การปรับปรุงอนุกรมวิธานหอยทากบกสกุล *Macrochlamys*, *Cryptozona* และ *Hemiplecta* ของประเทศไทย

นางสาวอัญชิรา มะณีวงศ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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TAXONOMIC REVISION OF TERRESTRIAL SNAILS GENERA *Macrochlamys*, *Cryptozona* AND *Hemiplecta* IN THAILAND

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นางสาวอัญชิรา มะณีวงศ์ : การปรับปรุงอนุกรมวิธานหอยทากบกสกุล *Macrochlamys*, *Cryptozona* และ *Hemiplecta* ในประเทศไทย. (Taxonomic revision of terrestrial snails genera *Macrochlamys, Cryptozona* and *Hemiplecta* in Thailand) อ. ที่ปรึกษา : รศ. ดร. สมศักดิ์ ปัญหา, 161 หน้า, ISBN 974-347-250-9.

หอยทากบกสกุล *Macrochlamys* ที่ได้ทำการศึกษาในครั้งนี้ มีตำแหน่งและลักษณะอวัยวะในระบบสืบพันธุ์เป็นของหอยทากบกสกุล *Sarika* ซึ่งเป็นกลุ่มที่มีความหลากหลายและซับซ้อนมาก การศึกษาจากเอกสารและตัวอย่างโดยละเอียดสรุปได้ว่า *Macrochlamys* ที่เคยมีรายงานในประเทศไทยต้องจัดจำแนกใหม่ไว้ในสกุล *Sarika* ด้วยลักษณะของ penial appendix ที่ตรงและกล้ามเนื้อ penial retractor muscle ที่ยึดอยู่บริเวณปลายของ penial appendix นอกจากนี้ยังพบว่า spermtophore ที่พบใน *Macrochlamys asamurai* และ *Syama diadema* มีลักษณะไม่มีหนามคล้ายกับสกุล *Sarika* ลักษณะเด่นของอวัยวะในระบบสืบพันธุ์ของหอยทากบกสกุล *Cryptozona* คือมีส่วน epiphallus เป็นสีดำ และมี epiphallic caecum ยาว ส่วนในหอยทากบกสกุล *Hemiplecta* มี spermatheca ขนาดสั้น และ epiphallic caecum มีลักษณะสั้นกุด จากการศึกษาครั้งนี้ยังพบว่า *Hemiplecta siamensis* ที่พบในจังหวัดสระบุรีมีลักษณะอวัยวะในระบบสืบพันธุ์เป็นของหอยทากบกสกุล *Sarika* และ *Hemiplecta weinkauffiana* ต้องจัดจำแนกใหม่ไว้ในสกุล *Dyakia* ด้วยลักษณะของ dart sac ที่มีขนาดสั้นซึ่งบริเวณปลายอวัยวะนี้จะมีท่อขนาดเล็กต่อเข้ากับ dart gland นอกจากนี้ spermatheca ยังมีตำแหน่งอยู่บนฐานของ dart sac ทั้งยังไม่มี penial appendix และ epiphallic caecum ในส่วนการศึกษามอร์โฟเมตริกของอวัยวะในระบบสืบพันธุ์พบว่าค่าอัตราส่วนเฉลี่ยระหว่างความยาวของ spermatheca และ vas deferens (SL/VDL) สามารถใช้จัดจำแนกสกุลทั้งสามสกุลได้ ภายในสกุล *Cryptozona* ค่าอัตราส่วนนี้ก็สามารถใช้แยก *Cryptozona siamensis* 1 และ *Cryptozona siamensis* 2 ออกจากกันได้ นอกจากนี้พบว่ามีค่าอัตราส่วนเฉลี่ยหลายค่า เช่น ความยาวของ penis ต่อ vas deferens (PeL/VDL), ความยาวของ penial appendix ต่อ vas deferens (PAL/VDL) และ ความยาวของ vas deferens ต่อ epiphallus (VDL/EL) สามารถใช้แยกหอยทากบกสกุล *Hemiplecta* ระหว่าง *Hemiplecta distincta* และ *Hemiplecta neptunus* ออกจากกันได้

ภาควิชา ชีววิทยา ลายมือชื่อนิสิต.....

สาขา สัตววิทยา ลายมือชื่ออาจารย์ที่ปรึกษา.....

ปีการศึกษา 2543 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.....

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ANCHIRA MANEEVONG: TAXNOMIC REVISION OF TERRESTRIAL SNAILS GENERA *Macrochlamys, Cryptozona* AND *Hemiplecta* IN THAILAND. THESIS ADVISOR : ASSOC. PROF. DR. SOMSAK PANHA.161 pp. ISBN 974-347-250-9.

Terrestrial snail genus *Macrochlamys* in the present study contains the genital characteristics as of the genus *Sarika* which later carefully studied from the literatures and collected specimens, can be concluded that the previous reported *Macrochlamys* from Thailand must be classified into *Sarika* by the straight penial appendix and penial retractor muscle position. *Macrochlamys asamurai* and *Syama diadema* also contain the spineless shaped spermatophore as of the genus *Sarika.* The main genital characteristic of genus *Cryptozona* is blackish epiphallus and long epiphallic caecum. While the genus *Hemiplecta* has a very short spermatheca and blunt knob epiphallic caecum. *Hemiplecta siamensis* from Saraburi Province has genital description as of the genus *Sarika* and must be reclassified into *Sarika siamensis. Hemiplecta weinkauffina* in this study looks very close to the genus *Dyakia* in a short dart sac with having a duct of dart gland at the distal end, spermatheca on the base of dart sac, no penial appendix and no epiphallic caecum. It must be reclassified into genus *Dyakia.* The mean ratio of spermatheca length to vas deferens length (SL/VDL) could be used to classified in generic level, and also could be classified in specific level of *Cryptozona siamensis* 1 and *Cryptozona siamensis* 2. Other ratios such as penis length to vas deferens length (PeL/VDL), penial appendix length to vas deferens length (PAL/VDL) and vas deferens length to epiphallus length (VDL/EL) could be used to classified in specific level of *Hemiplecta distincta* and *Hemiplecta neptunus.*

Department BIOLOGY	Student's signature……
Field of study ZOOLOGY	Advisor's signature……
Academic year 2000	Co-advisor's signature……

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List of Abbreviations

AG = albumen gland

C = carrefour

D = dart apparatus

DDG = duct of dart gland

DG = dart gland

DS = dart sac

E = epiphallus

EC = epiphallic caecum

FO = free oviduct

HD = hermaphroditic duct

HG = hermaphroditic gland

O = oviduct

PA = penial appendix

Pe = penis

Pr = prostate

PRM = penial retractor muscle

S = spermatheca

V = vagina

VD = vas deferens

Hn = *Hemiplecta neptunus*

Hd = *Hemiplecta distincta*

Sd = *Syama diadema*

Ma = *Macrochlamys asamurai*

Ms 1 = *Macrochlamys* sp. 1

Ms 2 = *Macrochlamys* sp. 2

Ms 622 = *Macrochlamys* sp. 622

Ms 685 = *Macrochlamys* sp. 685

Ms 699 = *Macrochlamys* sp. 699

Ms 690/688 = *Macrochlamys* sp. 690/688

Ms 703 = *Macrochlamys* sp. 703

Ms 711 = *Macrochlamys* sp. 711

Cs 1 = *Cryptozona siamensis* 1

Cs 2 = *Cryptozona siamensis* 2

Chapter 1

Introduction

Terrestrial snails genera *Macrochlamys, Cryptozona* and *Hemiplecta* belong to the subclass Pulmonata, the order Stylommatophora, the superfamily Helicarionoidea and to the family Ariophantidae. They are important in environmental food chain. As herbivorous, snails eat many kinds of fresh and dead leaves, and be eaten by many animals such as some predacious insects, snakes, birds and small mammals. They live under leaf, litter, logs, stones and trash. They are as economic and medical important such as *Hemiplecta distincta* a land snail, can be consumed by people in northeastern Thailand (Panha, 1986 and 1987). And it also would be an intermediate host of a rat lung worm *Angiostrongylus cantonensis* causing human meningitis (Panha, 1988). Macrochlamys is important as one of the chief carriers of the nematode Angiostrongylus which infects rats and which can infect human (Berry, 1974). These genera are common in tropical evergreen forest in Thailand for example *Cryptozona siamensis* distributes all forest types around Thailand, Laos and Burma (Panha, personal communication).

