length (HL) in mm.	18.4	33.3		
In percentage of standard Length				
Head Length	15.2	20.8	17.9	1.1
Snout to first dorsal spine	16.9	23.7	21.1	1.3
Snout to last externally visible dorsal spine	64.3	72.4	68.2	1.5
Snout to first anal spine	55.4	65.1	58.2	1.6
Preanal Length	52.8	59.2	56.2	1.5
Postanal Length	40.8	47.2	43.8	1.5
Head depth at posterior eye margin	3.3	5.0	4.1	0.3
Body depth at the origin of dorsal fin spine	7.0	10.5	8.2	0.7
Body depth at the origin of dorsal fin ray	9.3	12.6	11.1	0.8
Body depth at anus	9.8	14.2	12.2	0.9
Body depth at the origin of anal fin ray	9.4	13.5	11.8	0.8
Caudal fin Length	5.0	8.3	6.4	0.6
Anal fin base Length	32.6	42.0	36.8	1.6
The spinous dorsal-fin base Length	43.4	50.0	47.0	1.4
The soft dorsal-fin base Length	28.2	36.7	31.9	1.6
Distance from posterior edge of anus to anterior base of first anal-fin spine	0.9	3.0	1.9	0.5
Distance from posterior edge of anus to anterior base of first anal-fin ray	5.1	9.5	6.3	0.9
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	3.6	7.5	5.3	0.9
Dorsal spine origin to anal fin origin	39.1	45.5	41.7	1.3
Dorsal spine termination to anal fin termination	28.0	35.3	32.30	1.4
Anal fin origin to dorsal fin termination	34.2	40.6	37.3	1.4
Dorsal edge of pectoral-fin base to Dorsal fin origin	45.4	54.1	49.5	1.6
Ratios				
SL/HL	4.9	5.8		

TABLE 4.9. Morphometric data in percentage of head length for examined materials of *Macrognathus siamensis*. (SD = standard deviation).

	Macrognathus siamensis **N = 65**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	132.0	281.0		
Standard Length (SL) in mm.	123.2	262.0		
Head Length (HL) in mm.	25.0	49.2		
In percentage of Head Length				
Snout Length	40.5	48.5	44.1	1.6
Eye diameter	6.3	11.7	8.9	1.2
Interorbital distance	9.4	15.0	12.4	1.5
Rostral appendage Length	15.0	20.8	18.2	1.1
Angle of jaw to tip of rostral appendage	26.1	35.2	30.7	1.7
Postorbital Length of Head	52.1	58.7	55.0	1.9
Post-preorbital spine Length	-	-	-	-
Postjaw angle Length	70.2	77.0	73.9	1.6
Upper jaw Length	13.4	19.8	16.8	1.6
Lower jaw Length	10.1	16.0	12.8	1.6
Pectoral-fin Length	30.0	36.5	33.1	1.9
Pectoral fin base Length	8.6	12.7	10.6	0.9
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	-	-	-	-
Ventral edge of pectoral fin base to anterior base of first dorsal spine	-	-	-	-
Posterior edge of pectoral fin base to anterior base of first dorsal spine	-	-	-	-
Angle of jaws to eye	12.0	19.3	16.2	1.2
Angle of jaws to posterior eaxternal nare	7.6	11.7	9.6	0.9
Posterior external nare to eye	8.2	11.2	9.9	0.7
Pre-posterior external nare Length	31.2	38.2	34.9	1.6
Distance between base of tubular anterior nostril and posterior external nare	27.2	32.9	29.9	1.6

TABLE 4.10. Morphometric data in percentage of standard length for examined materials of *Macrognathus siamensis*. (SD = standard deviation).

	Macrognathus siamensis **N = 65**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	132.0	281.0		
Standard Length (SL) in mm.	123.2	262.0		
Head Length (HL) in mm.	25.0	49.2		
In percentage of standard Length				
Head Length	16.3	20.7	18.4	1.1
Snout to first dorsal spine	40.0	49.5	44.4	2.4
Snout to last externally visible dorsal spine	62.2	69.9	66.2	1.8
Snout to first anal spine	59.0	65.2	62.2	14
Preanal Length	57.3	67.2	60.7	1.5
Postanal Length	36.9	42.7	39.4	1.2
Head depth at posterior eye margin	3.8	5.3	4.4	0.3
Body depth at the origin of dorsal fin spine	10.4	14.7	13.0	0.9
Body depth at the origin of dorsal fin ray	9.9	14.6	12.7	1.0
Body depth at anus	9.6	15.6	13.8	1.1
Body depth at the origin of anal fin ray	9.5	14.8	12.9	1.1
Caudal fin Length	5.7	8.7	6.8	0.6
Anal fin base Length	29.8	35.6	32.7	1.3
The spinous dorsal-fin base Length	18.0	24.7	21.6	1.9
The soft dorsal-fin base Length	29.8	35.1	32.7	1.3
Distance from posterior edge of anus to anterior base of first anal-fin spine	0.9	2.5	1.8	0.4
Distance from posterior edge of anus to anterior base of first anal-fin ray	4.4	7.6	6.4	0.6
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	-	-	-	-
Dorsal spine origin to anal fin origin	21.2	29.7	25.8	2.0
Dorsal spine termination to anal fin termination	31.1	37.3	34.4	1.2
Anal fin origin to dorsal fin termination	30.1	36.0	32.9	1.1
Dorsal edge of pectoral-fin base to Dorsal fin origin	45.3	51.8	48.0	1.5
Ratios				
SL/HL	4.9	5.3		

TABLE 4.11. Morphometric data in percentage of head length for examined materials of *Macrognathus zebrinus*. (SD = standard deviation).

	Macrognathus zebrinus **N = 20**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	131.0	283.0		
Standard Length (SL) in mm.	123.0	267.0		
Head Length (HL) in mm.	24.4	45.6		
In percentage of Head Length				
Snout Length	36.9	43.6	40.0	1.7
Eye diameter	7.6	12.3	9.4	1.1
Interorbital distance	9.2	12.3	10.6	0.9
Rostral appendage Length	9.7	13.7	11.6	1.3
Angle of jaw to tip of rostral appendage	25.8	30.8	28.2	1.3
Postorbital Length of Head	53.9	60.1	56.8	1.8
Post-preorbital spine Length	63.4	68.6	66.3	1.3
Postjaw angle Length	73.4	79.2	76.1	1.4
Upper jaw Length	15.2	20.5	17.6	1.5
Lower jaw Length	11.4	15.7	13.0	1.1
Pectoral-fin Length	43.4	34.3	38.6	2.6
Pectoral fin base Length	9.8	15.1	12.6	1.3
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	13.0	20.9	16.3	2.4
Ventral edge of pectoral fin base to anterior base of first dorsal spine	8.2	17.0	11.5	2.3
Posterior edge of pectoral fin base to anterior base of first dorsal spine	17.0	34.6	26.1	4.0
Angle of jaws to eye	13.5	18.3	16.1	1.4
Angle of jaws to posterior eaxternal nare	8.0	10.9	9.3	0.9
Posterior external nare to eye	8.7	12.8	10.3	0.9
Pre-posterior external nare Length	27.5	32.4	30.4	1.4
Distance between base of tubular anterior nostril and posterior external nare	22.6	27.3	25.3	1.4

TABLE 4.12. Morphometric data in percentage of standard length for examined materials of *Macrognathus zebrinus*. (SD = standard deviation).

	Macrognathus zebrinus **N = 20**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	131.0	283.0		
Standard Length (SL) in mm.	123.0	267.0		
Head Length (HL) in mm.	24.4	45.6		
In percentage of standard Length				
Head Length	16.3	19.8	17.5	0.9
Snout to first dorsal spine	19.8	23.3	21.4	1.0
Snout to last externally visible dorsal spine	65.6	71.6	68.3	1.6
Snout to first anal spine	56.9	62.3	60.0	1.3
Preanal Length	56.0	60.1	58.0	1.1
Postanal Length	39.9	44.0	42.1	1.1
Head depth at posterior eye margin	3.7	5.3	4.1	0.3
Body depth at the origin of dorsal fin spine	7.4	9.2	8.3	0.5
Body depth at the origin of dorsal fin ray	10.2	12.9	11.5	0.7
Body depth at anus	10.5	15.1	13.0	1.1
Body depth at the origin of anal fin ray	10.4	14.4	12.3	0.9
Caudal fin Length	5.3	7.6	6.6	0.6
Anal fin base Length	31.6	37.0	34.0	1.4
The spinous dorsal-fin base Length	44.6	49.4	46.9	1.4
The soft dorsal-fin base Length	28.9	32.5	30.8	1.2
Distance from posterior edge of anus to anterior base of first anal-fin spine	1.6	2.9	2.3	0.4
Distance from posterior edge of anus to anterior base of first anal-fin ray	6.0	8.8	7.3	0.8
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	1.9	4.4	3.5	0.6
Dorsal spine origin to anal fin origin	41.1	47.4	44.3	1.5
Dorsal spine termination to anal fin termination	29.7	34.9	31.9	1.4
Anal fin origin to dorsal fin termination	31.6	37.9	34.7	1.5
Dorsal edge of pectoral-fin base to Dorsal fin origin	46.3	53.2	50.5	1.8
Ratios				
SL/HL	5.0	5.9		

TABLE 4.13. Morphometric data in percentage of head length for examined materials of *Mastacembelus alboguttatus*. (SD = standard deviation).

	Mastacembelus alboguttatus **N = 20**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	282.6	480.5		
Standard Length (SL) in mm.	263.7	454		
Head Length (HL) in mm.	48.0	74.4		
In percentage of Head Length				
Snout Length	44.2	46.6	45.6	0.6
Eye diameter	8.1	10.8	9.1	0.8
Interorbital distance	9.6	13.7	11.8	1.1
Rostral appendage Length	6.7	12.1	9.8	1.3
Angle of jaw to tip of rostral appendage	33.1	27.5	30.8	1.4
Postorbital Length of Head	49.1	54.5	51.6	1.6
Post-preorbital spine Length	58.0	65.3	61.7	2.0
Postjaw angle Length	69.2	74.7	72.1	1.7
Upper jaw Length	18.1	23.0	20.8	1.5
Lower jaw Length	14.5	19.6	17.2	1.5
Pectoral-fin Length	33.3	39.0	35.9	1.5
Pectoral fin base Length	15.1	18.3	16.7	0.9
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	12.9	20.5	16.8	2.2
Ventral edge of pectoral fin base to anterior base of first dorsal spine	6.3	12.1	9.7	1.7
Posterior edge of pectoral fin base to anterior base of first dorsal spine	19.5	28.3	24.6	2.2
Angle of jaws to eye	15.6	19.7	17.7	1.0
Angle of jaws to posterior eaxternal nare	8.0	12.4	9.7	1.0
Posterior external nare to eye	8.7	11.4	10.2	0.7
Pre-posterior external nare Length	34.7	39.0	36.3	0.9
Distance between base of tubular anterior nostril and posterior external nare	28.3	31.9	29.9	1.0

TABLE 4.14. Morphometric data in percentage of standard length for examined materials of *Mastacembelus alboguttatus*. (SD = standard deviation).

	Mastacembelus alboguttaus **N = 20**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	282.6	480.5		
Standard Length (SL) in mm.	263.7	454		
Head Length (HL) in mm.	48.0	74.4		
In percentage of standard Length				
Head Length	16.4	19.7	17.3	0.9
Snout to first dorsal spine	19.1	22.3	20.9	0.9
Snout to last externally visible dorsal spine	62.3	67.3	64.8	1.6
Snout to first anal spine	54.3	60.6	56.7	1.4
Preanal Length	52.4	58.1	54.3	1.2
Postanal Length	44.2	47.6	46.0	1.0
Head depth at posterior eye margin	3.5	4.8	3.9	0.3
Body depth at the origin of dorsal fin spine	6.9	9.1	7.7	0.5
Body depth at the origin of dorsal fin ray	8.8	11.6	10.1	0.6
Body depth at anus	10.1	13.3	11.4	0.9
Body depth at the origin of anal fin ray	9.1	12.7	10.5	0.8
Caudal fin Length	5.8	7.6	6.6	0.4
Anal fin base Length	36.2	41.6	38.7	1.5
The spinous dorsal-fin base Length	40.0	46.6	44.2	1.5
The soft dorsal-fin base Length	35.1	39.9	37.2	1.3
Distance from posterior edge of anus to anterior base of first anal-fin spine	1.6	2.7	2.2	0.3
Distance from posterior edge of anus to anterior base of first anal-fin ray	4.5	7.9	6.7	0.6
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	1.0	3.2	2.1	0.6
Dorsal spine origin to anal fin origin	40.4	46.6	42.9	1.4
Dorsal spine termination to anal fin termination	35.0	39.8	37.5	1.3
Anal fin origin to dorsal fin termination	36.7	41.4	39.2	1.2
Dorsal edge of pectoral-fin base to Dorsal fin origin	44.9	48.8	47.3	1.1
Ratios				
SL/HL	5.5	6.1		

TABLE 4.15. Morphometric data in percentage of head length for examined materials of *Mastacembelus armatus*. (SD = standard deviation).

	Mastacembelus armatus **N = 35**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	95.0	269.5		
Standard Length (SL) in mm.	89.6	256.3		
Head Length (HL) in mm.	16.8	48.2		
In percentage of Head Length				
Snout Length	33.3	41.1	37.7	1.5
Eye diameter	8.8	13.7	11.0	1.2
Interorbital distance	10.5	17.5	13.0	1.4
Rostral appendage Length	7.7	11.1	9.5	0.9
Angle of jaw to tip of rostral appendage	31.9	37.7	35.0	1.8
Postorbital Length of Head	52.4	59.9	56.9	1.6
Post-preorbital spine Length	60.2	65.8	63.2	1.8
Postjaw angle Length	64.6	70.2	67.7	1.8
Upper jaw Length	23.9	29.0	26.6	1.7
Lower jaw Length	20.5	25.8	23.2	1.8
Pectoral-fin Length	22.0	29.5	25.7	2.0
Pectoral fin base Length	10.6	17.5	13.3	1.3
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	0	16.4	10.3	4.4
Ventral edge of pectoral fin base to anterior base of first dorsal spine	0	10.6	5.3	2.9
Posterior edge of pectoral fin base to anterior base of first dorsal spine	11.8	26.8	18.2	3.2
Angle of jaws to eye	9.7	12.7	11.5	0.8
Angle of jaws to posterior eaxternal nare	8.5	13.5	11.2	1.4
Posterior external nare to eye	4.5	7.7	6.1	0.7
Pre -posterior external nare Length	29.8	34.7	31.9	1.2
Distance between base of tubular anterior nostril and posterior external nare	23.9	30.6	26.9	1.6

TABLE 4.16. Morphometric data in percentage of standard length for examined materials of *Mastacembelus armatus*. (SD = standard deviation).