These genera possess hermaphroditic reproductive system and exhibit interesting courtship behavior prior to copulation. They exchange sperm mass so called “spermatophore” during copulation into their partners. Spermatophore is a very complex shape and shows a distinct characteristic of species. It would appear to be secreted during copulation and would be seen broken up, absorbed and disappeared in the partners (Blanford & Godwin-Austen, 1908 and Runham & Hunter, 1970). They hibernate during dry season and active through rainy season. During the active peroid, the snails may sometimes enter a short-term quiescent state, with the formation of the same type of thin epiphragm (dried mucus) covering shell aperture, using in hibernation. This phenomenon is avoiding unnecessary loss of water, as the weather is unseasonably cold or dry. The generative organs were not found at their full stage of development during hibernation.

The report from Panha in 1996, on a checklist and classification of the terrestrial pulmonate snails in Thailand, reported 7 species of *Macrochlamys : M. anceps, M. asamurai, M. dugasti, M.limbata, M. molecula, M. pumicata* and *M. resplendens ;* 3 species of *Cryptozona* : *C. siamensis, C. praestans* and *C. granulosa ;* 8 species of *Hemiplecta : H. crossei, H. danae, H. distincta, H. hugonis, H. neptunus, H. siamensis, H.weinkauffiana* and *H. zimmayensis.* The shell and reproductive tracts in each genus vary considerably in size and shape. The past descriptions of the three genera have been using shell morphology, radula and reproductive system as key characters however there are still insufficient. Therefore, morphometric analysis of reproductive system has been sought in order to solve the problems encountered. Morphometric analysis of reproductive system is the current step, which will then be combined with spermatophore morphological data for distinct classification in the present study. The data will be of useful for phylogeny arrangement in the future.

Objectives

The purpose of this study is to revise the taxonomy of land snails genera *Macrochlamys, Cryptozona* and *Hemiplecta* in Thailand by using genital morphometric analysis.

Anticipated benefit

Morphometric analysis of reproductive system is an additional step in combination with spermatophore morphological data in order to clarify snails classification and create new finding.

Chapter 2

Literature Review

2.1) Reproduction in Stylommatophora

The pulmonates are hermaphrodites, the male and female gametes differentiate within a single gonad, called hermaphroditic gland (Fig. 2-1). This is different from other animals where there are two different portions. All Stylommatophoran are true simultaneous hermaphrodites (spermatogenesis and oogenesis develop almost at the same rate), although they may show protandry. In addition, self-fertilization and parthenogenesis are also found in some species (Takeda, 1989).

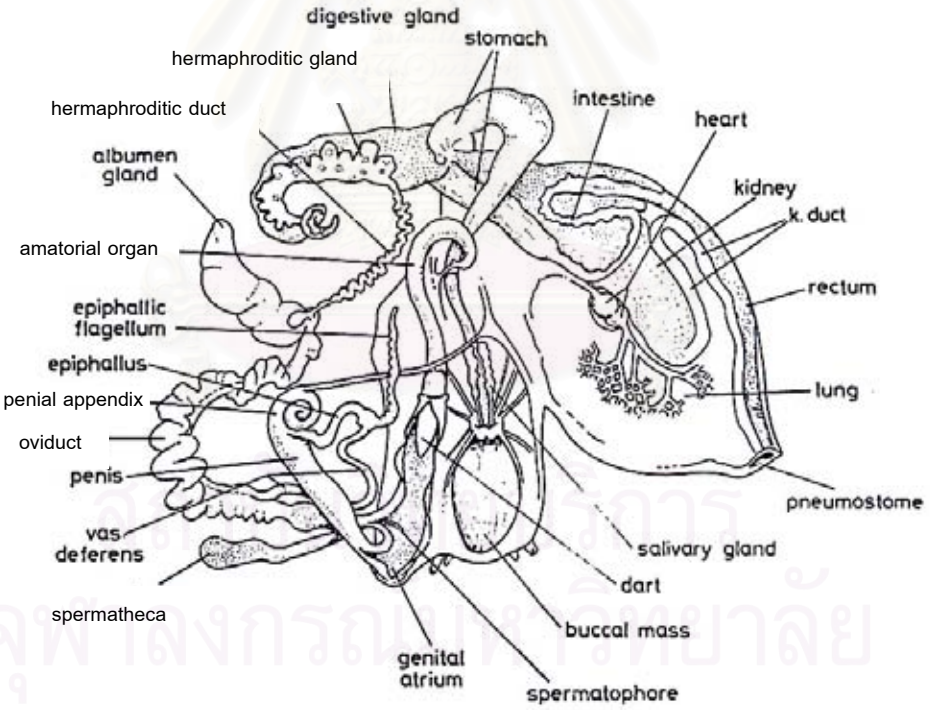


Figure 2-1. Anatomy of terrestrial snail *Macrochlamys resplendens*

(after Berry, 1974)

- Hermaphroditic gland (ovotestis)

The source of hermaphroditic system of some Indo-Burmese ariophantids lies far back in visceral sac, where buried in the posterior lobe of the liver called the hermaphroditic gland (ovotestis) (Blanford and Godwin-Austen, 1908).The hermaphroditic gland in snails *Euhadra peliomphala* and *Achantina fulica* resembles bunches of grapes and in partially embedded in the hepatopancreas, this is different from that of slugs where it is a separate mass. The gonad consists of a number of sac-like acini in which both gametes mature (Takeda , 1989). In slugs *Arion ater, Agriolimax reticulatus, Philomycus carolinianus* and *Vaginulus borellianus*, hermaphroditic gland open by way of efferent ducts into the hermaphroditic duct. Both efferent and hermaphroditic ducts are ciliated. Each acinus contains both male and female gametes, together with nutritive cells. In very young animals the hermaphroditic gland is a simple sac filled with undifferentiated cells, but enlarges and becomes lobed, first oocytes and later spermatocytes differentiate. The young gonad continues to enlarge, becoming more and more lobes, until it assumes the character of the mature gonad. The oocytes attached to the acinus' s wall while the various spermatozoa stages fill in lumen. There is a continuous production of ova, sperm and nutritive cells in the mature gonad during breeding season. Ova, sperm and nutritive cells arise from a ring of germinative cells at the neck of the acinus. The cells migrate around the wall of the acinus, the gametes gradually mature. Excess oocytes and probably also spermatocytes are resorbed at the base of the acinus by nutritive cells. Some resorbing oocytes are usually visible in all acini and are easily recognized by the large vacuolar channels in their cytoplasm (Runhum and Hunter, 1970).

- Hermaphroditic duct and talon

Ovotestis extends a long duct called the hermaphroditic duct, usually very much convoluted, and down which the ova and spermatozoa pass. The duct enters the albumen gland, an elongated mass (Blanford and Godwin-Austen, 1908). Just before the

hermaphroditic duct enters the albumen gland, there is a small enlargement pocket or sharp bending which is an actual site of fertilization in pulmonates, termed the seminal vesicle or fertilization pocket or fertilization pouch-seminal receptacle complex (=talon=carrefour). The ova here undergo a certain change and are separated from the spermatozoa – ova pass down the oviduct, while spermatozoa pass down the prostate (Blanford and Godwin-Austen, 1908 ; Runhum and Hunter, 1970 and Emberton, 1995).

- Albumen gland

The albumen gland is situated against the anterior concave surface of the digestive gland. It is a compound tubular structure consisting of secretary cells interspersed with ciliated cells and it secretes the granules of galactogen produced by the Golgi apparatus. Galactogen or yolk from albumen gland surrounds each fertilized egg and is catabolized by the developing embryo (Takeda, 1989). The albumen gland fluctuates in size and galactogen content during the reproductive cycle. It is largest and the galactogen content highest during the breeding season and minute with lowest content during the following egg laying period (Takeda, 1989). Galactogen appears to be the main energy source for embryos, together with proteins, glycoprotein, calcium and other minerals (Bayne, 1966 and 1967 referred by Rumhum and Hunter, 1970). The weight of the albumen gland and ratio of the albumen gland weight to the whole body weight related with sexual maturation in a land snail *Euhadra peliomphala* (Nyumura and Kajiyama, 1999).