	Mastacembelus armatus **N = 27**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	95.0	269.5		
Standard Length (SL) in mm.	89.6	256.3		
Head Length (HL) in mm.	16.8	48.2		
In percentage of standard Length				
Head Length	16.7	20.1	18.3	0.9
Snout to first dorsal spine	18.8	22.3	20.6	0.9
Snout to last externally visible dorsal spine	62.7	69.8	66.2	1.9
Snout to first anal spine	57.1	62.6	59.8	1.6
Preanal Length	54.5	60.8	57.7	1.7
Postanal Length	39.3	45.4	42.3	1.7
Head depth at posterior eye margin	4.2	5.3	4.8	0.3
Body depth at the origin of dorsal fin spine	6.3	8.8	7.6	0.6
Body depth at the origin of dorsal fin ray	5.5	10.4	8.3	1.0
Body depth at anus	7.3	12.3	9.6	1.2
Body depth at the origin of anal fin ray	7.2	11.7	8.8	1.0
Caudal fin Length	3.8	6.9	5.5	0.8
Anal fin base Length	32.1	38.4	35.1	1.6
The spinous dorsal-fin base Length	42.7	48.9	45.6	1.8
The soft dorsal-fin base Length	30.0	37.1	33.5	1.8
Distance from posterior edge of anus to anterior base of first anal-fin spine	0.9	3.8	2.1	0.6
Distance from posterior edge of anus to anterior base of first anal-fin ray	5.4	7.9	6.8	0.6
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	0.4	2.7	1.6	0.7
Dorsal spine origin to anal fin origin	41.0	46.9	43.9	1.7
Dorsal spine termination to anal fin termination	31.1	37.3	33.8	1.5
Anal fin origin to dorsal fin termination	32.4	39.6	35.4	1.7
Dorsal edge of pectoral-fin base to Dorsal fin origin	45.0	50.6	47.7	1.8
Ratios				
SL/HL	5.3	5.3		

TABLE 4.17. Morphometric data in percentage of standard length for examined materials of *Mastacembelus erythrotaenia*. (SD = standard deviation).

	Mastacembelus erythrotaenia **N = 21**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length	183.0	547.5		
Standard Length (SL) in mm	171.5	515.8		
Head Length (HL) in mm.	34.9	88.8		
In percentage of Head Length				
Snout length	37.4	43.2	40.7	1.5
Eye diameter	6.6	11.2	7.9	0.9
Interorbital distance	10.7	13.6	12.3	0.9
Rostral appendage length	8.6	14.4	11.7	1.6
Angle of jaws to tip of rostral appendage	33.4	39.2	37.2	1.6
Postorbital length of head	54.3	60.8	57.2	1.7
Post-preorbital spine length	58.7	64.7	61.9	1.7
Postjaw angle length	63.0	69.0	66.2	1.7
Upper jaw length	23.9	27.9	26.0	1.0
Lower jaw length	20.0	24.3	22.1	1.1
Pectoral-fin length	23.9	31.7	28.1	1.9
Pectoral-fin base length	12.3	15.4	13.4	0.8
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	9.0	19.4	13.8	3.2
Ventral edge of pectoral fin base to anterior base of first dorsal spine	3.8	15.0	9.6	3.0
Posterior edge of pectoral fin base to anterior base of first dorsal spine	13.0	22.8	17.5	2.8
Angle of jaws to eye	9.9	13.7	11.7	0.9
Angle of jaws to posterior eaxternal nare	9.2	12.8	11.0	0.9
Posterior external nare to eye	5.4	8.6	7.6	0.9
Pre-posterior external nare length	31.1	36.1	33.1	1.3
Distance between base of tubular anterior nostril and posterior external nare	24.1	29.0	26.4	1.4

TABLE 4.18. Morphometric data in percentage of standard length for examined materials of *Mastacembelus erythrotaenia*. (SD = standard deviation).

	Mastacembelus erythrotaenia **N = 21**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	183.0	547.5		
Standard Length (SL) in mm.	171.5	515.8		
Head Length (HL) in mm.	34.9	88.8		
In percentage of standard Length				
Head Length	16.0	20.3	17.7	1.0
Snout to first dorsal spine	19.5	24.1	21.0	1.0
Snout to last externally visible dorsal spine	66.0	71.6	67.6	1.5
Snout to first anal spine	58.7	63.9	61.3	1.3
Preanal Length	55.2	61.7	58.4	1.4
Postanal Length	38.3	44.8	41.6	1.4
Head depth at posterior eye margin	4.1	6.7	4.6	0.6
Body depth at the origin of dorsal fin spine	7.6	11.0	8.4	0.7
Body depth at the origin of dorsal fin ray	8.2	12.1	10.0	0.9
Body depth at anus	9.9	13.2	11.5	0.8
Body depth at the origin of anal fin ray	8.2	12.0	10.1	0.9
Caudal fin Length	4.6	6.7	5.8	0.4
Anal fin base Length	30.1	36.5	34.5	1.6
The spinous dorsal-fin base Length	45.3	51.7	46.7	1.5
The soft dorsal-fin base Length	31.5	36.9	34.6	1.5
Distance from posterior edge of anus to anterior base of first anal-fin spine	2.2	3.7	2.8	0.4
Distance from posterior edge of anus to anterior base of first anal-fin ray	6.9	9.1	7.7	0.6
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	-	-	-	-
Dorsal spine origin to anal fin origin	45.5	49.2	46.9	1.0
Dorsal spine termination to anal fin termination	31.3	37.9	35.1	1.3
Anal fin origin to dorsal fin termination	30.3	37.6	34.9	1.6
Dorsal edge of pectoral-fin base to Dorsal fin origin	47.8	52.1	49.7	1.2
Ratios				
SL/HL	4.9	5.8		

TABLE 4.19. Morphometric data in percentage of head length for examined materials of *Mastacembelus favus*. (SD = standard deviation).

	Mastacembelus favus **N = 58**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	100.0	374.0		
Standard Length (SL) in mm.	88.0	359.0		
Head Length (HL) in mm.	19.5	64.5		
In percentage of Head Length				
Snout Length	34.4	40.8	37.6	1.7
Eye diameter	7.8	13.0	10.5	1.7
Interorbital distance	10.0	16.5	12.7	1.6
Rostral appendage Length	7.0	11.0	9.0	1.1
Angle of jaws to tip of rostral appendage	32.2	38.5	35.3	2.1
Postorbital Length of Head	53.8	59.6	56.7	1.4
Post-preorbital spine Length	58.8	64.8	62.2	1.6
Postjaw angle Length	62.6	69.0	66.5	1.8
Upper jaw Length	23.1	32.6	27.6	2.1
Lower jaw Length	20.2	27.3	23.1	1.5
Pectoral-fin Length	23.7	31.6	28.0	1.5
Pectoral fin base Length	10.7	15.6	13.0	1.1
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	0.0	16.4	9.7	2.9
Ventral edge of pectoral fin base to anterior base of first dorsal spine	0.0	11.2	5.1	2.8
Posterior edge of pectoral fin base to anterior base of first dorsal spine	15.8	31.1	22.2	3.6
Angle of jaws to eye	10.0	14.6	11.5	1.0
Angle of jaws to posterior eaxternal nare	8.5	13.7	11.0	1.3
Posterior external nare to eye	4.7	7.5	6.1	0.6
Pre-posterior external nare Length	28.4	34.9	31.4	1.6
Distance between base of tubular anterior nostril and posterior external nare	23.0	30.4	26.2	1.6

TABLE 4.20. Morphometric data in percentage of standard length for examined materials of *Mastacembelus favus*. (SD = standard deviation).

	Mastacembelus favus **N = 58**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	100.0	374.0		
Standard Length (SL) in mm.	88.0	359.0		
Head Length (HL) in mm.	19.5	64.5		
In percentage of standard Length				
Head Length	17.2	23.6	19.3	1.3
Snout to first dorsal spine	18.5	26.9	21.6	1.6
Snout to last externally visible dorsal spine	64.0	71.8	67.6	1.7
Snout to first anal spine	56.5	66.4	61.7	1.6
Preanal Length	54.9	65.2	59.6	1.6
Postanal Length	34.3	44.8	40.5	1.6
Head depth at posterior eye margin	4.1	7.2	5.0	0.6
Body depth at the origin of dorsal fin spine	7.0	12.4	8.5	0.7
Body depth at the origin of dorsal fin ray	8.0	13.5	9.7	0.9
Body depth at anus	9.2	14.8	11.1	1.0
Body depth at the origin of anal fin ray	8.1	13.6	10.1	0.9
Caudal fin Length	4.2	8.5	6.6	0.9
Anal fin base Length	31.0	37.3	33.5	1.4
The spinous dorsal-fin base Length	42.6	49.7	46.1	1.6
The soft dorsal-fin base Length	29.8	36.8	33.2	1.5
Distance from posterior edge of anus to anterior base of first anal-fin spine	1.1	3.9	2.1	0.5
Distance from posterior edge of anus to anterior base of first anal-fin ray	5.6	9.1	7.1	0.7
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	0.0	0.0	0.0	0.0
Dorsal spine origin to anal fin origin	42.1	49.2	45.6	1.7
Dorsal spine termination to anal fin termination	30.8	37.3	33.6	1.4
Anal fin origin to dorsal fin termination	31.8	38.3	33.8	1.4
Dorsal edge of pectoral-fin base to Dorsal fin origin	45.5	52.7	48.1	1.4
Ratios				
SL/HL	4.5	5.6		

TABLE 4.21. Morphometric data in percentage of head length for examined materials of *Mastacembelus tinwini*. (SD = standard deviation).

	Mastacembelus tinwini **N = 9**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	160.83	400.5		
Standard Length (SL) in mm.	153.4	384.0		
Head Length (HL) in mm.	26.6	60.8		
In percentage of Head Length				
Snout Length	37.3	40.1	38.5	1.0
Eye diameter	7.5	11.3	9.3	1.3
Interorbital distance	10.5	15.4	13.1	1.5
Rostral appendage Length	8.3	11.1	9.4	0.9
Angle of jaws to tip of rostral appendage	33.5	38.5	35.9	1.6
Postorbital Length of Head	54.5	59.8	57.8	1.6
Post-preorbital spine Length	60.2	64.8	62.3	1.6
Postjaw angle Length	65.1	69.8	67.2	1.9
Upper jaw Length	24.6	29.6	27.0	1.9
Lower jaw Length	21.1	24.2	22.9	1.1
Pectoral-fin Length	23.9	26.3	25.2	0.9
Pectoral fin base Length	12.3	15.3	13.9	0.9
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	7.5	15.7	11.6	2.8
Ventral edge of pectoral fin base to anterior base of first dorsal spine	1.8	11.7	6.4	3.5
Posterior edge of pectoral fin base to anterior base of first dorsal spine	15.1	22.6	18.3	2.9
Angle of jaws to eye	9.7	12.5	11.7	0.9
Angle of jaws to posterior eaxternal nare	9.4	12.3	10.8	1.0
Posterior external nare to eye	5.7	7.7	6.4	0.6
Pre-posterior eaxternal nare Length	31.2	34.0	32.5	1.0
Distance between base of tubular anterior nostril and posterior external nare	24.2	28.6	26.4	1.6

TABLE 4.22. Morphometric data in percentage of standard length for examined materials of *Mastacembelus tinwini*. (SD = standard deviation).

	Mastacembelus tinwini **N = 9**			
	Minimum	**Maximum**	**Mean**	**SD**
Total Length (TL) in mm.	160.83	400.5		
Standard Length (SL) in mm.	153.4	384.0		
Head Length (HL) in mm.	26.6	60.8		
In percentage of standard Length				
Head Length	14.5	18.0	16.6	1.2
Snout to first dorsal spine	17.5	20.6	19.3	1.3
Snout to last externally visible dorsal spine	65.8	69.4	67.7	1.2
Snout to first anal spine	56.8	61.9	59.8	1.6
Preanal Length	54.8	60.2	57.9	1.7
Postanal Length	39.8	45.0	42.2	1.7
Head depth at posterior eye margin	4.0	4.9	4.3	0.3
Body depth at the origin of dorsal fin spine	6.4	8.4	7.3	0.5
Body depth at the origin of dorsal fin ray	7.3	8.9	8.0	0.5
Body depth at anus	8.6	10.6	9.4	0.7
Body depth at the origin of anal fin ray	7.3	9.6	8.5	0.8
Caudal fin Length	3.8	5.3	4.6	0.4
Anal fin base Length	32.3	37.0	34.6	1.7
The spinous dorsal-fin base Length	44.2	49.2	47.9	1.8
The soft dorsal-fin base Length	31.2	36.8	33.9	1.8
Distance from posterior edge of anus to anterior base of first anal-fin spine	0.8	2.4	1.9	0.5
Distance from posterior edge of anus to anterior base of first anal-fin ray	5.0	8.5	7.2	1.0
Distance between anterior base of first dorsal-fin ray and anterior base of first anal-fin ray	1.0	2.5	1.9	0.5
Dorsal spine origin to anal fin origin	44.5	50.5	47.2	2.1
Dorsal spine termination to anal fin termination	31.5	36.8	33.7	1.7
Anal fin origin to dorsal fin termination	32.5	37.5	35.2	1.6
Dorsal edge of pectoral-fin base to Dorsal fin origin	49.8	54.3	51.3	1.5
Ratios				
SL/HL	5.8	6.3		

TABLE 4.23. Morphometric data in SL/HL Ratio of Mastacembelid species.

SL/HL	Range		Mean	SD
	Min	Max		
Macrognathus				
M. aculeatus	3.7	4.4	4.1	0.5
M. circumcinctus	4.2	5.4	4.8	0.8
M. meklongensis	4.9	5	5.0	0.1
M. semiocellatus	4.9	5.8	5.4	0.6
M. siamensis	4.9	5.3	5.1	0.3
M. zebrinus	5.0	5.9	5.5	0.6
Mastacembelus				
M. alboguttaus	5.5	6.1	5.8	0.4
M. armatus	5.3	5.3	5.3	0.0
M. erythrotaenia	4.9	5.8	5.4	0.6
M. favus	4.5	5.6	5.1	0.8
M. tinwini	5.8	6.3	6.1	0.4

TABLE 4.24. Meristic Count of some mastacembelid species found in Thailand. (0 = the neural and haemal vertebral spines belong to two successive vertebrae. −= a negative score refers to the position of the first anal pterygiophore supporting vertebra, situated before the vertebra of which the neural spine supports the pterygiophore of the last externally visible dorsal spine.).

	Dorsal fin spines	Dorsal fin rays	Anal fin spines	Anal fin rays	Pectoral fin rays	Caudal fin rays	Predorsal vertebrae	Abdominal vertebrae	Caudal vertebrae	Total vertebrae	In-between vertebrae
Macrognathus											
M. aculeatus	15-19	48-54	3	44-51	24-27	13-16	15-17	30-32	39-42	70-74	0
M. meklongensis	17-21	46-57	3	47-54	20-23	16-19	17-20	32-34	40-44	72-76	0
M. siamensis	11-17	52-60	3	49-58	19-23	14-16	18-23	32-34	41-43	74-77	0
M. circumcinctus	27-31	44-53	3	42-56	18-23	12-14	4-6	28-31	35-38	64-70	0, −(1-2)
*M. maculatus**	29-31	54-66	3	54-67	24-27	11-14	6-8	32-33	42-49	74-82	-
M. semiocellatus	28-32	48-62	3	50-62	22-24	10-13	4-5	28-31	40-43	69-74	−(2-5)
M. zebrinus	28-30	46-54	3	48-58	18-20	18-19	5	28-32	40-43	70-73	−(1-3)
Mastacembelus											
M. alboguttatus	34-37	75-85	3	70-82	22-24	21-23	4-5	34-36	46-50	81-86	−(1-2)
M. erythrotaenia	32-34	72-78	3	72-80	22-24	15-17	4-5	37-40	45-48	83-86	0
M. favus	32-37	74-80	3	72-80	24-28	13-15	4-5	37-39	47-52	86-91	0, −1
M. armatus	35-39	68-82	3	68-80	24-26	16-18	4	38-40	53-54	92-94	0, −1
M. tinwini	36-39	68-74	3	65-76	24-25	18-20	4-5	41-42	48-50	90-91	−(1-2)

* All data of meristic characters are based on Sufi (1956)’s data.