- Common duct

The common duct is located below the albumen gland. The lumen of common duct is partially subdivided by lateral folds into the male and female duct. The gland opening into the male duct constitutes the prostate gland and those opening into the female duct the oviducal gland. The prostate gland of most stylommatophoran species connected to the sperm groove along of the length of the spermoviduct. Most prostate tubules have two cell

types, gland cells and ciliated non-secretory cells. The female part of the spermoviduct is extremely glandular. The duct wall consists of an inner ciliated epithelium, the middle glandular layer and the outer connective tissue (Fig. 2-2) (Takeda, 1989).

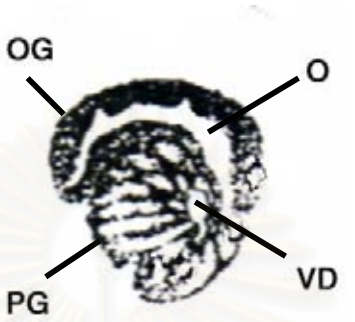


Figure 2-2. Cross section of common duct in the slug, *Limax maginatus*
OG = oviducal gland PG = prostate gland
O = oviduct VD = vas deferens (Takeda, 1989).

The oviduct is whitish colour, with large convoluted folds. The fertilized eggs pass down into it. The zygotes receive layers of material, which from first the jelly layer. And then they reach the lower part of the gland where the egg shell are added. The jelly layer consists of mucopolysaccharide together with some calcium. The shell layer contains a polysaccharide, protein and calcium (Bayne, 1966 referred by Runhum and Hunter, 1970). These two coalesced ducts run side by side for a considerable distance and them separate. The ovotestis becoming a stout hollow tube, the free oviduct leading onwards to the genital aperture, the prostate or sperm duct becoming a slender tube, the vas deferens carrying the spermatic contents to the male organ (Blanford and Godwin-Austen, 1908).

- Spermatheca

Before the free oviduct reaches the genital aperture, it give off a more or less globose or pear-shaped sac, varying much in size ; this is spermatheca. It receives spermatophore, which issues from the male organ of the other individual (Blanford and

Godwin-Austen, 1908). When the spermatophore is transferred at copulation, it passes to the spermatheca where the outer material is digested away and the sperm released. The fate of these sperm is still uncertain but some undoubtedly pass to hermaphroditic duct and fertilize the eggs (Maury and Reygrobellet, 1963 referred by Rumhum and Hunter, 1970). Spermatophore is probably digested by proteolytic enzymes in spermatheca (or bursa copulatrix). But a few sperm escape down the spermathecal duct to swim up through oviduct and uterus to reach talon, where they are stored and perhaps matured. Ova move through hermaphroditic duct, are fertilized by allosperms from the talon, receive a yolk from albumen gland, then pass into uterus, where egg shells are added. Clutches of complete fertilized eggs travel down the oviduct and eventually lay out the genital opening (Emberton, 1985).

- Male organ

Male organ consists of a muscular reversible sheath or tube extending a short distance from the genital aperture backwardes, and gives off, generally where it doubles back, a strong muscle called the retractor penis muscle. The next part contracts into a smaller length of tube, the epiphallus, to which jointed by the vas deferens. After this latter has formed a loop forward and close up to the genital aperture (Blanford and Godwin-Austen, 1908). At the junction of vas deferens and epiphallus is usually a caecum-like, whip-like appendage, flagellum or the kalc-sac, which spermatophore is formed. The spermatophore is a complex structure built up or moulded within the walls of flagellum during the period of generative activity. It consists of two distinct parts : one long and gutter-like, generally spined called flum ; the other a thin-walled cylindrical sac in which the spermatozoa passing down the vas deferens collect (Fig. 2-3) and are retained until transferred into the sperm sac (spermatheca) of another individual to fructify its ova. The spermatophore has various forms in different genera and is still unknown in the great majority of the Land-Mollusca ; it would appear to be secreted rapidly and its remains broken up are soon absorbed and disappeared (Blanford and Godwin-Austen, 1908).

Figure 2-3. Spermatophore morphology of *Macrochlamys pedina* (Blanford and Godwin-Austen, 1908).

During courtship, a large number of sperm pass from the hermaphroditic duct into the male groove, where the sperm are coated with secretion from the prostate gland. In many Stylommatophoran slugs this secretion is hardened forming a spermatophore within a swollen part of vas deferens and epiphallus. The spermatophore may have a very complicated shape, a characteristic of the species, which mirrors the internal form of the epiphallus (Runhum and Hunter, 1970). Spermatophore can often be found in the spermatheca where they were received from another snail during mating (Berry, 1974).

- Amatorial organ

Amatorial organ is a usually tough cylindrical muscular in form, with a retractor muscle at the distal end ; within it is a pointed style, which is protrusive at the genital orifice. In mating, it is protruded from the body to stimulate a partner. The male organ and adjacent parts is reversible and protruded externally during copulation (Blanford and Godwin-Austen, 1908 and Berry, 1974). The amatorial organ of *Hemiplecta distincta* consists of circular and longitudinal muscles, granule secreting cell with secrete neutral – mucopolysacharides, mucocytes which secrete acid – mucopolysacharides and lumen cell which produce zymogenic granules. It is probable that the snail use this secretion for two purposes, first for making the hard swollen structure of amatorial organ in order to protrude out of the body by the accumulation of the secretion granules, second for forming the spermatophore. The ultrastructure of granule secreting cells is discussed. Cytoplasm have a large quantity of

rough endoplasmic reticulum, Golgi bodies and free ribosomes. This organ is protruded externally from the genital aperture and respiratory pore before and during copulation, and secreted some substances which are introduced into the partners (Panha, 1987).

The common genital aperture opens on the right side of the head (Fig. 2-4). The hermaphrodite branch runs along the parietal side of the visceral mass to a point above the stomach, where the hermaphrodite gland, formed one or several clumps of acini, is embedded in the upper lobe of the digestive gland. In large species, the vagina is attached to the pedal wall by very short muscles. Exceptionally, one branch of the free retractors might insert on the atrium or close to the base of the spermatheca. The penis connects the hermaphrodite branch of the genital apparatus into a genital atrium close to the genital aperture, and is generally attached by a penial retractor muscle to either the lung floor (diaphragm) or the stem of the free retractor muscle (Tillier, 1989).

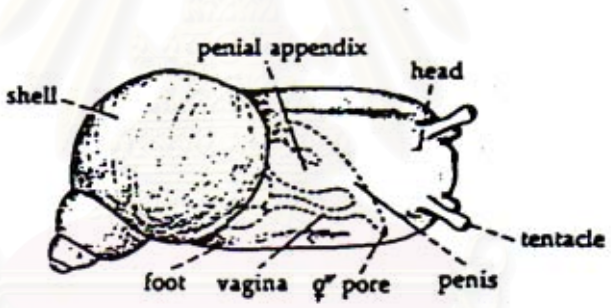


Figure 2-4. Dorsal view of animal showing natural position of terminal genitalia (Burch and Pearce, 1990).

2.2) The morphological description of genus *Macrochlamys,* Cryptozona and *Hemiplecta* in Thailand

Solem (1966) reported on subfamily Ariophantinae that possess long cylindrical dart sac with muscular or calcareous papilla surrounded by its gland (frequently lost) ; epiphallus varying from large and sac-like to a small bulge ; penial retractor rarely simple,

usually with a large coiled retractor caecum or a large straight caecum except in genera with reduced shell. This subfamily divided to 4 tribe : tribe Ariophanti, tribe Macrochlamydi, tribe Girasii and tribe Durgelli

Tribe Ariophanti – They are the largest and most Helicoid like species in the Helicarionidae. The dart apparatus is large. There is generally a prominent retractor caecum, occasionally coiled. The spermatheca is usually short. The epiphallus is greatly enlarged at its head and far removed from the retractor insertion. Occasionally (*Euplecta* and *Hemiplecta*) there will be a distinct epiphallic flagellum, but usually the epiphallus will be a simply swollen tube equal in diameter to that of the penis with the vas deferens entering laterally on the epiphallus head such as in the Dergelli. In many genera the marginal teeth of radula are aculeate. The shell is large with reflected lip or reduced ; tripartite sole with caudal horn and caudal foss. The ectocones of marginal teeth commonly reduced. According to Godwin-Austen in 1881, the spermatophore has very small and close-set spines, quite different from that of the Macrochlamydi. The genera in tribe Ariophanti are *Naninia* Sowerby 1842, *Xesta* Albers 1850, *Euplecta* Semper 1870, *Rhyssotopsis* Ancey 1887(= *Haughtonia* Godwin-Austen 1899) *Hemiplecta* Aibers 1850, *Cryptozona* Morch 1872, *Arioplanta* Desmoulins 1829, *Indrella* Godwin-Austen 1901, *Ravana* Godwin-Austen 1901, *Ratnadvipia* Godwin-Austen 1899, and *Platymma* Tomlin 1938.

The study by Blanford and Godwin-Austen (1908) on snail genus *Hemiplecta* found both developments of right and left shell lobes, but small. The dorsal lobes are large. The left divided into two parts. Mucous pore large, sometimes with an overhanging lobe above. In the generative organ, dart sac is large and cylindrical. The spermatheca is small and pear-shaped. The retracted muscle of the penis attached at about two-third of the length from the distal extremity to the junction of the vas deferens, without any free penial appendix and no epiphallic caecum (Fig. 2-5). Radula is long and broad, with many teeth in a row. The median and admedian are almost triangular, without distinct lateral cusps. The lateral

teeth are unicuspid at the first, but soon become bicuspid and towards the margin are small and narrow (Blanford and Godwin-Austen, 1908).

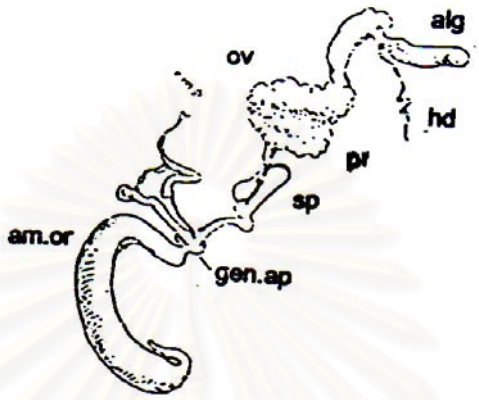


Figure 2-5. Genital morphology of land snail genus *Hemiplecta*
hd=hermaproditic duct, alg=albumen gland, ov=oviduct, pr=prostate, sp=spermatheca, am.or=amatorial organ, gen.ap=generative aperture (Blanford and Godwin-Austen , 1908).

Tribe Macrochlamydi – It is the largest and most varied group. They have very small shell laps and mantle lobes ; a large helicoid shell into which the animal can withdraw ; a rather small caudal horn and a short tail. The spermatheca is long and finger-like. The penis is large, with or without a verge. The penial retractor has a large coiled retractor caecum, rarely straight or free. At the head of the epiphallus lies a large finger-like or flagellar lime-sac appendage (sometime reduced). The large muscular dart apparatus is present in at least some species of most genera. The radula has tricuspid at central and laterals with bicuspid marginals (rarely unicuspid). The jaw has median cutting edge.

Several genera are clustered around the variable grouping termed ''*Macrochlamys*". These genus contain more than 100 described species with general smooth depressed helicoidal shell and certainly will require alteration when retudied (Solem, 1966).

The snail genus *Macrochlamys* has very varied form in shell and shell-lobes as present in some genera. Mantle lobes well developed, the right and left shell lobes both present, short or elongate and generally pointed, extending in some species nearly or quite to the apex of the shell and constantly in motion. One of the most important defining characters in the snail genus *Macrochlamys* is the shell rubbing behavior. When a snail is exposed to sunlight, it often uses the mantle lappet with a mass of mucus to rub on the upper shell, which is the reason for polishing shell. This behavior probably protects the thin shell from heat and desiccation (Panha, 1997).

The study on genitalia of *Macrochlamys* by Blanford and Godwin-Austen in 1908 described a lot of significant portions as follow ; the retractor muscle attachment is at the basal end of the caecum, The coiled caecum is typical form of *Macrochlamys* (Fig. 2-6). The epiphallus is short, the epiphallic caecum is close to the junction with epiphallus with of the vas deferens, and is a long flagellum, a short diverticulum, or a blunt knob. The dart sac or amatrorial organ is usually large, long and cylindrical, the dart muscular. The spermatheca is elongated, more or less club-shaped, sometimes with the bulbous termination. Its shape is necessarily dependent on whether it is empty or containing one or more spermatophores (Blanford and Godwin-Austen, 1908). Spermatophore's length bearing a relative proportion to the flagellum and the spermatophore when it is formed (Godwin-Austen, 1898).

Macrochlamys asamurai is an endemic species from a tropical evergreen forest of Surat Thani. It is compared to the closely related *Syama diadema,* differing by its deep channeled ribs, which are more slender in the upper shell after two and half whorls. Anteriorly, the body is very dark coloured and is red posteriorly, with a black caudal foss and caudal horn. This species is similar in shell morphology to *Nanina (Macrochlamys) diadema* Dall 1897 [the name *Syama diadema* (Dall, 1897) was used by Abbott in1989] from Prang, Malay Peninsula. It has smaller and more numerous ribs, and more delicate

sculpture in upper shell. *N. (M.) diadema* possesses 38 radial grooves, while *M. asamurai* has radial grooves varying in number from 54-59. The generic name *Macrochlamys* for this snail was used because of the significance of its anatomical character (Panha, 1997).

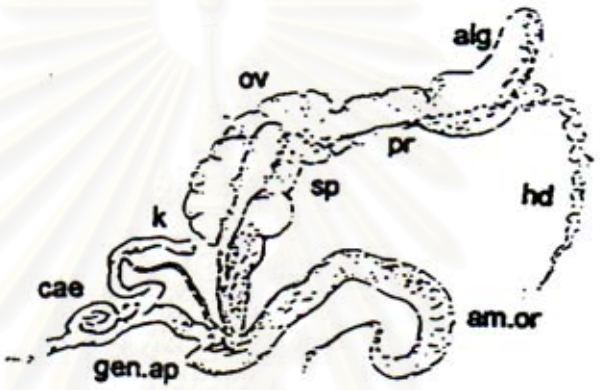


Figure 2-6. Genital morphology of land snail in the genus *Macrochlamys* hd=hermaproditic duct, alg=albumen gland, ov=oviduct, pr=prostate, sp=spermatheca, am.or=amatorial organ, k=kalc sac, cae=caecum, gen.ap=generative aperture (Blanford and Godwin-Austen , 1908).

Sarika Godwin-Austen 1907 is the eastern replacement of *Macrochlamys*, having a large straight retractor caecum (as in many Ariophanti), but otherwise the same genitalia as *Macrochlamys*. *Syama* Godwin-Austen 1908 differs from *Macrochlamys* only in lacking the dart apparatus, a character of doubtful generic value (Solem, 1966). In genus *Syama ;* animal mostly very dark coloured, with right and left shell lobes. No amatorial organ: the male organs are the same as *Macrochlamys* (Blanford and Godwin-Austen, 1908). The present of a long, straight epiphallic retractor caecum is the main character separating Sarika from *Macrochlamys.* Godwin-Austen considered *Sarika* as an eastern geographical replacement of the primarily Indian *Macrochlamys*, and probably most of *Macrochlamys*

from Malaya, Thailand, former Indo-China and southern China should be transferred to *Sarika* (Solem, 1966).

2.3) Genital morphological studies

The basic systematically useful characteristics while dissection of pulmonate snails were outlined by Pilsbry in 1893 referred by Solem in 1972 as follows : shape of the penis : presence or absence of internal papilla and external appendix ; presence or absence of flagellum or epiphallus ; point of insertion of retractor muscle and of vas deferens. Upon the female system should be noticed, the absence or presence of dart sac, dart, mucous gland or appendicular ; the length of the spermathecal duct; the form of caeca of the ovotestis and whether they are embedded in the liver or free locating; and finally whether the right eye-peduncle is retracted between the branches of the genitalia or to the left side.