TABLE 4.25. Frequency Distribution of Predorsal Vertebrae Counts in Mastacembelidae in Thailand.

Predorsal Vertebrae	**4**	**5**	**6**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Macrognathus												
M. aculeatus				5	9	3						
M. meklongensis						10	9	7	4			
M. siamensis							7	10	9	3		3
M. circumcintus	4	22	2									
M. semiocellatus	25	4										
M. zebrinus		18										
Mastacembelus												
M. alboguttatus	1	17										
M. armatus	7											
M. erythrotaenia	2	10										
M. favus	28	4										
M. tinwini	6	3										

TABLE 4.26. Frequency Distribution of Abdominal Vertebrae Counts in Mastacembelidae in Thailand.

Abdominal Vertebrae	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**
Macrognathus															
M. aculeatus			2	7	8										
M. meklongensis					6	17	7								
M. siamensis					3	20	9								
M. circumcintus	1	5	15	7											
M. semiocellatus	3	10	13	3											
M. zebrinus	1	1	12	3	1										
Mastacembelus															
M. alboguttatus							1	12	5						
M. armatus											1	2	4		
M. erythrotaenia										1	7	3	1		
M. favus										4	13	15			
M. tinwini														6	3

TABLE 4.27. Frequency Distribution of Caudal Vertebrae Counts in Mastacembelidae in Thailand.

Caudal Vertebrae	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**
Macrognathus										
M. aculeatus					2	10	3	2		
M. meklongensis						4	17	4	4	1
M. siamensis							3	19	10	
M. circumcintus	3	6	10	5						
M. semiocellatus						3	9	12	5	
M. zebrinus						1	12	3	2	

Caudal Vertebrae	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**
Mastacembelus										
M. alboguttatus		2	4	5	6	1				
M. erythrotaenia	3	1	6	2						
M. favus			5	14	4	7	1	1		
M. armatus									1	6
M. tinwini				2	5	2				

TABLE 4.28. Frequency Distribution of Total Vertebrae Counts in Mastacembelidae in Thailand.

Total Vertebrae	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**
Macrognathus														
M. aculeatus							1	8	5	2	1			
M. meklongensis									1	4	13	6	6	
M. siamensis											4	12	15	1
M. circumcintus	2	2	4	11	5		1							
M. semiocellatus						2	8	8	6	3	2			
M. zebrinus							2	9	4	3				

Total Vertebrae	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**
Mastacembelus														
M. alboguttatus	2	4	5	3	3	1								
M. erythrotaenia			1	4	4	2		1						
M. favus						16	6	6	3		1			
M. armatus												1	3	3
M. tinwini										6	3			

TABLE 4.29. Frequency Distribution of In-between Vertebrae Counts in Mastacembelidae in Thailand. (0 = the neural and haemal vertebral spines belong to two successive vertebrae. −= a negative score refers to the position of the first anal pterygiophore supporting vertebra, situated before the vertebra of which the neural spine supports the pterygiophore of the last externally visible dorsal spine.).

In-between Vertebrae	0	−1	−2	−3	−4	−5
Macrognathus						
M. aculeatus	17					
M. meklongensis	29					
M. siamensis	32					
M. circumcintus	2	19	7			
M. semiocellatus			3	21	5	1
M. zebrinus		4	10	4		
Mastacembelus						
M. albuoguttatus		14	4			
M. armatus	3	4				
M. erythrotaenia	12					
M. favus	28	4				
M. tinwini		6	3			

TABLE 4.30. Frequency Distribution of Dorsal Spines.

Dorsal-fin spines	11	12	13	14	15	16	17	18	19	20	21
Macrognathus aculeatus					3	8	9	5	2		
Macrognathus meklongensis						2	5	14	7	1	1
Macrognathus siamensis	3	7	14	16	24	10	2				

Dorsal-fin spines	23	24	25	26	27	28	29	30	31	32
Macrognathus circumcinctus					4	19	21	7	1	
Macrognathus maculatus	1									
Macrognathus semiocellatus						1	1	17	25	9
Macrognathus zebrinus						2	12	6		

Dorsal-fin spines	32	33	34	35	36	37	38	39
Mastacembelus alboguttatus			2	12	5	1		
Mastacembelus armatus				4	12	20	5	1
Mastacembelus erythrotaenia	12	8	1					
Mastacembelus favus	3	8	40	19	5	2		
Mastacembelus tinwini					1	1	5	2

TABLE 4.31. Frequency Distribution of Pectoral-fin Rays

Pectoral-fin Rays	18	19	20	21	22	23	24	25	26	27	28
Macrognathus											
M. aculeatus							4	6	6	1	
M. meklogensis			2	5	15	8					
M. siamensis		3	14	12	2	1					
M. circumcinctus		2	2	8	16	2					
M. semiocellatus					9	18	3				
M. zebrinus	10	7	1								
Mastacembelus											
M. alboguttatus					9	8	3				
M. armatus							7	5	2		
M. erythrotaenia					2	5	14				
M. favus							2	13	7	2	1
M. tinwini							3	6			

TABLE 4.32. Frequency Distribution of Caudal-fin Rays

Caudal-fin Rays	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Macrognathus															
M. aculeatus				3	8	2	3								
M. meklogensis							5	9	14	2					
M. siamensis					7	18	5								
M. circumcinctus			20	7	3										
M. semiocellatus	4	14	9	3											
M. zebrinus									13	5					
Mastacembelus															
M. alboguttatus												1	15	4	
M. armatus							1	2	11						
M. erythrotaenia						7	10	4							
M. favus				3	8	14									
M. tinwini									1	6	2				

TABLE 4.33. Frequency Distribution of Rostral toothplates

Rostral toothplates	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26-30	31-35	36-40	41-45	46-50
M. aculeatus																					3	7	6	1
M. meklongensis		2	2	16	10																			
M. siamensis				6	14	9	1																	

TABLE 4.34. Frequency Distribution of Preorbital and Preopercular Spines

Genus	Scientific Name	N	Preorbital Spine	Preopercular spine
Macrognathus				
	M. aculeatus	27	0L/0R	0L/0R (27)
	M. circumcinctus	53	1L/1R	1L/2R (1); 2L/2R (24); 2L/3R (5); 3L/2R (3); 3L/3R (20)
	M. maculatus	1	1L/1R	2L/2R (1)
	M. meklogensis	30	0L/0R	0L/0R (30)
	M. semiocellatus	51	1L/1R	2L/2R (38); 3L/3R (9); 2L/3R (3); 3L/2R (1)
	M. siamensis	65	0L/0R	0L/0R (65)
	M. zebrinus	20	1L/1R	3L/3R (12); 3L/4R (5); 2L/3R (1); 3L/2R (1); 4L/4R (1)
Mastacembelus				
	M. alboguttatus	20	1L/1R	3L/3R (6); 3L/4R (1), 4L/3R (4); 4L/4R (9)
	M. armatus	35	1L/1R	2L/2R (5); 3L/2R (1), 3L/3R (29)
	M. erythrotaenia	21	1L/1R	2L/2R (1); 2L/3R (2); 3L/2R (3); 3L/3R (15)
	M. favus	65	1L/1R	1L/2R (1); 2L/2R (8); 2L/3R (2); 3R/2L (6); 3L/3R (47); 4L/4R (1)
	M. tinwini	9	1L/1R	2L/2R (3); 2L/3R (1); 3L/2R (1); 3L/3R (4)

4.2 CLUSTER ANALYSES

4.2.1 Cluster Analysis of Morphometric Measurements

The dendogram was constructed using the Between-groups linkage method of Hierarchical Cluster Analysis on Squared Euclidian distances. From the morphometric dendogram of **FIGURE 4.36**, it indicated that eleven mastacembelid species, excluding *Macrognathus maculatus*, were classified into two groups. The first upper group consisted of eight mastacembelid species, whereas the second lower group consisted of three species.

It is interesting to note that the upper group comprised members belonging to the genera *Macrognathus* and *Mastacembelus*, while the lower group comprised the members belonging to the genus *Macrognathus* only. Based on the dendogram using only morphometric data, it is also worth mentioning that some mastacembelid species in the genus *Macrognathus* is more close to spiny eels in the genus *Mastacembelus* more than members in their genus.

The first upper group can be subdivided into two sub-groups. The first sub-group comprised 4 species belonging to the genus *Mastacembelus*, whilst the second sub-group consisted of three species belonging to the genus *Macrognathus* and one species belonging to the genus *Mastacembelus*. Interestingly, *M. alboguttatus* is morphologically similar to *M. circumcinctus*, *M. semiocellatus* and *M. zebrinus* more than other species in *Mastacembelus*.

From the Dendogram it pointed out that *M. aculeatus*, *M. meklongensis* and *M. siamensis* can be distinguished apparently from all other *Mastacembelus* species by their morphometric characters.

4.2.2 Cluster Analysis of Meristic Counts

The dendogram was constructed using the Between-groups linkage method of Hierarchical Cluster Analysis on Squared Euclidian distances. From the dendogram of **FIGURE 4.37**, it indicated that eleven mastacembelid species, excluding *Macrognathus maculatus*, were classified into three groups. The first group consisted of five mastacembelid species. The second group consisted of five mastacembelid species. The last group has only one species.

It is interesting to note that the first group comprised the members belonging to the genus *Mastacembelus*, while the second and the last group comprised the members belonging to the genus *Macrognathus*.

For *Macrognathus* they can be separated into three sub-groups. In contrast to the morphometric dendogram, the meristic dendogram shows that the first sub-group consisting of *M. meklongensis* and *M. siamensis* was separated from *M. aculeatus*. It also point out that *M. meklongensis* is more similar to *M. siamensis* than *M. aculeatus*. Moreover, *Macrognathus aculeatus* (last sub-group) was apparently separated from all other species. The second sub-group consisting of *M. circumcinctus*, *M. semiocellatus* and *M. zebrinus* indicated that they are close to each other more than another sub-group. *M. semiocellatus* is similar to *M. zebrinus* more than *M. circumcinctus*.

On the other hand, the second group or *Mastacembelus* can be subdivided into three sub-groups just like *Macrognathus*. The first sub-group comprising *M. favus*, *M. erythrotaenia* and *M. alboguttatus* indicates that they are closely related species more than *M. armatus* and *M. tinwini*. Relationships between *M. armatus* and *M. tinwini* are unknown.

As a final point, based on the dendogram using only meristic data, it is also worth mentioning that meristic counts were considered as the useful taxonomic characters for distinguishing mastacembelid both in generic and species level.

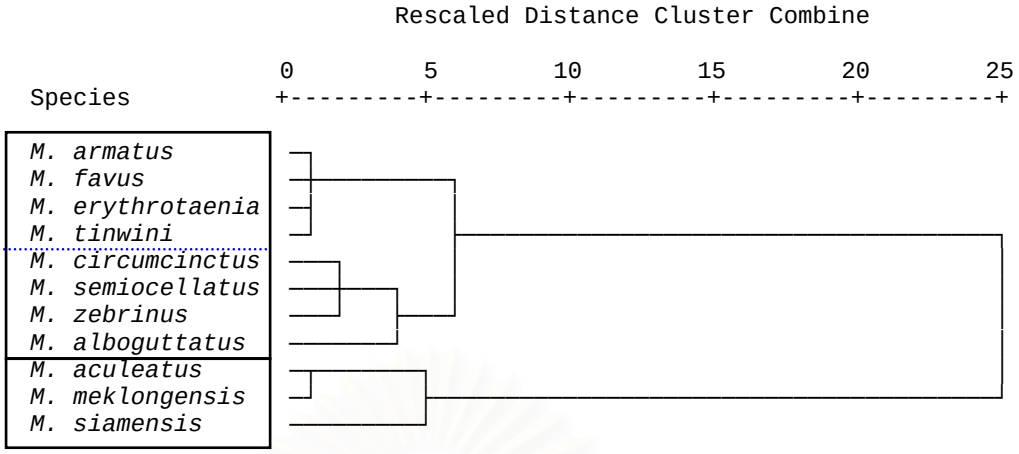

FIGURE 4.36. Morphometric dendogram of eleven mastacembelid species using Average Linkage (Between Groups).

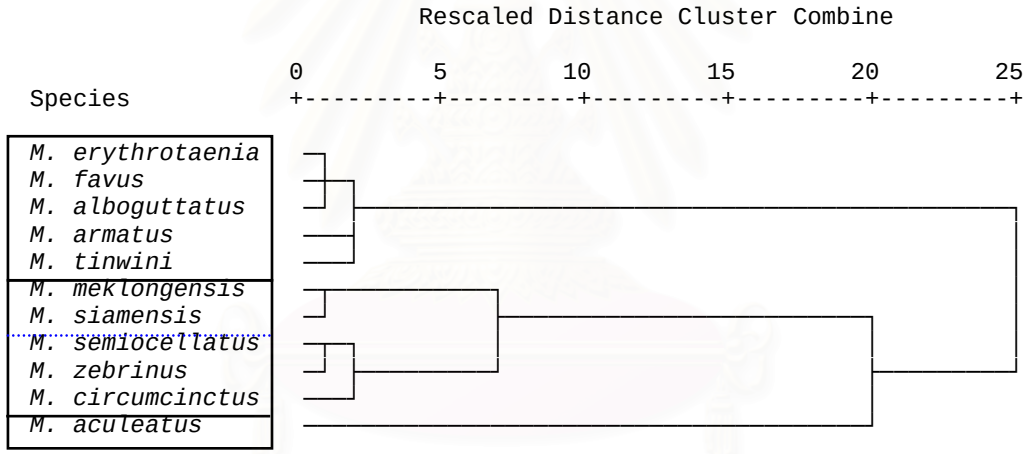

FIGURE 4.37 Meristic dendogram of eleven mastacembelid species using Average Linkage (Between Groups).

CHAPTER V
DISCUSSIONS

5.1 MORPHOLOGICAL CHARACTERS

- **Eyes**

Eyes of all mastacembelid species are small and round. They are located on the lateral sides of their skulls and are placed nearer to the dorsal profile of their heads. The eyes are not covered by anything. The size of the eyes varies slightly.

- **Rostral toothplates**

I strongly agree with **Roberts (1980)** that number of rostral toothplate pairs provides perhaps the most important characters for distinguishing mastacembelid species belonging to the genus *Macrognathus*. In this study rostral appendages appear in three species, *M. aculeatus, M. meklongensis* and *M. siamensis*.

According to **Roberts (1980)**, the number of rostral toothplates shows populational variation in *M. aculeatus*. Population samples of *M. aculeatus* from lowland localities in the Kapuas basin, Borneo, have 38-45, 47-51, 49-51 and 53-55, whereas in Thailand population samples of *M. aculeatus* from the Southern basins have 34-46. For *M. meklongensis* and *M. siamensis* the number of rostral toothplates are overlapped in ranges of 8-12. Furthermore, **Roberts (1980)** reported that there dose not appear to be any ontogenic change in number of rostral toothplates within the size range (39-247 mm L_S) of the genus *Macrognathus*.

- **Projections on rim of tubular anterior nostrils**

Both in the genera *Macrognathus* and *Mastacembelus* their apertures of tubular anterior nostrils are guarded by fleshy projections, but different in patterns. The number of flaps or fimbriae is one of the most important characters for mastacembelid diagnoses at generic level. The rim of tubular anterior nostrils is also employed in species identification of the genus *Macrognathus*.