There are many reports using genital morphology combine with other methods such as shell morphology, reproductive behavior and chromosome numbers studies for classification. The report of Emberton in 1995 showed when shell could not use for classification. So reproductive behavior and genital morphology brought to solve the problem during *Patera laevior* and *Xolotrema foateri* which closest known convergence in sympathy on the flat shell forms, from Hawesville, Hancock County, Kentucky. *P. laevior* has lengthy courtship and mating, intertwinging of penis and external deposition of sperm mass on mate's everted penis. But *X. foateri* has brief courtship and mating, insertion of penis and internal deposition of sperm mass in spermathecal duct. The genital morphology of both species are different in penis and spermatheca shape (Fig. 2-7) (Emberton, 1995).

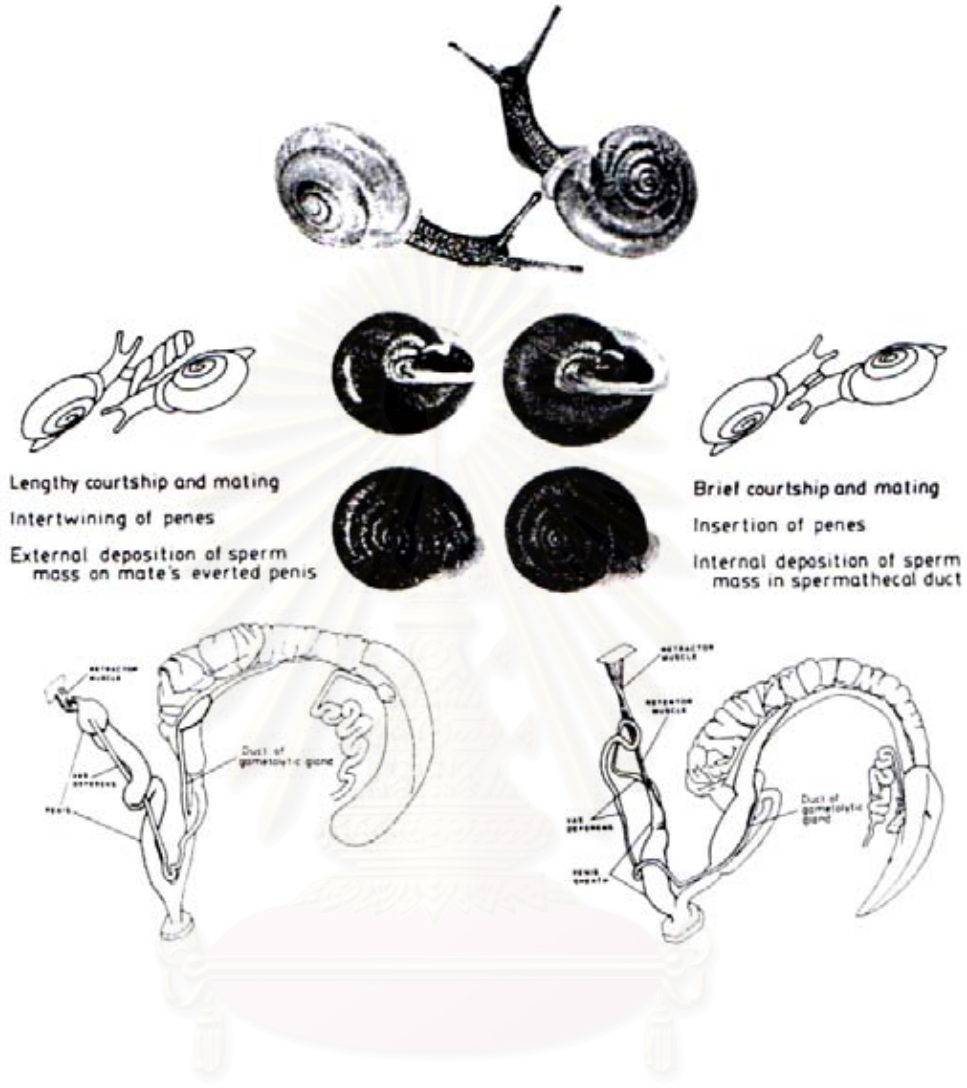


Figure 2-7. Show *Patera laevior* (left) and *Xolotrema fosteri* (right) from Hawesville, Hancock County, Kentucky. Center : external anatomies and shells in two views. Botton : dissected reproductive anotomies. Sides : mating behavioral. (Emberton, 1995)

The study by Porter (1965) in Northwest Pacific, the family Haplotrematidae is represented by two closely related species *Haplotrema vancouverense* and *Haplotrema sportella.* The basic for identification of Pulmonata have been using the shell characteristics; the height/diameter ratio; number of whorls; and radula formula. In recent studies, the shell characteristics have not always been considered satisfactory for classification. The descriptions of the Northwest Pacific pulmonates are based upon somewhat inadequate shell and radula characteristics, the purpose of this study was to attempt the correlation of the genital characters with radula and shell characters for identification. The only shell characters were not sufficient to distinguish the two species. Variations in reproductive tracts of these two species proved to be useful in separating them and were used along with conventional methods. There are 3 basic differences in the morphology of the reproductive tracts of *H. vancouverense* and *H. sportella*. The comparative location of the muscular collar on the vagina, the size of vas deferens, and the shape and size of talon are characteristics for each species. These will be combined with shell and radula characteristics.

When the shell characteristics have not always good characters for classification of gastropods. Consequently, other methods have been sought in order to solve the problems encountered. For examples: Mead studied the morphology of the genitalia of two pulmonates *Ariolimax* and *Achantinida* in 1943. The differences in the genital system between genera and species are considered. As a result, he was able to revise taxonomy of the west coast slugs of the genus *Ariolimax*. Abdel-Malik was able to separate *Helisoma trivolvis* and *Biomphalaria boissyi* by using the histological differences found in the genital organs. Boettger, Webb and Franzen used the morphology of the genitalia to separate genera in the family Succineidae. Watson, Fretter, Johansson and Creek also found these structures useful and necessary in the prosobranch identification (Porter, 1965).

The study by Minato (1984) on genital system of *Satsuma (Luchuhadra) shigetai* in the family Camaenidae characterized by a short appendix of penis, longer penis sheath and

strikingly broadened receptaculum seminis. It is remarkably similar to *Satsuma (Luchuhadra) adelinae* which shell has (1) strikingly low spires, (2) small appendix of penis in genitalia, (3) long penis sheath, (4) broadened stalk of receptaculum seminis at the base.

Minato (1984) also reported on genital system of *Nipponochloritis takedai* in the family Camaenidae characterized by a large appendix of penis and short flagellum. Only two specimens were taken. By its wide umbilicus, this species is closely related to *N. hirasei* from Kii Peninsula, *N. tasanus* from Oki Island , but it easily separated by the following points : (1) smaller shell, (2) delicated hairs at shell (3) larger appendix of penis and (4) shorter flagellum. Later in 1987 Minato illustrated and compared viewpoints of genitalia morphology in the subgenera *Satsuma* and *Luchuhadra* of Japanese camaenid.

Azuma and Okamura (1987) reported on *Euhadra senckenbergiana occidentalis* in the family Bradybaenidae is easily distinguished from typical *Euhadra senckenbergiana* in having oblique and triangularly ovate aperture, 2-4 mucous gland and longer stalk of receptaculum seminis. Also, this subspecies is separated from *Euhadra senckenbergiana ibukicola* by absence of flame pattern and white longer stalk of receptaculum seminis. Further, this subspecies differed from *Euhadra senckenbergiana notoensis*, *Euhadra senckenbergiana minoensis*, *Euhadra senckenbergiana aomoriensis*, and *Euhadra senckenbergiana minoensisiformis* in having large shell and different genital system. *E. senckenbergiana occidentalis* is more or less alike *Euhadra sandai daisenica* but it easily distinguished by the shell surface without flame pattern and different genitalia system. Moreover, *E. senckenbergiana occidentalis* resembles *Euhadra eoa gulicki*, but it easily separated from the latter by very large shell, different color of the soft part, and different genitalia system.