Based on the pattern of the projections all members in the family Mastacembelidae can be divided apparently into two groups. For the first group belonging to the genus *Macrognathus* almost all species in this genus have nostril rims bearing six equally finger-like projections (digitiform fimbriae). However, *M. semiocellatus* has nostril rims with two fingerlike projections and two broad-based flaps. In contrast, for the second group belonging to the genus *Mastacembelus* all species in this genus have the apertures guarded by two broad-based alternating with a pair of slender finger-like fimbriae.

- **Caudal-fin ray pattern**

  The patterns of caudal fin can be separated into three categories as follows:

  1) caudal fin entirely free from soft-rayed portions of dorsal and anal fins: *M. aculeatus, M. meklongensis, M. siamensis, M. zebrinus* and *M. alboguttatus*;

  2) caudal fin broadly joined with soft dorsal and anal fin: *M. circumcinctus, M. maculatus, M. semiocellatus, M. erythrotaenia* and *M. favus*;

  3) caudal fin united incompletely with dorsal and anal fin rays: *M. armatus* and *M. tinwini*.

As can be seen that the patterns of caudal fin can be used for identifying in a basic step, but can not indicated both in generic and species level of mastacembelid species. Moreover, these patterns are not reliable because the caudal area of spiny eels may be damaged by predators. The damaged caudal fin can regenerate itself, but its original pattern may be changed. For example, the caudal fins of *M. siamensis* became to be confluent with soft dorsal and soft anal fins. It is worth to mentioning that if any species has a caudal fin pattern 2 or 3 and its caudal fin was damaged, the caudal fin with would not be the pattern 1. In contrast, if any species has a caudal pattern with pattern 1 when it is damaged, it will become a pattern 2 or 3.

- **Colour Pattern**

Even though colour characters may vary intraspecifically due to environmental, ontogenetic, and dietary factors as well as genetic variation, colour patterns are often employed in species identification. Colour features are considerably involved both in inter- and intraspecific interactions particularly species and sexual recognition.

For the subfamily Mastacembelinae species level taxonomy has depended heavily on colour characters because of their relative morphological homogeneity. The colour pattern is as useful as the number of rostral toothplates for distinguishing species; however, it is nearly infallible for freshly preserved specimens particularly the *Mastacembelus armatus* species-group. In addition, in fade specimens colour patterns can not provide reliable features for species identification. For example, series of 14-17 oblique dark bars on the body is diagnostic for *M. aculeatus*; nonetheless, this pattern is absent even in well preserved specimens from Javanese *M. aculeatus* **(Roberts, 1986)**.

Additionally, the colouration can be used for distinguishing *M. circumcinctus* from *M. semiocellatus*. *M. circumcinctus* has a body with 17-22 very regular dark, slightly oblique bars on body, usually most of them continued by a very narrow extension toward or across abdomen**,** while *M. semiocellatus* has just a series of 4-10 roundish dark marks along the base of soft dorsal fin, some or all imperfect ocelli extending onto its belly but not continued onto abdomen or across abdomen like *M. circumcinctus*. Although *M. zebrinus* has a body with narrow dark vertical bars, its vertical bars are not extended or across onto its abdomen (different from *M. circumcinctus*).

For distinguishing *M. meklongensis* from *M. siamensis*, colouration can be served because *M. siamensis* is very distinctive from *M. meklongensis* by larger and fewer number of ocelli along the base of dorsal fin. Moreover dorsal and anal fins of *M. meklongensis* have a fine dark striation, but absent in *M. siamensis*. Both *M. aculeatus* and *M meklongensis* have no caudal ocellus, but present in *M. siamensis* only. Consequently, for *M. siamensis*, presence of an ocelllus on the

caudal fin is almost a perfect diagnostic character. However some specimens of *M. siamensis* have no caudal ocellus on one or both sides of the caudal fin. Moreover the ocelli along base of soft-rayed portions of dorsal fin can be absent on one or both sides of soft-dorsal fin. The number of ocelli on the both sides of *M. siamensis* may be equal or not.

For the genus *Mastacembelus* very unique colourations of *M. alboguttatus* and *M. erythrotaenia* can be employed for distinguishing them from all other mastacembelids. It is apparently seen that the colourations were employed in species identification. **Roberts (1986)** strongly believe that *M. armatus* and *M. favus* is closely related but differs in colouration. **Britz (2007)** described *M. tinwini* as a new species and distinguished *M. tinwini* from the *M. armatus* group by its colouration. **Verven and Teugels (1997)** described a new species, *Aethiomastacembelus traversi* which was distinguished from *A. paucispinis* and *A. congicus* species-complex by its unique colouration.

The colour pattern of *M. armatus* differs from *M. favus* in having a body with 1-3 darker and longitudinal zigzag lines or a reticulated pattern restricted to upper two thirds of body but disappearing dorsally and ventrally, whereas a reticulated pattern of *M. favus* are encircled its abdomen. *M. tinwini* is diagnosed from *M. armatus* and *M. favus* by its four-five parallel and longitudinal bands along the body, expressed as series of interrupted lines or broken up into individual blotches and its soft-rayed potions of dorsal, anal and caudal fins edged with white distal margin.

5.2 MORPHOMETRICS

The snout length in this study is identical to the snout length as defined by Sufi (1956) but differs from the snout length as defined by **Vreven and Teugels (1996)**. Most mastacembelid materials examined particularly *M. aculeatus*, *M. meklongensis* and *M. siamensis* can not be found an accurate point of anterior end of snout, causing to an inaccuracy distance and personal error in measurements. Therefore in this study snout length, head length, preanal length, and standard length are included distance between tip of rostrum and anterior end of snout.

However there are some measurements defined in different names and definitions. For instance, the preorbital distance of **Travers (1992)** is identical to the snout length as defined by **Vreven and Teugels (1996)**. As an example in different definition, the postorbital distance of **Vreven and Teugels (1996)** is different from the definition given by **Travers (1992)**. The postorbital distance of Travers is the distance from the posterior edge of the eye to the posterior margin of the cranium, whereas the postorbital length of **Vreven and Teugels (1996)** is defined as the distance from the posterior edge of the eye to the dorsal edge of the pectoral fin.

Based on the morphometric measurements, the following differences with the diagnosis were found. Some morphometric characters can be used for distinguishing mastacembelid species, for instance snout length, rostral appendage length, while several measurements can not be diagnosed mastacembelid species, for example eye diameter and head width. See statistical analyses in Appendix II.

5.3 MERISTIC COUNTS

- **Dorsal spine**

The number of dorsal spines can be useful for distinguishing spiny eels in generic and species level. In generic level counts of dorsal spine can be used for as a diagnosed character. The number of dorsal spines can be divided into two genera, *Macrognathus* and *Mastacembelus* (11-32 *vs*. 32-39). However there are overlapped between genera *Macrognathus* and *Mastacembelus* in some species.

- **Anal spine**

Anal spines are closet together. The first two anal-fin spines can be externally visible. The first anal spine is smaller than the second. The last anal spine is very short and small, always hidden under the skin and situated anterior to the base of the first anal-fin ray. Counts of anal-fin spines are completely invariable in this study. Both genera *Macrognathus* and *Mastacembelus* have three anal spines. So the anal spine is not considered as a taxonomic character for distinguishing mastacembelid species.

- **Soft dorsal and anal fins**

Although the uses of meristic counts in dorsal and anal fin ray as a taxonomic character are very limited when compared with other fins (dorsal-fin spine, pectoral fin and caudal fin), they can provide a useful separating feature in generic level between genera *Macrognathus* and *Mastacembelus*. The *Macrognathus* can be distinguished from the *Mastacembelus* in having lesser fin ray both in soft dorsal and anal fin. The number of soft fin rays and anal-fin ray of dorsal-fin are high varied, whilst number of dorsal spines has a lower variation. So, the number of dorsal spines can be used for basic classification in generic level.

- **Vertebrae**

The number of vertebrae gives perhaps the most important character for distinguishing all mastacembelid species. The vertebrae character was widely used for species identification in the family Mastacembelidae. For example **Britz (2007)** distinguished *M. tinwini* and *M. pantherinus* from other species in the *Mastacembelus armatus* species-complex by their numbers of vertebrae.

In this study the number of vertebrae including predorsal, abdominal, caudal, total and in-between vertebrae can be used for distinguishing among mastacembelid species. *M. aculeatus*, *M. meklongensis* and *M. siamensis* differ from all other species in having more predorsal vertebrae [15-23 *vs.* 4-6].

For distinguishing *M. circumcinctus* from all other species in the genus *Macrognathus*, the number of caudal vertebrae can be employed [35-38 *vs.* 39-44]. Within the genus *Mastacembelus M. alboguttatus* differs from all other species in *Mastacembelus* in having fewer abdominal vertebrae. *M. semiocellatus* has the highest number of in-between vertebrae.

For the *Mastacembelus armatus* species-complex *M. tinwini* differs from *M. armatus* in having fewer caudal and total vertebrae. However, a thorough revision of the *Mastacembelus armatus* complex by **Britz (2007)** assured that large differences in vertebral counts among the different samples of the *M. armatus* from various areas

including India, Myanmar and Thailand can be expected that it will result in additional species to be resurrected from synonym and new species to be described.

5.4 RELATIONSHIPS AMOMG MASTACEMBELIDS

Within the subfamily Mastacembelinae restricted to Asia two genera, *Macrognathus* and *Mastacembelus* are recognized. Both Asian genera and species were evaluated mainly through morphometric measurements and meristic characters. Based on 38 morphometric measurements and 13 meristic characters the Hierarchical cluster analysis using the Between-groups linkage method were resulted in morphometric and meristic dendograms (**FIGURE 4.36 and 4.37**). Both morphometric and meristic dendograms can indicate initially their relationships among the mastacembelid group (11 species from Thailand).

Overall, it is important to note that the meristic dendogram using is considerably different from the morphometric dendogram. Based on the meristic dendogram, 11 mastacembelid species were clustered completely into two clades. The first clade consisted of 6 species belonging to the genus *Macrognathus*, whereas the second clade consisted of 5 species belonging to the genus *Mastacembelus*. In contrast, from the morphometric dendogram 11 mastacembelids were clustered into two clades, but the first clades included species belonging to both the genera *Macrognathus* and *Mastacembelus*.

- ***M. aculeatus, M. meklongensis* and *M. siamensis***

Based on the morphometric dendogram, *M. aculeatus* was morphologically close to *M. meklongensis* more than *M. siamensis* and the rest of species in the genus *Macrognathus*, whilst meristic dendogram indicated that *M. meklongensis* was related to *M. siamensis* more than *M. aculeatus* and the rest of *Macrognathus* species. Consequently, it is possible that *M. meklongensis* might be a liking species between *M. aculeatus* and *M. meklongensis*. Both morphometric measurements and meristic counts can be employed for distinguishing among *M. aculeatus, M. meklongensis* and *M. siamensis*.

- ***M. circumcinctus*, *M. semiocellatus* and *M. zebrinus***

M. circumcinctus, *M. semiocellatus* and *M. zebrinus* exhibit similarities in colourations (dark vertical bars), similarly high counts of dorsal spines and confluent dorsal, anal and caudal fins. The three species also have preorbital and preopercular spines and lack rostral toothplates. So, they do not seem particularly closely related to other species placed within the genus *Macrognathus* especially *M. aculeatus*, *M. meklongensis* and *M. siamensis*.

Both the morphometric and meristic dendograms can support the fact that *M. circumcinctus*, *M. semiocellatus* and *M. zebrinus* are similar each other more than all other species. As can be seen from the meristic dendogram *M. semiocellatus* was morphologically close to *M. zebrinus* more than *M. circumcinctus*, while the morphometric dendogram can not indicate whether *M. semiocellatus* is related to *M. zebrinus* more than *M. circumcinctus*.

- ***Mastacembelus alboguttatus* and *Mastacembelus erythrotaenia***

It is worth mentioning that based on morphometric dendogram *Mastacembelus alboguttatus* was separated from all other species in the genus *Mastacembelus*, but it was clustered together with three *Macrognathus* species (*M. circumcinctus*, *M. semiocellatus* and *M. zebrinus*). It is unbelievable that the measurements of *M. alboguttaus* were similar to the *Macrognathus* species more than all other *Mastacembelus* species. In contrast, the meristic dendogram indicated that the meristic characters of *M. alboguttatus* were close to all other *Mastacembelus* species more than all *Macrognathus* species.

Based on the morphometric dendogram *M. erythrotaenia* was grouped together with other species in the genus *Mastacembelus*, excluding *M. alboguttatus*, while the meristic dendogram indicated that the meristic characters of *M. erythrotaenia* was similar to *M. alboguttatus* and *M. favus* more than *M. armatus* and *M. tinwini*.

- ***M. armatus, M. favus* and *M. tinwini***

For relationships of certain species belonging to the *M. armatus* species-complex the meristic dendogram pointed out that *M. armatus* was similar to *M. tinwini* more than *M. favus*, whereas the morphometric dendogram can not indicate whether *M. armatus* is related to *M. tinwini* more than *M. favus*.

Consequently, the meristic dendogram can be employed as an evidence for supporting a split into two genera, *Macrognathus* and *Mastacembelus* because the dendogram provide a relevant result supporting this classification of the family Mastacembelidae. Moreover, the present diagnosis of the Asian genera is proved to be workable and the evidence supporting their relationships is available. In contrast, the morphometric dendogram can not be used for supporting this classification. The measurements may be inappropriate characters for this classification in generic level. However, several measurements were used for classifying mastacembelids in species level as diagnostic characters (**Vreven and Teugels, 1997; Vreven, 2005b).** For example the post anal length (%L_S) was used for distinguishing a new species, *Aethiomastacembelus traversi*, from *A. robertsi* (**Vreven and Teugels, 1997)**. In addition, a new species, *Mastacembelus polli*, was distinguished from *M. ophidium* by its distance from anterior border of snout to last externally visible anal spine (%L_S), its post anal length (%L_S), and its body depth (%L_S), (**Vreven, 2005b)**. Furthermore the morphometric dendogram would be employed in discussion together with morphologically phylogenetic relationships.

In conclusion, the new information based on Hierarchical cluster analysis on Squared Euclidian distances especially the meristic dendogram is recommended for supporting this classification both in generic and species levels. Moreover, the meristic characters may be suitable for explaining phylogenetic relationships among all Asian mastacembelid more than the morphometric measurements. For this classification they were also considered as more suitably diagnostic characters than the measurements. However, both morphological and molecular phylogenies should be constructed for clarifying relationships among Asian mastacembelid species. A combined analysis of nuclear and mtDNA data is really needed to complete a comprehensive phylogeny.

5.5 DISTRIBUTIONS

The distributions of each species are illustrated on **FIGURE 4.18-4.29**. Five mastacembelid species are restricted to a specific basin in Thailand. *Macrognathus aculeatus* and *Macrognathus maculatus* are found in the Southern basins only. *Macrognathus zebrinus* and *Mastacembelus alboguttatus* are found only in Salween basin. *Macrognathus meklongensis* is endemic in the Meklong basin.

- ***Macrognathus aculeatus***

In Thailand, *M. aculeatus* is probably endemic to the Southern basins from Kra isthmus to the Malaysian border**.** *M. aculeatus* has never been founded in a region located above Kra isthmus of Thailand. In addition, **Roberts (1980)** reported that Trang was the northernmost locality for *M. aculeatus*, but from this study Nakhon Si Thammarat is the northernmost locality. **Roberts (1980)** also discussed that *M. aculeatus*, *M. siamensis* and *M. aral* are nearly contiguous but do not overlap (**FIGURE 5.1)**. The range of *M. aculeatus* extends somewhat beyond the hydrographic limits of the ancient central Sundaland drainage, most notably in Java **(Robert, 1980)**.

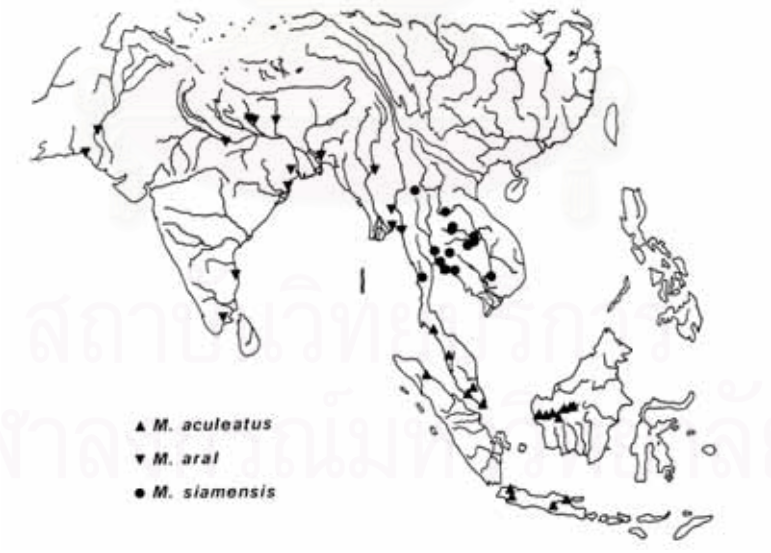

FIGURE 5.1. Geographic distributions of three species of *Macrognathus* **(Roberts, 1986)**.

In the past, there were many previous studies reported that *M. aculeatus* was distributed in other basins, for example Eastern basin of Thailand **(Vidthayanon,**

1997), based on literature reviews and my investigation on numerous specimens *M. aculeatus* can be found only in the southern basin. Therefore, if any studies named spiny eel found in the other basins as *Macrognathus aculeatus*, it may be possibly *Macrognathus siamensis*.

The figure of *M. aculeatus* in **Soonthornkit (2001)** is not matched with the description. **Soonthornkit (2001)** identified it as *M. circumcinctus*. Consequently the Khao Khitchakut National Park and Khao Soi Dao Wildlife Sanctuary in Chanthaburi are untrustworthy localities for *M. aculeatus*.

- ***Macrognathus circumcinctus***

M. circumcinctus can be found in the Chao Phraya, the Mekong, the Eastern and the Southern basins, excluding Salween and Meklong basins. The Mekong basin is an additional locality for *M. circumcinctus*. It was found in Oon River, Sakon Nakon. In addition, it also was recorded in Song Khram basin (Thailand), presumably in Laos, Malay Peninsula and Sumatra **(Kottelat, 2001)**. It is not known from Myanmar.

- ***Macrognathus maculatus***

M. maculatus is probably endemic to Southern basins. It was recorded in Krabi and Nakhon Si Thammarat. Although **Champasi (1999)** reported that *M. maculatus* was found in Yom River, I strongly believe that *M. maculatus* is restricted to the Southern basins. Based on the literature review and specimens examination, the Pliew Waterfall, Thung Song district, Nakhon Si Thammarat is the northernmost area where *M. maculatus* was recorded.

- ***Macrognathus meklongensis***

I disagree with **Vidthayanon (2005)** that *M. meklongensis* is endemic to Meklong River. Some materials of *M. meklongensis* were come from Myanmar and sold in fish market at Mae Sot, Tak. In my opinion *M. meklongensis* is presumably distributed in the Salween basin.

- ***Macrognathus semiocellatus***

M. semiocellatus is distributed in the Chao Phraya, the Mekong and the Eastern basins. Based on my surveys *M. semiocellatus* is considerably less abundant than *M. siamensis*.

- ***Macrognathus siamensis***

M. siamensis is distributed in the Chao Phraya, the Mekong, the Meklong and the Eastern basins. It might presumably occur in the Salween and the Southern basins. Phetchaburi and Chanthaburi are the southernmost and the southeastmost localities for *M. siamensis* respectively. In addition, it is known from Laos, Cambodia and Vietnam but not known from Myanmar and Malaysia.

- ***Macrognathus zebrinus***

M. zebrinus is distributed only in the Salween basin. The Sakae Krang River basin (Chao Phraya basin) is a new record locality for *M. zebrinus*. In this study the Chao Phraya basin is an additional locality for *M. zebrinus* (specimens deposited in CUMZ and collected by Prof. Thosaporn Wongratana, Ph.D.).

- ***Mastacembelus alboguttatus***

M. alboguttatus is distributed only in the Salween basin (Moei, Pai and Salween Rivers). *M. alboguttatus* is possibly endemic to the Salween basin.

- ***Mastacembelus erythriatenia***

In Thailand *M. erythrotaenia* is well known from the Eastern basins (Bang Pakong River), the Southern basins (Tapi River) and the Chao Phraya basin (Chao Phraya River). **Vidthayanon *et al*. (1997)** did not report the Eastern basins as localities of *M. erythrotaenia* because they combine the Bang Pakong River basin with the Chao Phraya basin. However, in the Eastern basins it is not known from other river basins such as the Trat, the Welu and the Chanthaburi river basins.

- ***Mastacembelus armatus, Mastacembelus favus* and *Mastacembelus tinwini***

According to **Roberts (1986)**, the distribution of *M. favus* is quite different from that of *M. armatus*. *M. favus* is not known from the Indian subcontinent and Burma including the Salween basin, but extends southward into the western Malaysia **(Roberts, 1986)**. The present study shows that *M. favus* is widely distributed in Thailand, but it is not known from the Salween basin. Consequently, I strongly agree with **Roberts (1986)** on the distributions of *M. favus*. However the Salween basin considered as an uncertain locality for *M. favus* should be proved.

It is important to note that *M. favus* and *M. armatus* are sympatric because I have examined several specimens (deposited in KUMF) collected from both Huai Kha Khaeng and Huai Mae Dee in the Huai Kha Khaeng Wildlife Sanctuary and found that they consisted of *M. armatus* and *M. favus*. Moreover, **Roberts (1986)** obtained five specimens of *M. armatus* and two specimens of *M. favus* all of which were collected together in the Khlong Sok, a small tributary of the Tapi River. Therefore **Roberts (1986)** believed that *M. armatus* and *M. favus* are sympatric.

In contrast, the *M. armatus* is known well from the Indian subcontinent **(Sufi, 1956; Roberts, 1986; Britz, 2007)** and is extended southward into the Malaysia. *M. armatus* is distributed throughout Thailand; however, from my surveys *M. armatus* seems to be considerably less abundant than *M. favus*.

For a new record *M. tinwini* is known from the Nan River (the Chao Phraya basin), Ratchaprapha Reservoir in Surat Thani and Khlong Klai and Yong Water fall in Nakhon Si Thammarat (the Southern basins), but there is no report from the Mekong, the Meklong, the Salween and the Eastern basins. However it might appear in parts of Thailand drained by the Salween River because its distributions are known from the Salween basin in Myanmar and possibly from the Sittang River located in the south of the country between the Irrawaddy and the Salween Rivers.

In at least some localities I believe that *M. tinwini* and *M. favus* are sympatric because I obtained two specimens of *M. tinwini* and two specimens of *M. favus* from the Nan River in Mueang Nan. Based on my surveys *M. tinwini* is considerably less abundant than *M. favus* and *M. armatus*.

TABLE 5.1. Present Distributions of Mastacembelid Species in Thailand based on specimens deposited in museums and institutions.

	Chao Phraya basin	Salween basin	Mekong basin	Meklong basin	Southern basins	Eastern basins
Macrognathus aculeatus					×	
Macrognathus circumcinctus	×		×		×	×
Macrognathus maculatus					×	
Macrognathus meklongensis		×?		×		
Macrognathus semiocellatus	×		×			×
Macrognathus siamensis	×		×	×		×
Macrognathus zebrinus	×	×				
Mastacembelus alboguttatus		×				
Mastacembelus armatus	×	×	×	×?	×	×
Mastacembelus erythrotaenia	×		×?		×	×
Mastacembelus favus	×	×?	×	×	×	×
Mastacembelus tinwini	×	×?			×	

? = for any uncertain or possible distribution, occurring to that basin.

TABLE 5.2. Previous Distributions of Mastacembelid Species in Thailand based on literature reviews **(Vidthayanon *et al.*, 1997)**.

	Chao Phraya basin	Salween basin	Mekong basin	Meklong basin	Southern basins	Eastern basins
Macrognathus aculeatus					×	×
Macrognathus circumcinctus					×	×
Macrognathus maculatus					×	
Macrognathus meklongensis				×		
Macrognathus semiocellatus	×		×			×
Macrognathus siamensis	×		×	×	×	×
Macrognathus zebrinus		×				
Mastacembelus alboguttatus		×				×
Mastacembelus armatus	×	×	×	×	×	×
Mastacembelus erythrotaenia	×		×		×	
Mastacembelus favus	×		×	×	×	
Mastacembelus sp.	×	×		×		

REMARKS:

However, the Eastern basins as defined in this study are slightly different from **Vidthayanon *et al.* (1997)**. The Bang Pakong and Prachin Buri Rivers are included in the Eastern basins, but are excluded from the Eastern basins as defined in **Vidthayanon *et al.* (1997)**.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

(1) Two genera and twelve mastacembelid species belonging to the family Mastacembelidae were recognized in Thailand.

Genus *Macrognathus* Lacepède, 1800

1. *Macrognathus aculeatus* (Bloch, 1786)
2. *Macrognathus circumcinctus* (Hora, 1924)
3. *Macrognathus maculatus* (Val. In Cuv. & Val., 1831)
4. *Macrognathus meklongensis* Roberts, 1986
5. *Macrognathus semiocellatus* Roberts, 1986
6. *Macrognathus siamensis* (Günther, 1861)
7. *Macrognathus zebrinus* (Blyth, 1858)

Genus *Mastacembelus* Scopoli, 1777

8. *Mastacembelus alboguttatus* Boulenger, 1893
9. *Mastacembelus armatus* (Lacepède, 1800)
10. *Mastacembelus erythrotaenia* Bleeker, 1853
11. *Mastacembelus favus* Hora, 1923
12. *Mastacembelus tinwini* Britz, 2007

(2) *Mastacembelus tinwini* is a newly record species.

(3) If any previous reported named spiny eel found in the Chao Phraya basin as *Macrognathus aculeatus*, it means *Macrognathus siamensis*.

(4) Five mastacembelid species are restricted to specific basins in Thailand. *Macrognathus aculeatus* and *Macrognathus maculatus* are endemic in the Southern basin. *Macrognathus meklongensis* is endemic in the Meklong basin. *Macrognathus zebrinus* and *Mastacembelus alboguttatus* are restricted to the Salween basin.

(5) Most of spiny eels were found in freshwater except *Mastacembelus erythrotaenia* can be found in both freshwater and brackish water.

(6) Most of *Macrognathus* were found at the bottom depths of slow-flowing or standing waters and floodplain areas, whereas *M. circumcinctus* found in riffle sections of large open gravel and boulder streams amongst the spaces between the gravels and boulders. Most *Mastacembelus* were found along the bottom of flowing rivers including streams and lowland wetlands, whilst *Mastacembelus alboguttatus* found in river with sand substrates.

(7) *Macrognathus siamensis* and *Mastacembelus favus* are the most common species of the spiny eels. *M. favus* is widely distributed throughout Thailand, while *M. siamensis* can be found in almost all basins in Thailand excluding the Salween and the southern basins.

(8) New information based on Hierarchical cluster analysis on Squared Euclidian distances especially the meristic dendogram is recommended for supporting this classification both in generic and species levels. Meristic characters are suitable for explaining phylogenetic relationships among all Asian mastacembelid more than morphometric measurements.

(9) The Chao Phraya basin has the highest number of mastacembelid species, whereas the Meklong basin has the lowest number of species.

6.2 RECOMMENDATIONS

(1) Molecular and morphological phylogenetic trees should be constructed.

(2) For any uncertain or possible distribution occurring to that basin should be proved.

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APPENDICES

APPENDIX I: Cataloging Specimens

Macrognathus aculeatus

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Southern Basins			
CUMZ 2006.10.19:1-4	Khlong Cha-uat, Cha-uat, Nakhon Si Thammarat	Salinee Khachonpisitsak	2006.10.19
CUMZ 2006.10.18:5	Khlong Ro, Khian Sa, Surat Thani	Salinee Khachonpisitsak	2006.10.18
CUMZ 2006.10.20:6	Mueang, Phatthalung	Salinee Khachonpisitsak	2006.10.20
CUMZ 2006.10.20:7-18	Khlong Cha-uat, Cha-uat, Nakhon Si Thammarat	Salinee Khachonpisitsak	2006.10.20
NIFI 00615	Nakhon Si Thammarat	Sompote Ukkatawewat	1981.08.21
NIFI 01219	Khlong Saeng, Ratchaprapha Reservoir, Surat Thani	Jaranthada Kannasooth	1983.04.20
NIFI 3220	Pru Toh Daeng, Narathiwat	-	1998.07.07
NIFI 3221	Southern basins	-	-

Macrognathus circumcinctus

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Chao Phraya Basin			
CUMZ 1997.09.04:31	Phra Nakhon Si Ayutthaya	Thosaporn Wongratana	1997.09.04
CUMZ 2007.05.12:32	Chet Khot Waterfall, Kaeng Khoi, Saraburi	Salinee Khachonpisitsak	2007.05.12
NIFI 00613	Sarika Waterfall, Mueang Nakhon Nayok, Nakhon Nayok	-	1977.09.16
Mekong Basin			
NIFI 00622	Oon River, Sakon Nakhon	Sopha Areerat	1968.12.--
Southern Basins			
CUMZ 2006.10.17:1	Khlong Ro, Khian Sa, Surat Thani	Salinee Khachonpisitsak	2006.10.17
CUMZ 2006.10.18:2-12	Thale Noi, Khuan Khanun, Phatthalung	Salinee Khachonpisitsak	2006.10.19
CUMZ 2006.10.19:13-30	Cha-uat, Nakhon Si Thammarat	Salinee Khachonpisitsak	2006.10.19
CUMZ 2006.10.18:42-56	Thale Noi, Khuan Khanun, Phatthalung	Salinee Khachonpisitsak	2006.10.20
NIFI 01168	Wipavadi Waterfall, Surat Thani	Jaranthada Kanasooth	1978.09.--
NIFI 3222	Thai Mueang, Phang-nga	-	1998.01.20
NIFI 3223	Thai Mueang, Phang-nga	-	1998.01.20
NIFI 3224	Sirinthorn Waterfall, Narathiwat	-	1998.10.01-05
KUMF 1303	Thale Noi, Khuan Khanun, Phatthalung	H. M. Smith	1923.10.08
KUMF 1304	Khlong Nakhon Noi, Nakhon Si Thammarat	H. M. Smith	1923.10.08
UMMZ 2704	Khlong Toh Daeng, Narathiwat	Chavalit Vidthayanon	1994.02.06-08