Minato (1989) reported on genitalia of *Nipponochloritis hiromitadae* in the family Camaenidae characterized by very long flagellum. It resembles *Nipponochloritis perpunctalus* in the density of shell hairs, but the latter differs in having flatter penultimate

and the earlier whorls, and genitalia having a small flagellum. *N. hiromitadae* is closely related to *N.okiensis, N. hirasei*, *N. fragosus* and *N. pumila pumila*, in the possession of long flagellum. Among them, two species, *N. okiensis* and *N. hirasei* differ from *N. hiromitadae* in sparser shell hairs and in having very wide umbilicus. *N. fragosus* also resembles *N. hiromitadae* in their density and outer lip with white callus inside, but differs in very larger size and in retractor muscle of penis that is connected to both of penis sheath and epiphallus. Furthermore, *N. pumila pumila* differs from *N. hiromitadae* in lacking of a whitish ringed apertural callus and stalk of receptaculum semisis.

Minato (1989) also reported on genitalia of *Nipponocholitis silvaticus* in the family Camaenidae characteristic by absence of appendix of penis and very long flagellum. It is closely related to *Nipponocholitis hiromitadae* in hair density and outer lip with white callus inside of shell in adult, but differs from the latter in lacking of penial appendix. Furthermore, *Nipponocholitis occidentalis* is very similar to *N. silvaticus* in general appearance of shell, but is distinguished from the latter by structure of genitalia with distinct appendix and no flagellum.

Manganelli et al. (1996) revised on the status of *Xeroamanda*. Anatomical study showed that the type species of *Xeroamanda* is *Helix amanda.*

And the study by Tomiyama (1988) on genital system was showed intraspecific morphological variation in a camaenid land snail, *Satsuma tanegashimae*, which is distributed in the northern parts of the Ryukyu Islands. In the genus *Satsuma,* genital system is rather stable structure. Some characters such as the shape of appendix of epiphallus and flagellum, vary among populations of the same species or even between individuals of the same population, so that they cannot always be used in species discrimination. Discriminant analysis was selected to estimate the distances (Maharanobis D-square: MD) between populations based on genital system characters.

Chapter 3

Materials and Methods

Materials

1) Samples

Most specimens using in the present study were from Chulalongkorn University Museum of Zoology (CUMZ). Additional specimens were collected from many localities in Thailand. (Table 3-1)

2) Genital morphological study

- erlenmeryer flasks
- petri dish
- vials
- forceps
- stainless steel insect pins
- dissecting scissors
- dissecting vessel
- 70% ethanol
- vernier calipers
- stereoscopic dissecting microscope
- camera and color films

3) Radula study

- glass tube
- hot plate
- forceps
- beaker
- brush pen
- petri dish

- vials
- 10% NaOH
- 70% ethanol

Methods

1) Genital morphological study

The snails were maintained in the laboratory in plastic box filled with soil and organic debris from the original habitat. The snails were killed while in a relax state in an erlenmeryer flask filled with cold water for 24-36 hours. When these snails were fully extended, they were then fixed in 70% ethanol. The specimens were later dissected (Fig. 3-1) and the soft parts were held in position on the dissecting vessel by stainless steel insect pins. The genitalia were removed and measured in centimeter. The tissues were preserved in 70% ethanol. Specimens were labeled for record, including the collection number, scientific name, collected date and number of specimens.

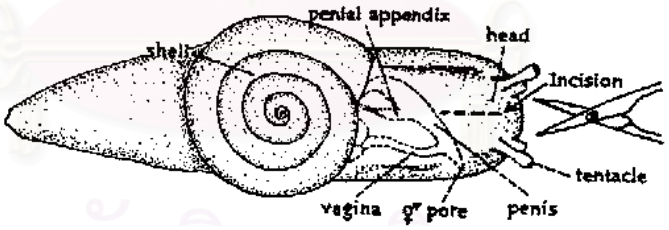


Figure 3-1 Dorsal view of animal showing natural position of terminal genitalia and place for incision to open the dorsal head – foot to observe the lower reproductive system.

All dissected snails were sexually mature and active. After that reproductive tracts were drawn and distinct characteristics were noted.

Table 3-1 Samples of collected land snails genus *Macrochlamys*, *Cryptozona* and *Hemiplecta* in the present study.

Species	Locality	Collection number
Macrochlamys asamurai	Surat Thani	620
Macrochlamys asamurai	Surat Thani	567
Macrochlamys sp.	Chon Buri	685
Macrochlamys sp.	Chanthaburi	557
Macrochlamys sp.	Nakhon Si Thammarat	549
Macrochlamys sp.	Chanthaburi	548
Macrochlamys sp.	Prachuap Khirikhan	690/688
Macrochlamys sp.	Kanchanaburi	703
Macrochlamys sp.	Nakhon Si Thammarat	699
Macrochlamys sp.	Chon Buri	622
Macrochlamys sp.	Chon Buri	711
Macrochlamys sp.	Chanthaburi	719/621
Macrochlamys dugasti	Chiang Mai	632
Syama diadema	Trang	624
Cryptozona siamensis	Mae Hong Son	623
Cryptozona siamensis	Kanchanaburi	633
Cryptozona siamensis	Chiang Rai	637
Cryptozona siamensis	Chon Buri	686
Cryptozona siamensis	Chon Buri	709
Hemiplecta distincta	Paroito	566
Hemiplecta siamensis	Saraburi	226
Hemiplecta neptunus	Laos	635

2) Radula study

The buccal mass was dissected from the snail's head region, and radula was carefully removed. The tissues remaining on radula were removed by using 10% sodium hydroxide solution. The radula was rinsed in water and then preserved in 70% ethanol. Radula was observed by SEM.

3) Measurements

Six genital characters were measured in each snail (Fig. 3-2):

1. Length of penis (PeL) : distance from junction of the penial appendix with the epiphallus to junction with the vagina.
2. Length of penial appendix (PAL) : distance from penial appendix's tip to junction of the epiphallus with the penis.
3. Length of epiphallus (EL) : distance from junction of the epiphallic caecum with the vas deferens to junction of the penial appendix with the penis.
4. Length of epiphallic caecum (ECL) : distance from epiphallic caecum's tip to junction of the vas deferens with the epiphallus.
5. Length of vas deferens (VDL) : distance from junction of the epiphallic caecum with the epiphallus to junction with the prostate.
6. Length of spermatheca (SL) : distance from spermatheca's tip to junction with the vagina.

The shells were measured in 6 variables, method modified from Burch and Pearce in 1990 (Fig. 3-3):

1. Major diameter of shell (MAD)
2. Minor diameter of shell (MID)
3. Height of shell (H)
4. Height of spire (S)
5. Height of aperture (HA)
6. Width of aperture (WA)

Measurements were made with vernier calipers. Anatomical measurements of the genitalia were made under stereoscopic dissecting microscope. All measurements were made by one person to ensure the consistency of any individual error (Johnson et al., 1993). The shell and genital data are given in the Appendix I and II.