Macrognathus circumcinctus

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Eastern Basins			
CUMZ 2007.02.24:33-41	Khao Rakam Reservoir, Mueang Trat, Trat	Salinee Khachonpisitsak	2007.02.24
CUMZ 2007.02.24:57-65	Khao Rakam Reservoir, Mueang Trat, Trat	Salinee Khachonpisitsak	2007.02.24
NIFI 00611	Kra Thing Waterfall, Chanthaburi	Jaranthada Kanasooth	1975.12.25
NIFI 01590	Swamp near Khao Hin Son, Chachoengsao	Songphan Lamlertdecha	1984.08.29
NIFI 01591	Khao Hin Son, Chachoengsao	Songphan Lamlertdecha	1984.08.29
NIFI 02554	Surat Thani	Thasaphon	1994.01.--
KUMF 1299	Nong Or, foot of Khao Sabap, Chanthaburi	-	-
KUMF 1300	Tale Sap Khlong Ranawt (Ranant), Khlong Narai Waterfall, Chanthaburi	-	-
KUMF 1301	Pong Raed Waterfall, Kao Sabap, Chanthaburi	-	-
KUMF 1302	Khlong Song Pee Nong, Chakadon, Rayong	Prajit Wongrat and Suebsin Sonthirat	1971.07.04
KUMF uncat.	Khlong Hin, Khao Chamao National Park, Huai Thap Mon, Khao Chamao, Rayong	-	1997.05.05
KUMF uncat.	Khlong Reaw, Khao Chamao National Park, Huai Thap Mon, Khao Chamao, Rayong	-	1997.05.05
KUMF uncat.	Khlong Poon, Khao Chamao National Park, Huai Thap Mon, Khao Chamao, Rayong	-	1997.05.05
KUMF uncat.	Khlong Nam Pen, Khao Chamao National Park, Rayong	-	1997.05.05
KUMF uncat.	Khlong Takhian, Chanthaburi	-	1997.05.05
KUMF uncat.	Kaeng Hang Maeo, Chanthaburi	-	
KUMF uncat.	Kaeng Hang Maeo, Chanthaburi	-	1997.04.30

Macrognathus maculatus

Catalogue No.	Locality	Collector or other Source	Date (yy/mm/dd)
Southern Basins			
UMMZ 2575	Khlong Bang Tieu, Khao Nor Chuchi, Krabi	Chavalit Vidthayanon	1994.02.12-13

Macrognathus meklongensis

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Southern Basins			
CUMZ 2006.08.12:1-10	Kwae Noi River, Sangkhla Buri, Kanchanaburi	Salinee Khachonpisitsak	2006.08.12
CUMZ 2006.12.14:11-30	Fish market, Mae Sod, Tak	Salinee Khachonpisitsak	2006.12.14
CUMZ 2006.09.13:31-50	Fish market, Pak Thong Chai, Nakhon Ratchasima	Salinee Khachonpisitsak	2006.09.13
CUMZ 2006.09.13:51-70	Fish market, Pak Thong chai, Nakhon Ratchasima	Salinee Khachonpisitsak	2006.09.13

Macrognathus semiocellatus

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Chao Phraya Basin			
CUMZ 2006.11.18:1-3	Tron, Uttaradit	Salinee Khachonpisitsak	2006.11.18
CUMZ 2006.11.19:9-17	Bueng Boraphet, Nakhon Sawan	Salinee Khachonpisitsak	2006.11.18
CUMZ 1997.08.25:18-22	Phra Nakhon Si Ayutthaya	Thosaporn Wongratana	1997.08.25
CUMZ 1997.03.08:23-24	Chai Nat	Thosaporn Wongratana	1997.03.08
CUMZ 2006.11.18:31	Mueang Phrae, Phrae	Salinee Khachonpisitsak	2006.11.18
CUMZ 1997.11.07:32-35	Chao Phraya River, Chai Nat	Thosaporn Wongratana	1997.11.07
CUMZ 2006.06.24:36-45	Yom River basin, Mueang, Sukhothai	Salinee Khachonpisitsak	2006.06.24
CUMZ 2006.07.15:46-90	Bueng Borapeth, Nakhon Sawan	Salinee Khachonpisitsak	2006.07.15
CUMZ 2006.07.15:91-138	Bueng Borapeth, Nakhon Sawan	Salinee Khachonpisitsak	2006.07.16
NIFI 00618	Bueng Borapeth, Nakhon Sawan	Sompote Ukkatawewat	1981.08.26
NIFI 01674	Fresh market, Nakhon Sawan	-	1978.08.--
NIFI 02109	Bueng Borapeth, Nakhon Sawan	Songphan Lamlerdecha	1985.10.08
Mekong Basin			
NIFI 00612	Songkram River, Nakhon Phanom	Preecha Thiencharoen	1966.05.01
NIFI 01675	Ubon Ratana Reservoir, Khon Kaen	-	-
NIFI 01678	Oon River near Sakon Nakhon	-	-
NIFI 02121	Ubon Ratana Reservoir, Khon Kaen	Phanom Sodsuk	1987.06.01-05
Eastern Basins			
CUMZ 2006.06.22:4-5	Mueang, Prachin Buri	Jarin Khachonpisitsak	2006.06.12
CUMZ 2006.09.12:6-8	Kabinburi, Prachin Buri	Salinee Khachonpisitsak	2006.09.22
CUMZ 1997.11.11:25-30	Khao Soi Dao, Chanthaburi	Thosaporn Wongratana	1997.11.11
CUMZ 1997.11.12:139-153	Khao Soi Dao, Chanthaburi	Thosaporn Wongratana	1997.11.12
KUMF uncat.	St.18, Chachoengsao	-	1997.04.17
KUMF uncat.	St.20, Chachoengsao	-	1997.04.18
KUMF uncat.	Chachoengsao	-	1997.04.18

Macrognathus siamensis

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Chao Phraya Basin			
CUMZ 2006.06.25:1-4	Yom River basin, Mueang Sukhothai, Sukhothai	Salinee Khachonpisitsak	2006.06.25
CUMZ 2006.11.20:5-20	Tron, Uttaradit	Salinee Khachonpisitsak	2006.11.20
CUMZ 2006.11.20:21-30	Tron, Uttaradit	Salinee Khachonpisitsak	2006.11.20
CUMZ 2006.11.20:31-50	Tron, Uttaradit	Salinee Khachonpisitsak	2006.11.20
CUMZ 2006.11.21:51-56	Bangrakam, Phitsanulok	Salinee Khachonpisitsak	2006.11.21
CUMZ 2006.11.19:57-61	Mueang Phrae, Phrae	Salinee Khachonpisitsak	2006.11.19
CUMZ 2006.11.20:62-66	Mueang Uthai Thani, Uthai Thani	Salinee Khachonpisitsak	2006.11.20
CUMZ 2006.11.18:67-72	Mueang Nan, Nan	Salinee Khachonpisitsak	2006.11.18
CUMZ 2006.06.24:73-80	Mueang Sukhothai, Sukhothai	Salinee Khachonpisitsak	2006.06.24
CUMZ 2006.02.25:152-156	Kampang Phet	Salinee Khachonpisitsak	2006.02.25
CUMZ 2006.11.07:157-161	Chai Nat	Salinee Khachonpisitsak	2006.11.07
CUMZ 2006.11.18:162-178	Nakhon Sawan	Salinee Khachonpisitsak	2006.11.18
CUMZ 2007.07.14:179-189	Phichit	Piyanut Tontragool	2007.07.14
CUMZ 2007.08.22:190-204	Phichit	Piyanut Tontragool	2007.08.22
CUMZ 2006.06.24:205-213	Nan River, Phitsanulok	Salinee Khachonpisitsak	2006.06.24
CUMZ 1990.11.24:214	Nonthaburi	-	1990.11.24
CUMZ 1997.10.19:215	Sing Buri	Thosaporn Wongratana	1997.10.19
KUMF 1290	Lop Buri	S. Mongkolprasit *et al.*	1971.01.12
KUMF 2643	Nonthaburi	Jarin	1974.01.11
KUMF 6888	Huai Kra Siao, Ban Chao Wat, Ban Rai, Uthai Thani	Naruechit	2002.03.25
KUMF 6892	Bantha Plara, Dan Chang, Suphan Buri;	Naruechit	2002.07.09
KUMF 6896	Pak Huai Dur, Dan Chang, Suphan Buri	Naruechit	2002.07.08
NIFI 00619	Phra Nakhon Si Ayutthaya	Preecha Thiencharoen	1966.12.--
NIFI 01262	Chao Phraya Reservoir, Chai Nat	Songphan Sunthornsathid	1982.05.--
Mekong Basin			
CUMZ 2006.09.11:81-83	Songkram River, Si Songkhram, Nakhon Phanom	Salinee Khachonpisitsak	2006.09.11
CUMZ 2006.09.12:84-88	Mekong River basin, Mueang Mukdahan, Mukdahan	Salinee Khachonpisitsak	2006.09.12
CUMZ 2006.09.10:89-99	Khok Kong, Si Wilai, Nong Khai	Salinee Khachonpisitsak	2006.09.10
CUMZ 2006.09.09:100-103	Bueang Kan, Nong Khai	Salinee Khachonpisitsak	2006.09.09
CUMZ 2006.09.09:104-113	Mueang Nong Khai, Nong Khai	Salinee Khachonpisitsak	2006.09.09
CUMZ 2006.09.11:114-116	Nong Han, Sakon Nakhon	Salinee Khachonpisitsak	2006.09.11
CUMZ 2006.11.28:117-128	Bamnet Narong, Chaiyaphum	Salinee Khachonpisitsak	2006.11.28
CUMZ 2006.11.28:129-149	Bamnet Narong, Chaiyaphum	Salinee Khachonpisitsak	2006.11.28
CUMZ 2006.11.28:150-151	Wang Nam Khiao, Nakhon Ratchasima	Salinee Khachonpisitsak	2006.11.28

Macrognathus siamensis

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Mekong Basin			
NIFI 00616	Lam Pao Reservoir, Kalasin	Jaranthada Kanasooth	1976.11.19
NIFI 00620	Ubon Ratana Reservoir, Khon Kaen	Sompote Ukkatawewat	1978.03.06-11
NIFI 01740	Nong Han, Sakon Nakhon	Songphan Lamlerdecha	1985.10.03
NIFI 01772	Lam Takhlong, Nakon Ratchasima	Songphan Lamlerdecha	1980.12.24
NIFI 02087	Lam Dome Yai, Det Udom, Ubon Rachathani	Rangsan Chaiyaboonthan	1987.01.13
NIFI 02131	Lam Dome Noi, Ubon Rachathani	Phanom Sodsuk	1987.05.20
NIFI 02006	Huai Luang Reservoir, Udonthani	Songphan Lamlerdecha	1986.04.23
NIFI 3225	Ubon Ratana Reservoir, Khon Kaen	Songphan Lamlerdecha	1985.02.13
Meklong Basin			
KUMF 1285, 1286	Nong Bang Ngu, Ratchaburi	Prajit Wongrat and K. F. Lagler	1964.11.12
Eastern Basins			
NIFI 00617	Bang Phra Reservoir, Siracha, Chonburi	Jaranthada Khanasooth	1976.01.26

Macrognathus zebrinus

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Salween Basin			
CUMZ 2006.12.16:1-9	Moei River, Tha Song Yang, Tak	Salinee Khachonpisitsak	2006.12.16
CUMZ 2006.12.16:10-18	Moei River, Tha Song Yang, Tak	Salinee Khachonpisitsak	2006.12.16
NIFI 01672	Pegu Division, Kha Yein, Chuang, 4 miles NE of Hlegu, Myanmar	Tyson Roberts	1985.03.09
NIFI 02408	Rangoon River, Rangoon, Myanmar	Y. Taki	1973.10.11
NIFI 12476	Mae Sam Lap, Salween River, Mae Sariang, Mae Hong Son	Suwit	1993.10.16

Genus *Mastacembelus*

8. *Mastacembelus alboguttatus*

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Salween Basin			
CUMZ 2006.12.17:1-3	Moei River, Mae Ramad, Tak	Salinee Khachonpisitsak	2006.12.17
CUMZ 2006.12.18:4-18	Moei River, Tha Song Yang, Tak	Salinee Khachonpisitsak	2006.12.18
CUMZ uncat.	Huai Mae Sam Laep**,** Salween River basin, Mae Hong Son	Tyson R. Roberts	-
NIFI 00972	Pai river, Nam Phiang Din Village**,** Mueang, Mae Hong Son	Sompote Ukkatawewat	1982.03.23
KUMF 1292	Pai River, Mae Hong Son	Jinda Thiemmedth	1969.06.08

9. ***Mastacembelus armatus***

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Chao Phraya Basin			
UMMZ 2743	Nam Wa River basin, Nan	Chavalit Vidthayanon	1994.04.25
UMMZ 2755	Mae Sa-nga, Mae Hong Son	Chavalit Vidthayanon	1995.04.29
UMMZ 2756	Sob Mang, Bor Klur, Nan	Chavalit Vidthayanon	1995.04.26
KUMF uncat.	Huai Kha Khaeng Wildlife Sanctuary, 200 m. above Pong Kra-Tao, Kaen Makut, Ban Rai, Uthai Thani	-	1998.02.22
KUMF uncat.	St. C, Huai Kha Khaeng Wildlife Sanctuary, Pong Kra-Tao, Kaen Makut, Ban Rai, Uthai Thani	-	1998.02.23
KUMF uncat.	St. t, Huai Kha Khaeng Wildlife Sanctuary, Taling Sung, Kaen Makut, Ban Rai, Uthai Thani	-	1998.02.24
KUMF uncat.	Huai Kha Khaeng Wildlife Sanctuary, Huai Mae Dee, Kaen Makut, Ban Rai, Uthai Thani	-	1997.07.13
KUMF uncat.	St. 38, Huai Kha Khaeng Wildlife Sanctuary, Huai Kha Khaeng, Kaen Makut, Ban Rai, Uthai Thani	-	1997.07.15
KUMF uncat.	Huai Kha Khaeng Wildlife Sanctuary, Huai Kha Khaeng, Kaen Makut, Ban Rai, Uthai Thani	-	1997.07.14
Salween Basin			
CUMZ 2006.11:16:1-4	Pai River, Pai, Mae Hong Son	Salinee Khachonpisitsak	
CUMZ 2006.11.15:5-10	Huai Sue Thao, Mae Hong Son	Salinee Khachonpisitsak	
CUMZ 2007.09.26:11-14	Pai River, Mueang, Mae Hong Son.	Sutipong Arsirapoj	2007.09.26
UMMZ 2755	Mae Sa-Nga, Mueang Mae Hong Son, Mae Hong Son	Chavalit Vidthayanon	1995.04.29
Mekong Basin			
NIFI 00610	Mekong River, Bueng Kan, Nong Khai	Jaranthada Kanasooth	1976.02.02
NIFI 00614	Mae Chan, Chiang Rai	Sompote Ukkatawewat	1978.05.10
Southern Basins			
NIFI 01129	Lan Saka Waterfall, Nakhon Si Thammarat	-	1970.03.23
NIFI 02162	Ratchaphrapha Reservoir, Surat Thani	Rangsan	1987.12.26
NIFI 3226	Bok Krai Waterfall, Ranong	-	1999.10.07

10. ***Mastacembelus erythrotaenia***

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Chao Phraya Basin			
NIFI 01143	Nakhon Chaisi River, Nakhon Pathom	-	-
NIFI 01256	Phra Nakhon Si Ayutthaya	Preecha Thiencharoen	year.12.09
Southern Basins			
CUMZ 2006.12.26: 7-18	Tapi River, Phunpin, Surat Thani	Salinee Khachonpisitsak	
KUMF 1305	Phathaluang	H.M.Smith	1930.04.05
KUMF 1306	Surat Thani	Sopana Boonyapiwat	1971.12.--
Eastern Basins			
CUMZ 2006.11.12: 1-6	Bangpakong River, Bang Khla, Chachoengsao	Salinee Khachonpisitsak	2006.11.12