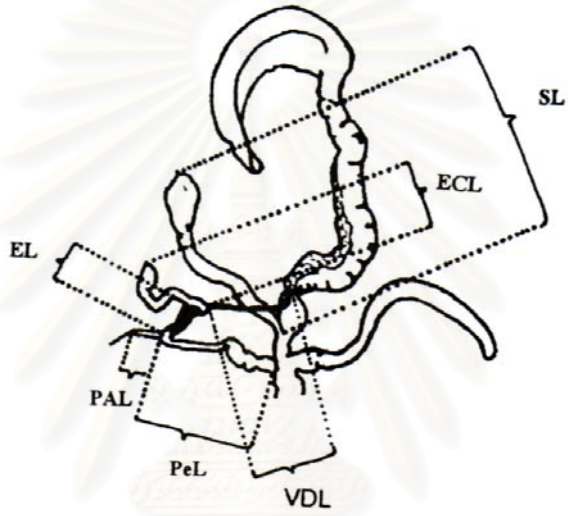


Figure 3-2. Genital characters measurement of snails genus *Macrochlamys, Cryptozona* and *Hemiplecta.* (Abbreviation appeared in the text)

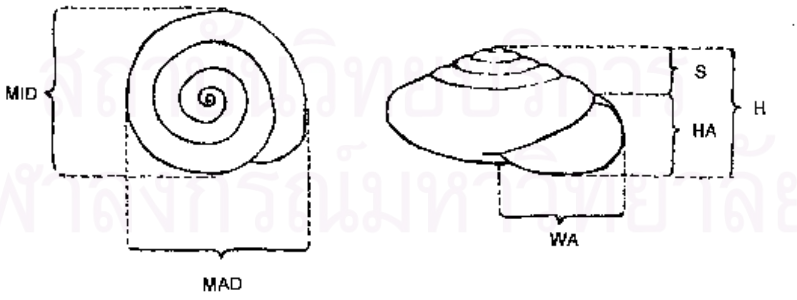


Figure 3-3. Shell morphology measurement of snails genus *Macrochlamys, Cryptozona* and *Hemiplecta.* (Abbreviation appeared in the text)

4) Analyses

After taking these measurements from the 10-20 snails and returning them to vials, the same measurement were repeated. The mean data was used for this analysis. For each of six genital measurements, the regression analysis were performed and regression lines were tested for significance ($p \leq 0.05$) using Analysis of Variance (ANOVA). In order to minimize size error, the recorded genitalia morphological characters were transformed into relative quantity to penial appendix length (PAL), epiphallus length (EL), epiphallic caecum length (ECL) and vas deferens length (VDL).(Ratios data are given in the Appendix III.) One-way analysis of variance (ANOVA) was used to test for significant difference among all species. Duncan's multiple range test was used to classify homogeneous subsets of the means. Probability of $p \leq 0.05$ was considered to be significantly different.

General calculations were performed on computer by Microsoft Excel for Windows 98 version 7.0. Statistical analyses were performed on computer by SPSS for Windows release 7.5.

Chapter 4

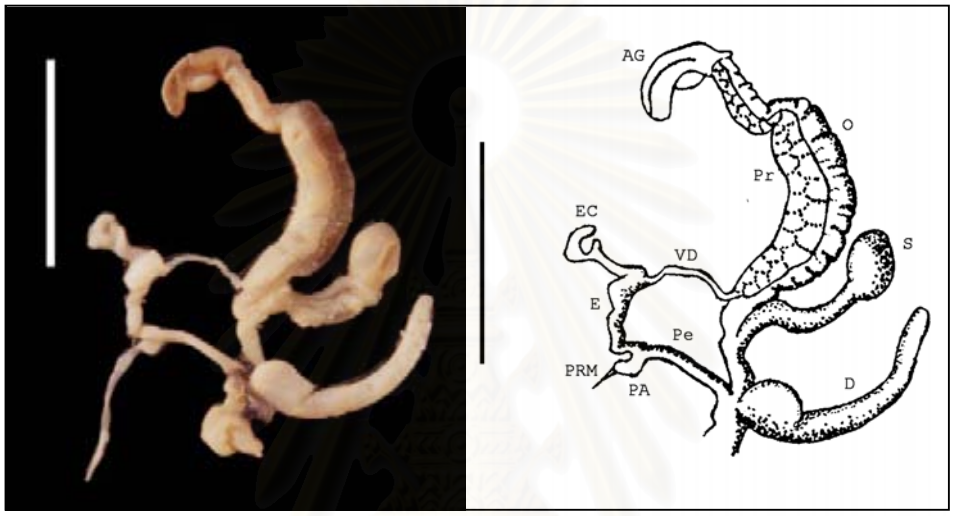
Results

Terrestrial snails genus *Macrochlamys, Cryptozona* and *Hemiplecta* belong to the order Stylommatophora, the superfamily Helicarionoidea and to the family Ariophantidae were collected, observed and classified. Ten species of *Macrochlamys*, one species of *Syama*, two species of *Cryptozona* and four species of *Hemiplecta* are reported. The list is shown in Table 4-1. The details about extreme genitalia are described below.

Table 4-1 Species list of the four ariophantid genera found in Thailand and one species from Laos.

Family	Genus	Species
Ariophantidae	*Macrochlamys*	*M. asamurai* *M. dugasti* *M.* sp. 1 *M.* sp. 2
	Syama	*S. diadema*
	Cryptozona	*C. siamensis* 1 *C. siamensis* 2
	Hemiplecta	*H. distincta* *H. neptunus* *H. siamensis* *H. weinkauffiana*

A



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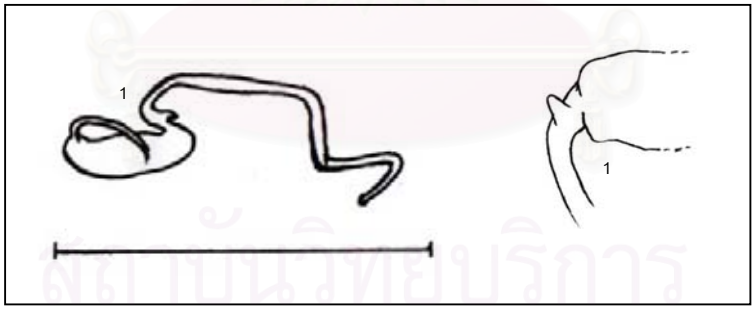


C

Figure 4-1 (A) Shell morphology of *Macrochlamys asamurai* (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys asamurai* (Bar = 1 cm)

(C) Spermatophore morphology of *Macrochlamys asamurai* (Bar = 1 cm)

Macrochlamys asamurai Panha, 1996

(Fig. 4-1A)

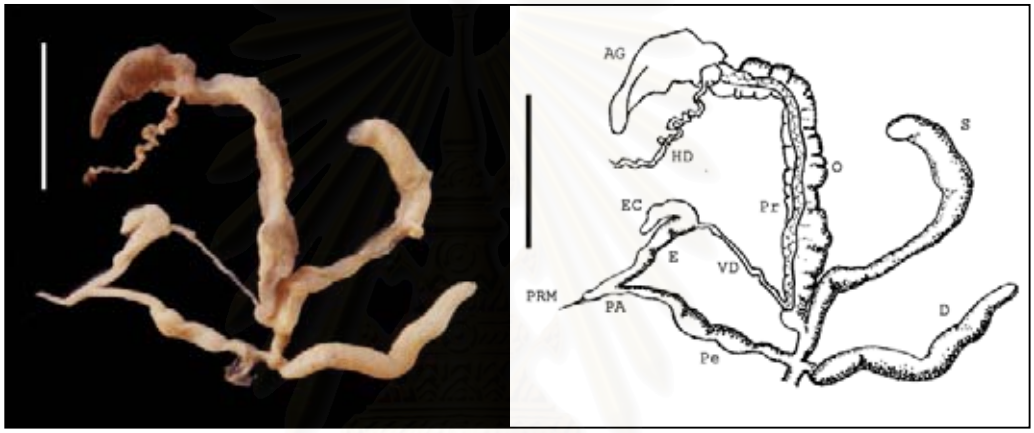
Localities : Khao Sok Wararam and Tepitak temple, Surat Thani

Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. Within the length of the epiphallus of an investigated specimen, a spermatophore was found at an advanced stage of development, the sac of which is indicated by the swollen portion close to vas deferens. There is a moderately long finger-like epiphallic caecum. The spermatheca locating on female side is elongate, sometimes with a bulbous termination, containing one perfectly formed spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 4-1B)

Spermatophore : Spermatophore is spineless shaped. It consists of two distinct parts; (1) very long and gutter-like called flum, quite free of spines on the side (2) a thin-walled long cylindrical sac (or capsule), one knob only at the base of it and with the usually short gutter-like terminal end. (Fig. 4-1C)

Diagnosis : *M. asamurai* should be reclassified as *Sarika asamurai* because of the straight penial appendix, retractor muscle position and spermatophore characteristic are of the genus *Sarika.*