11. *Mastacembelus favus*

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Chao Phraya Basin			
CUMZ 2006.11.18:1-2	Yom River, Mueang, Phrae	Salinee Khachonpisitsak	2006.11.18
CUMZ 2006.06.24:3-7	Yom River, Mueang, Sukhothai	Salinee Khachonpisitsak	2006.06.24
CUMZ 2006.11.18:8-17	Nan River, Tron, Uttaradit	Salinee Khachonpisitsak	2006.11.18
CUMZ 2006.11.18:18-20	Yom River, Bang Rakam, Phitsanulok	Salinee Khachonpisitsak	2006.11.18
CUMZ 2006.11.19:21-34	Chao Phraya River, Nakhon Sawan	Salinee Khachonpisitsak	2006.11.19
CUMZ 1997.08.25:35-36	Chao Phraya River, Phra Nakhon Si Ayutthaya	Thosaporn Wongratana	1997.08.25
CUMZ 2006.11.17:37-38	Nan River, Mueang, Nan	Salinee Khachonpisitsak	2006.11.17
CUMZ 2006.11.14:39-40	Doi Tao Lake, Chiang Mai	Salinee Khachonpisitsak	2006.11.14
CUMZ 2006.11.14:41-43	Ping River, Hod, Chiang Mai	Salinee Khachonpisitsak	2006.11.14
CUMZ 1997.03.09:44	Uthai Thani	Thosaporn Wongratana	1997.03.09
CUMZ 2006.11.20:45-56	Nong Bon, Nakhon Sawan	Salinee Khachonpisitsak	2006.11.20
CUMZ 1990.11.05:57-63	Nonthaburi	-	1990.11.05
CUMZ 2007.06.14:64-67	Pond, Taphan Hin, Phichit	Piyanut Tontragool	2007.06.14
NIFI 00609	Chao Phraya River, Chai Nat	Preecha Tienchoroen	1967.01.--
NIFI 01763	Bueng Boraphet, Nakhon Sawan	Songphan Lamlertdecha	1985.10.08
KUMF 1294	Nong Bang Ngu, Ratchaburi	Prajit Wongrat	1967.--.--
KUMF 1295	Nong Bang Ngu, Ratchaburi	K. F. Lagler	1964.12.11
KUMF 1297	Lop Buri market	Prajit Wongrat	1971.01.12
KUMF 1298	Nong Bang Ngu, Ratchaburi	Thosaporn Wongratana	1964.12.25
KUMF 2674	Sukhothai	-	-
KUMF 2703	Nan River, Phichit	Sanan	1974.02.03
KUMF 2730	Phitsanulok	Somboon	1974.02.05
KUMF 6902	Huai Hang, Dan Chang, Suphan Buri	Naruechit	2002.03.25
KUMF 6906	Huai Krasiao, Ban Rai, Uthai Thani	Naruechit	2002.07.02
KUMF 6907	Dan Chang, Suphan Buri	Naruechit	2002.07.01
KUMF uncat.	Huai Kha Khaeng Wildlife Sanctuary, Kaen Makut, Ban Rai, Uthai Thani	-	1997.07.14
KUMF uncat.	Huai Kha Khaeng Wildlife Sanctuary, Kaen Makut, Ban Rai, Uthai Thani	-	1997.07.12

11. *Mastacembelus favus* (cont.)

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Mekong Basin			
CUMZ 2006.11.17:68-83	Kok River, Muaeng Chaing Rai, Chaing Rai	Salinee Khachonpisitsak	2006.11.17
CUMZ 2006.09.10:84-87	Mekong River, Bueng Kan, Nong Khai	Salinee Khachonpisitsak	2006.09.10
CUMZ 2006.09.10:88-90	Kud Thing, Si Wilai, Nong Khai	Salinee Khachonpisitsak	2006.09.10
CUMZ 2006.09.11:91-98	Songkhram River, Si Songkhram, Nakhon Phanom	Salinee Khachonpisitsak	2006.09.11
CUMZ 2006.09.12:99-103	Nam Oon Reservoir, Kudbak, Sakon Nakhon.	Salinee Khachonpisitsak	2006.09.12
NIFI 00607	Lam Pao Reservoir, Kalasin	Narong Sukomol	1978.02.25
NIFI 01529	Ubon Ratana Reservoir, Khon Kaen	Songphan Lamlertdecha	1985.02.12
NIFI 01915	Chi River	-	-
NIFI 02088	Lam Dome Yai, Ubon Ratchathani	Chaiyaboontan	1987.01.13
NIFI 02112	Ubon Ratana Reservoir, Khon Kaen	Phanom Sodsuk	1987.06.1-5
NIFI 01784	Lam Takhlong Reservoir, Nakhon Ratchasima	Sompote Ukkatawewat	1982.12.24
KUMF 1293	Nam Pong Reservoir, Nongwai, 32 km from Khon Kaen to Udon Thani	-	-
Meklong Basin			
CUMZ 2007.07.22:104-105	Sangkla Buri, Kanchanaburi	Ezra Mongkhonchaichana	2007.07.22
CUMZ 2007.08.17:106-107	Srinakharin Reservoir, Kanchanaburi	Ezra Mongkhonchaichana	2007.08.17
NIFI 00621	Kwae Yai River, Kanchanaburi	Sompote Ukkatawewat	1970.06.09
NIFI 01044	Kwae Noi River, Kanchanaburi	-	-
NIFI 3227	Chao Nane Reservoir, Kanchanaburi	-	1978.03.16
Southern Basins			
CUMZ 2006.10.18:131-132	Khlong Ro, Phunphin, Surat Thani	Salinee Khachonpisitsak	2006.10.18
CUMZ 2006.10.19:133	Muaeng Phatthalung, Phatthalung	Salinee Khachonpisitsak	2006.10.19
NIFI 00178	Surathani	-	-
NIFI 01482	Bang Lang Reservoir, Pattani River, Yala	Tawan Cookhachon	1984.12.19
NIFI 3228	Narathiwat	Tawan Cookhachon	1985.05.02
Eastern Basins			
CUMZ 2007.01.06:108-126	Pond, Phanat Nikhom, Chonburi	Jarin Khachonpisitsak	2007.01.06
CUMZ 1997.11.11:127-129	Khao Soi Dao, Chanthaburi	Thosaporn Wongratana	1997.11.11
CUMZ 2007.02.24:130	Chanthaburi River, Chanthaburi	Jaran Thadakanasooth	1978.06.15
NIFI 00608	Chanthaburi River, Chanthaburi	Jaran Thadakanasooth	1978.06.15
KUMF uncat.	St. 50(4), Khlong Tap Mon, Khao Chamao National Park, Rayong	-	1997.04.30

11. *Mastacembelus favus* (cont.)

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Mekong Basin			
KUMF uncat.	St. 54, Khlong Phawa-habatara, Khao Chamao National Park, Rayong	-	1997.04.30

12. *Mastacembelus tinwini*

Catalogue No.	Locality	Collector name	Date (yy/mm/dd)
Chao Phraya Basin			
CUMZ 2006.11.17:1-2	Nan River, Mueang Nan, Nan	Salinee Khachonpisitsak	2006.11.17
NIFI 00614	Pangsa, Mae Chan, Chiang Rai	Sompote Ukkatawewat	1978.05.10
UMMZ 2744	Nam Wa River basin, Nan	Chavalit Vidthayanon	1994.04.25
UMMZ 2782	Nam Wa River basin, Nan	Chavalit Vidthayanon	1995.04.25
Southern Basins			
NIFI 02162	Ratchaprapha Reservoir, Surat Thani	Rangsan	1987.12.26

APPENDIX II Statistical Analysis

SnL: Snout Length

Scheffe

Species	N	Subset for alpha = 0.05							
		1	2	3	4	5	6	7	8
M. favus	58	37.648							
M. armatus	35	37.714							
M. tinwini	9	38.500	38.500						
M. zebrinus	20		40.045	40.045					
M. erythrotaenia	21			40.748	40.748				
M. semiocellatus	51			41.278	41.278				
M. circumcinctus	53				42.558	42.558			
M. siamensis	65					44.103	44.103		
M. alboguttatus	20						45.555		
M. meklongensis	30							**48.623**	
M. aculeatus	27								**52.048**
Sig.		.949	.231	.604	.063	.231	.328	1.000	1.000

ED: Eye Diameter

Scheffe

Species	N	Subset for alpha = 0.05			
		1	2	3	4
M. erythrotaenia	21	7.881			
M. siamensis	65	8.931	8.931		
M. meklongensis	30	9.037	9.037		
M. alboguttatus	20	9.155	9.155	9.155	
M. tinwini	9	9.289	9.289	9.289	
M. zebrinus	20		9.440	9.440	
M. semiocellatus	51		9.475	9.475	
M. aculeatus	27		9.633	9.633	9.633
M. circumcinctus	53		10.081	10.081	10.081
M. favus	58			10.478	10.478
M. armatus	35				10.977
Sig.		.063	.299	.114	.099

HW: Head Width

Scheffe

Species	N	Subset for alpha = 0.05		
		1	2	3
M. zebrinus	20	10.600		
M. meklongensis	30	11.017	11.017	
M. semiocellatus	51	11.567	11.567	11.567
M. alboguttatus	20	11.765	11.765	11.765
M. erythrotaenia	21	12.252	12.252	12.252
M. siamensis	65		12.378	12.378
M. favus	58			12.741
M. aculeatus	27			12.889
M. circumcinctus	53			12.960
M. armatus	35			12.971
M. tinwini	9			13.067
Sig.		.061	.280	.147

RAL: Rostral Appendage Length

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. favus	58	9.048					
M. tinwini	9	9.378					
M. armatus	35	9.497					
M. alboguttatus	20	9.770					
M. zebrinus	20		11.575				
M. erythrotaenia	21		11.662				
M. circumcinctus	53			14.104			
M. semiocellatus	51			14.449			
M. siamensis	65				18.205		
M. meklongensis	30					22.800	
M. aculeatus	27						27.022
Sig.		.944	1.000	1.000	1.000	1.000	1.000

AjTRA: Angle of jaws to tip of rostral appendage

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. zebrinus	20	**28.225**					
M. siamensis	65		30.652				
M. alboguttatus	20		30.760				
M. circumcinctus	53			32.977			
M. semiocellatus	51			33.616	33.616		
M. meklongensis	30			33.620	33.620		
M. armatus	35			35.026	35.026	35.026	
M. favus	58				35.305	35.305	
M. tinwini	9					35.856	35.856
M. erythrotaenia	21					37.200	37.200
M. aculeatus	27						37.756
Sig.		1.000	1.000	.098	.358	.054	.180

PoL: Postorbital Length

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. aculeatus	27	**44.059**					
M. meklongensis	30		**46.483**				
M. alboguttatus	20			**51.595**			
M. circumcinctus	53				53.949		
M. semiocellatus	51				54.992	54.992	
M. siamensis	65				55.046	55.046	
M. favus	58					56.712	56.712
M. zebrinus	20					56.855	56.855
M. armatus	35					56.917	56.917
M. erythrotaenia	21						57.181
M. tinwini	9						57.844
Sig.		1.000	1.000	1.000	.877	.106	.852

PJaL: Postjaw angle Length

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. aculeatus	27	64.578				
M. erythrotaenia	21	66.200	66.200			
M. favus	58	66.505	66.505			
M. tinwini	9		67.233			
M. meklongensis	30		67.607			
M. armatus	35		67.711			
M. semiocellatus	51			71.308		
M. circumcinctus	53			71.374		
M. alboguttatus	20			72.060	72.060	
M. siamensis	65				73.925	73.925
M. zebrinus	20					76.150
Sig.		.260	.661	.997	.312	.088

PpobsL: Post-preorbital spine Length

Scheffe

species	N	Subset for alpha = 0.05		
		1	2	3
M. alboguttatus	20	61.725		
M. erythrotaenia	21	61.857	61.857	
M. favus	58	62.145	62.145	
M. tinwini	9	62.244	62.244	
M. circumcinctus	53	62.940	62.940	
M. armatus	35	63.223	63.223	
M. semiocellatus	51		63.712	
M. zebrinus	20			**66.350**
Sig.		.307	.082	1.000

UjL: Upper jaw Length

Scheffe

Species	N	Subset for alpha = 0.05			
		1	2	3	4
M. aculeatus	27	14.144			
M. meklongensis	30	14.877	14.877		
M. siamensis	65		16.829		
M. semiocellatus	51			19.237	
M. circumcinctus	53			19.668	
M. zebrinus	20			20.835	
M. alboguttatus	20			20.835	
M. erythrotaenia	21				26.000
M. armatus	35				26.634
M. tinwini	9				27.000
M. favus	58				27.562
Sig.		.992	.079	.333	.371

LjL: Lower jaw Length

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. aculeatus	27	10.726				
M. meklongensis	30	11.480	11.480			
M. siamensis	65		12.825			
M. semiocellatus	51			14.978		
M. circumcinctus	53			15.175		
M. zebrinus	20				17.160	
M. alboguttatus	20				17.160	
M. erythrotaenia	21					22.067
M. tinwini	9					22.944
M. favus	58					23.055
M. armatus	35					23.209
Sig.		.983	.511	1.000	1.000	.756

PecfL: Pectoral fin Length

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. tinwini	9	25.189					
M. armatus	35	25.749	25.749				
M. favus	58	27.403	27.403	27.403			
M. erythrotaenia	21		28.062	28.062	28.062		
M. meklongensis	30			29.133	29.133		
M. aculeatus	27			29.230	29.230		
M. circumcinctus	53				29.942		
M. siamensis	65					33.142	
M. semiocellatus	51					34.027	34.027
M. zebrinus	20						35.905
M. alboguttatus	20						35.905
Sig.		.162	.114	.463	.413	.993	.415

PecfbL: Pectoral fin-base Length

Scheffe

Species	N	Subset for alpha = 0.05			
		1	2	3	4
M. meklongensis	30	9.870			
M. aculeatus	27	10.330			
M. siamensis	65	10.592	10.592		
M. semiocellatus	51		11.659		
M. circumcinctus	53		11.762		
M. favus	58			13.022	
M. armatus	35			13.334	
M. erythrotaenia	21			13.419	
M. tinwini	9			13.867	
M. zebrinus	20				16.675
M. alboguttatus	20				16.675
Sig.		.772	.079	.546	1.000

AjE: Angle of jaws to eye

Scheffe

Species	N	Subset for alpha = 0.05			
		1	2	3	4
M. favus	58	11.478			
M. armatus	35	11.486			
M. erythrotaenia	21	11.671			
M. tinwini	9	11.700			
M. semiocellatus	51		**13.324**		
M. circumcinctus	53			14.849	
M. siamensis	65			16.202	
M. zebrinus	20				17.680
M. alboguttatus	20				17.680
M. aculeatus	27				17.774
M. meklongensis	30				18.157
Sig.		1.000	1.000	.108	.996

AjPen: Angle of jaws to posterior external nare

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. semiocellatus	51	9.235				
M. aculeatus	27	9.404				
M. siamensis	65	9.558	9.558			
M. circumcinctus	53	9.606	9.606			
M. zebrinus	20	9.705	9.705	9.705		
M. alboguttatus	20	9.705	9.705	9.705		
M. meklongensis	30	9.903	9.903	9.903	9.903	
M. tinwini	9		10.789	10.789	10.789	10.789
M. erythrotaenia	21			10.943	10.943	10.943
M. favus	58				11.047	11.047
M. armatus	35					11.246
Sig.		.909	.106	.100	.189	.994

PenE: Posterior external nare to eye

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. favus	58	6.059				
M. armatus	35	6.074				
M. tinwini	9	6.378				
M. erythrotaenia	21		**7.605**			
M. circumcinctus	53			9.775		
M. siamensis	65			9.862		
M. zebrinus	20			10.195	10.195	
M. alboguttatus	20			10.195	10.195	
M. semiocellatus	51			10.294	10.294	
M. meklongensis	30				10.863	10.863
M. aculeatus	27					11.570
Sig.		.996	1.000	.867	.548	.452

PPenL: Pre-posterior external nare Length

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. favus	58	31.364					
M. armatus	35	31.946					
M. semiocellatus	51	31.980					
M. tinwini	9	32.511	32.511				
M. erythrotaenia	21	33.119	33.119				
M. circumcinctus	53		33.789	33.789			
M. siamensis	65			34.928	34.928		
M. zebrinus	20				36.320		
M. alboguttatus	20				36.320		
M. meklongensis	30					**38.337**	
M. aculeatus	27						**41.096**
Sig.		.054	.470	.658	.323	1.000	1.000

DTanPen: Distance between base of tubular anterior nostril and posterior external nare

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. semiocellatus	51	24.792					
M. favus	58	26.159	26.159				
M. tinwini	9	26.433	26.433				
M. erythrotaenia	21	26.438	26.438				
M. armatus	35		26.923	26.923			
M. circumcinctus	53			28.577	28.577		
M. siamensis	65				29.925		
M. zebrinus	20				29.940		
M. alboguttatus	20				29.940		
M. meklongensis	30					**32.873**	
M. aculeatus	27						**35.322**
Sig.		.118	.971	.113	.388	1.000	1.000

HL: Head Length

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. tinwini	9	16.567					
M. alboguttatus	20	17.290	17.290				
M. zebrinus	20	17.505	17.505	17.505			
M. erythrotaenia	21	17.662	17.662	17.662			
M. semiocellatus	51	17.920	17.920	17.920			
M. armatus	35		18.309	18.309	18.309		
M. siamensis	65		18.445	18.445	18.445		
M. circumcinctus	53			18.738	18.738		
M. favus	58				19.321	19.321	
M. meklongensis	30					20.550	
M. aculeatus	27						**23.078**
Sig.		.054	.210	.130	.422	.133	1.000

SnFDs: Snout to first dorsal spine

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. tinwini	9	19.289				
M. armatus	35	20.609	20.609			
M. alboguttatus	20	20.840	20.840			
M. erythrotaenia	21	20.962	20.962			
M. semiocellatus	51	21.086	21.086			
M. zebrinus	20		21.430			
M. favus	58		21.633			
M. circumcinctus	53			23.666		
M. meklongensis	30				41.590	
M. aculeatus	27				42.719	42.719
M. siamensis	65					44.449
Sig.		.102	.874	1.000	.784	.140

SnLDs: Snout to last externally visible dorsal spine

Scheffe

Species	N	Subset for alpha = 0.05			
		1	2	3	4
M. alboguttatus	20	64.820			
M. armatus	35	66.160	66.160		
M. siamensis	65	66.232	66.232		
M. meklongensis	30		67.180	67.180	
M. favus	58		67.562	67.562	67.562
M. erythrotaenia	21		67.619	67.619	67.619
M. tinwini	9		67.678	67.678	67.678
M. semiocellatus	51		68.200	68.200	68.200
M. zebrinus	20			68.335	68.335
M. circumcinctus	53			69.149	69.149
M. aculeatus	27				69.574
Sig.		.551	.053	.076	.061

SnFAs: Snout to first anal spine

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. alboguttatus	20	56.730					
M. semiocellatus	51	58.237	58.237				
M. armatus	35		59.751	59.751			
M. tinwini	9		59.833	59.833			
M. zebrinus	20		59.950	59.950	59.950		
M. erythrotaenia	21			61.262	61.262	61.262	
M. favus	58				61.684	61.684	
M. circumcinctus	53					61.825	61.825
M. siamensis	65					62.192	62.192
M. meklongensis	30						63.450
M. aculeatus	27						63.522
Sig.		.193	.065	.190	.057	.875	.071

PreAnL: Preanal Length

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. alboguttatus	20	**54.330**					
M. semiocellatus	51		56.214				
M. armatus	35		57.683	57.683			
M. tinwini	9		57.933	57.933	57.933		
M. zebrinus	20			57.955	57.955		
M. erythrotaenia	21			58.414	58.414		
M. circumcinctus	53			59.294	59.294	59.294	
M. favus	58				59.605	59.605	
M. siamensis	65					60.680	60.680
M. meklongensis	30						61.640
M. aculeatus	27						62.148
Sig.		1.000	.056	.106	.075	.304	.216

PostAnL: Postanal Length

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. aculeatus	27	37.952					
M. meklongensis	30	38.360					
M. siamensis	65	39.457	39.457				
M. favus	58		40.476	40.476			
M. circumcinctus	53		40.745	40.745	40.745		
M. erythrotaenia	21			41.605	41.605		
M. zebrinus	20			42.140	42.140	42.140	
M. tinwini	9			42.156	42.156	42.156	
M. armatus	35				42.314	42.314	
M. semiocellatus	51					43.749	
M. alboguttatus	20						**45.970**
Sig.		.153	.386	.056	.109	.087	1.000

HD: Head depth at posterior eye margin

Scheffe

Species	N	Subset for alpha = 0.05			
		1	2	3	4
M. alboguttatus	20	3.930			
M. semiocellatus	51	4.059			
M. zebrinus	20	4.115			
M. tinwini	9	4.333	4.333		
M. siamensis	65	4.366	4.366		
M. erythrotaenia	21		4.614	4.614	
M. circumcinctus	53		4.713	4.713	
M. meklongensis	30		4.733	4.733	
M. armatus	35		4.766	4.766	
M. favus	58			5.016	5.016
M. aculeatus	27				5.381
Sig.		.101	.109	.195	.335

BDds: Body depth at the origin of dorsal spine

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. tinwini	9	7.322					
M. armatus	35	7.560	7.560				
M. alboguttatus	20	7.755	7.755	7.755			
M. semiocellatus	51	8.171	8.171	8.171			
M. zebrinus	20		8.310	8.310	8.310		
M. erythrotaenia	21		8.395	8.395	8.395		
M. favus	58			8.472	8.472		
M. circumcinctus	53				9.108		
M. meklongensis	30					11.910	
M. aculeatus	27					12.511	12.511
M. siamensis	65						12.988
Sig.		.100	.114	.319	.165	.618	.883

BDdfr: Body depth at the origin of dorsal-fin ray

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. tinwini	9	8.022					
M. armatus	35	8.317					
M. favus	58		9.740				
M. erythrotaenia	21		10.048	10.048			
M. alboguttatus	20		10.060	10.060			
M. semiocellatus	51			11.086	11.086		
M. zebrinus	20				11.480		
M. meklongensis	30				11.877	11.877	
M. siamensis	65					12.720	12.720
M. circumcinctus	53					12.738	12.738
M. aculeatus	27						13.133
Sig.		.999	.999	.096	.493	.346	.989

BDan: Body depth at anus

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. tinwini	9	9.433				
M. armatus	35	9.594				
M. favus	58		11.133			
M. alboguttatus	20		11.370			
M. erythrotaenia	21		11.481			
M. semiocellatus	51		12.231	12.231		
M. meklongensis	30			12.860	12.860	
M. zebrinus	20			13.040	13.040	13.040
M. siamensis	65				13.808	13.808
M. circumcinctus	53				13.985	13.985
M. aculeatus	27					14.222
Sig.		1.000	.145	.628	.120	.076

BDafr: Body depth at anal-fin ray

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. tinwini	9	8.456				
M. armatus	35	8.823				
M. erythrotaenia	21		10.057			
M. favus	58		10.122			
M. alboguttatus	20		10.515			
M. semiocellatus	51			11.767		
M. meklongensis	30			12.170		
M. zebrinus	20			12.260	12.260	
M. siamensis	65			12.857	12.857	12.857
M. aculeatus	27				13.407	13.407
M. circumcinctus	53					13.432
Sig.		.997	.984	.100	.061	.921

CL: Caudal Length

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. tinwini	9	**4.611**				
M. armatus	35		5.491			
M. erythrotaenia	21		5.833	5.833		
M. semiocellatus	51			6.431	6.431	
M. zebrinus	20			6.545	6.545	
M. favus	58			6.564	6.564	
M. alboguttatus	20			6.640	6.640	
M. siamensis	65				6.794	
M. aculeatus	26				7.200	7.200
M. meklongensis	30				7.263	7.263
M. circumcinctus	53					7.843
Sig.		1.000	.981	.084	.061	.386

AfbL: Anal fin-base Length

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. meklongensis	30	31.500					
M. aculeatus	27	31.585					
M. siamensis	65	32.663	32.663				
M. circumcinctus	53	33.058	33.058	33.058			
M. favus	58		33.528	33.528	33.528		
M. zebrinus	20		33.970	33.970	33.970		
M. erythrotaenia	21			34.533	34.533		
M. tinwini	9			34.556	34.556		
M. armatus	35				35.057	35.057	
M. semiocellatus	51					36.786	
M. alboguttatus	20						**38.660**
Sig.		.172	.448	.226	.196	.070	1.000

SpdfbL: Spinous dorsal-fin base Length

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. siamensis	65	**21.637**				
M. meklongensis	30		25.583			
M. aculeatus	27		26.915			
M. alboguttatus	20			44.175		
M. circumcinctus	53			45.540	45.540	
M. armatus	35			45.560	45.560	
M. favus	58			46.081	46.081	46.081
M. erythrotaenia	21				46.676	46.676
M. zebrinus	20				46.890	46.890
M. semiocellatus	51				46.963	46.963
M. tinwini	9					47.911
Sig.		1.000	.653	.108	.547	.150

SodfbL: Soft dorsal-fin base Length

Scheffe

Species	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
M. circumcinctus	53	30.675						
M. zebrinus	20	30.790						
M. meklongensis	30	31.083	31.083					
M. aculeatus	27	31.541	31.541	31.541				
M. semiocellatus	51	31.945	31.945	31.945	31.945			
M. siamensis	65		32.737	32.737	32.737	32.737		
M. favus	58			33.229	33.229	33.229	33.229	
M. armatus	35				33.474	33.474	33.474	
M. tinwini	9					33.878	33.878	
M. erythrotaenia	21						34.643	
M. alboguttatus	20							**37.195**
Sig.		.547	.136	.115	.237	.711	.363	1.000

DPeAnFAs: Distance from posterior edge of anus to anterior base of first anal-fin spine

Scheffe

Species	N	Subset for alpha = 0.05			
		1	2	3	4
M. aculeatus	27	1.470			
M. meklongensis	30	1.810	1.810		
M. siamensis	65	1.811	1.811		
M. tinwini	9	1.867	1.867		
M. semiocellatus	51	1.880	1.880	1.880	
M. favus	58		2.067	2.067	
M. armatus	35		2.086	2.086	
M. alboguttatus	20		2.210	2.210	
M. zebrinus	20		2.325	2.325	2.325
M. circumcinctus	53			2.425	2.425
M. erythrotaenia	21				2.848
Sig.		.438	.108	.064	.095

DAnFAr: Distance from posterior edge of anus to anterior base of first anal-fin ray

Scheffe

Species	N	Subset for alpha = 0.05			
		1	2	3	4
M. semiocellatus	51	6.290			
M. meklongensis	30	6.310			
M. aculeatus	27	6.352	6.352		
M. siamensis	65	6.397	6.397		
M. alboguttatus	20	6.670	6.670	6.670	
M. armatus	35	6.763	6.763	6.763	
M. favus	58	7.100	7.100	7.100	7.100
M. tinwini	9		7.222	7.222	7.222
M. zebrinus	20			7.335	7.335
M. circumcinctus	53			7.434	7.434
M. erythrotaenia	21				7.700
Sig.		.109	.054	.173	.562

DsoAfro: Dorsal spine origin to anal-fin ray origin

Scheffe

Species	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
M. siamensis	65	**25.783**					
M. meklongensis	30		27.870				
M. aculeatus	27		28.867				
M. semiocellatus	51			41.659			
M. alboguttatus	20			42.895	42.895		
M. armatus	35				43.903	43.903	
M. circumcinctus	53				43.957	43.957	
M. zebrinus	20				44.325	44.325	
M. favus	58					45.647	45.647
M. erythrotaenia	21						46.948
M. tinwini	9						47.156
Sig.		1.000	.929	.752	.536	.210	.443

DstAfrt: Dorsal spine termination to anal-fin ray termination

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. aculeatus	27	31.589				
M. zebrinus	20	31.865				
M. circumcinctus	53	32.025	32.025			
M. semiocellatus	51	32.198	32.198	32.198		
M. meklongensis	30	32.487	32.487	32.487		
M. favus	58		33.622	33.622	33.622	
M. tinwini	9			33.689	33.689	
M. armatus	35			33.771	33.771	
M. siamensis	65				34.378	
M. erythrotaenia	21				35.086	
M. alboguttatus	20					**37.510**
Sig.		.837	.057	.067	.130	1.000

AfroDfrt: Anal-fin ray origin to Dorsal-fin ray termination

Scheffe

Species	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
M. aculeatus	27	31.056						
M. meklongensis	30	31.650	31.650					
M. siamensis	65		32.852	32.852				
M. circumcinctus	53			33.485	33.485			
M. favus	58			33.821	33.821	33.821		
M. zebrinus	20				34.730	34.730		
M. erythrotaenia	21				34.919	34.919		
M. tinwini	9					35.222		
M. armatus	35					35.394		
M. semiocellatus	51						**37.267**	
M. alboguttatus	20							**39.185**
Sig.		.992	.449	.776	.172	.079	1.000	1.000

DepfbDfro: Dorsal edge of pectoral-fin base to dorsal-fin ray origin

Scheffe

Species	N	Subset for alpha = 0.05				
		1	2	3	4	5
M. aculeatus	27	46.237				
M. alboguttatus	20	47.260	47.260			
M. meklongensis	30	47.503	47.503			
M. armatus	35	47.700	47.700	47.700		
M. siamensis	65	47.965	47.965	47.965	47.965	
M. favus	58		48.155	48.155	48.155	
M. semiocellatus	51			49.457	49.457	49.457
M. erythrotaenia	21				49.695	49.695
M. circumcinctus	53					50.198
M. zebrinus	20					50.545
M. tinwini	9					51.300
Sig.		.112	.936	.097	.111	.061

BIOGRAPHY

Miss Salinee Khachonpisitsak, daughter of Mr. Sawang and Ms. Jarin Khachonpisitsak, was born on the 4th August 1983 in Chonburi province, Thailand. After she had finished the secondary high school from Chonkanyanukoon School in 2001, she went to Chulalongkorn University on the Development and Promotion of Science and Technology talents project of Thailand (DPST) scholarship. She obtained the Bachelor of Science in Biology with 1st Class Honours in 2004. She then entered the Zoology program in the same institute and conducted taxonomic study on Mastacembelid species. She completed her Master of Science in Zoology program in the academic year 2007.

Research publications:

Khachonpisitsak, S., Thirakhupt, K. and Wongratana, T. 2007. Species Diversity and Distribution of Spiny Eels (Synbranchiformes: Mastacembelidae) in the Chao Phraya Basin, Thailand. Abstract. *The 12th Biological Science Graduate Congress*, University of Malaya, Kuala Lumpur, Malaysia.

Khachonpisitsak, S., Thirakhupt, K. and Wongratana, T. 2007. Taxonomy of Spiny Eels (Synbranchiformes: Mastacembelidae) in the Chao Phraya Basin, Thailand. Abstract. *The 11th BRT Annual Conference*. Udonthani, Thailand.