A



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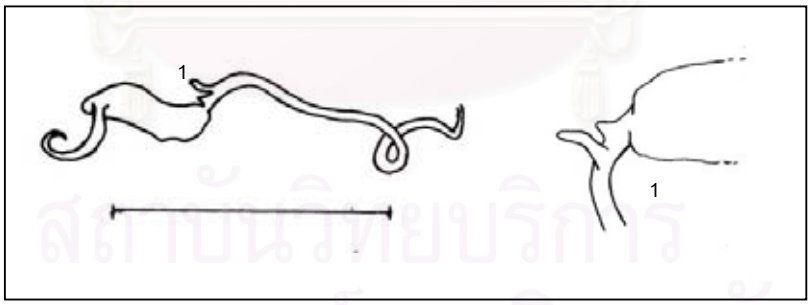


C

Figure 4-2 (A) Shell morphology of *Syama diadema* (Bar = 1 cm)

(B) Genital morphology of *Syama diadema* (Bar = 1 cm)

(C) Spermatophore morphology of *Syama diadema* (Bar = 1 cm)

Syama diadema (Dall, 1897)

(Fig. 4-2A)

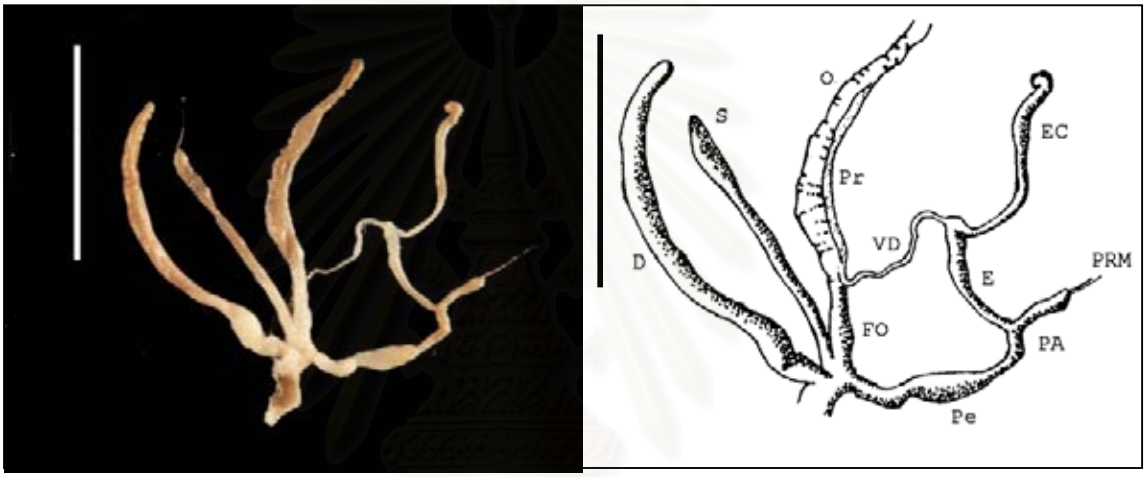
Localities : Botanical Garden, Trang

Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The base of epiphallic caecum where it is joined by vas deferens is thickened. The spermatheca locating on female side is elongate, sometimes with a bulbous termination, containing two perfectly formed spermatophores. The dart apparatus is large, long and cylindrical. (Fig. 4-2B)

Spermatophore : Spermatophore is spineless shaped. It consists of two distinct parts; (1) very long and gutter-like called flum, quite free of spines on the side (2) a thin-walled long cylindrical sac (or capsule), one knob and one spine at the base of it and with the usually short gutter-like terminal end. (Fig. 4-2C)

Diagnosis : *S. diadema* should be reclassified as *Sarika diadema* because of the straight penial appendix, retractor muscle position and spermatophore characteristic are of the genus *Sarika.*

A



B

Figure 4-3 (A) Shell morphology of *Macrochlamys dugasti* (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys dugasti* (Bar = 1 cm)

Macrochlamys dugasti Morelet, 1891

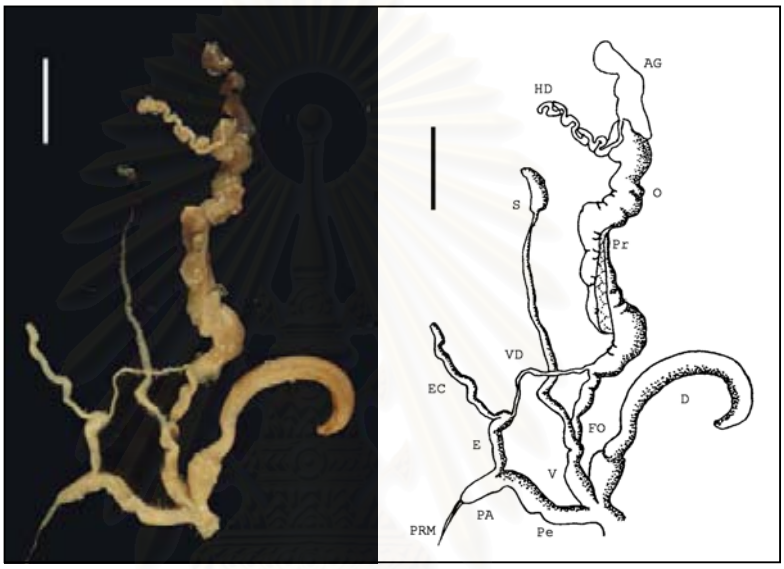
(Fig. 4-3A)

Localities : Doi Intanon, Chiang Mai

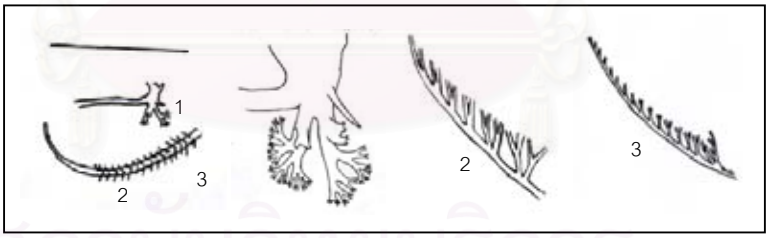
Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The epiphallus is moderately long. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate. Spermatophore is not found. The dart apparatus is large, long and cylindrical. (Fig. 4-3B)

Diagnosis : *M. dugasti* should be reclassified as *Sarika dugasti* because of the straight penial appendix and retractor muscle position are of the genus *Sarika.*

A



B



C

Figure 4-4 (A) Shell morphology of *Macrochlamys* sp 1 (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys* sp 1 (Bar = 1 cm)

(C) Spermatophore morphology of *Macrochlamys* sp 1 (Bar = 1 cm)

Macrochlamys sp. 1

(Fig. 4-4A)

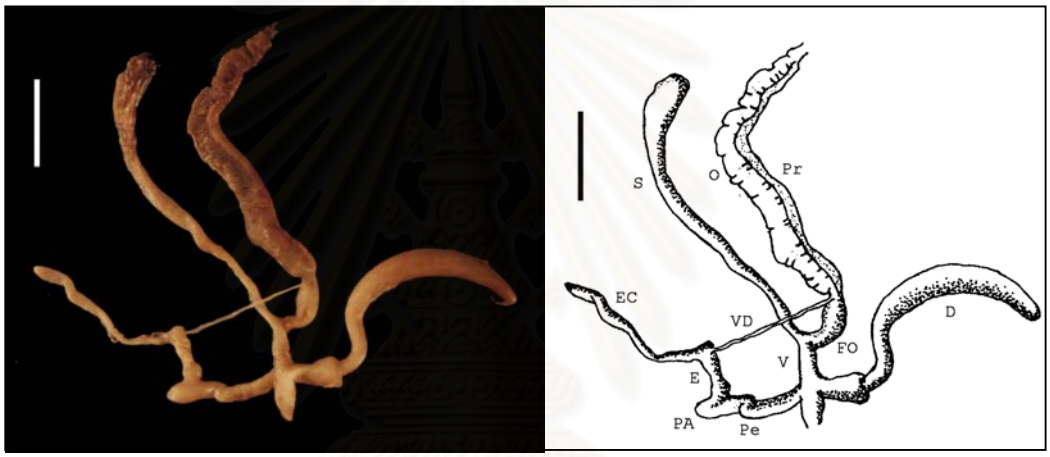
Localities : Khao Soi Dao, Chanthaburi

Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate, sometimes with a bulbous termination, containing one spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 4-4B)

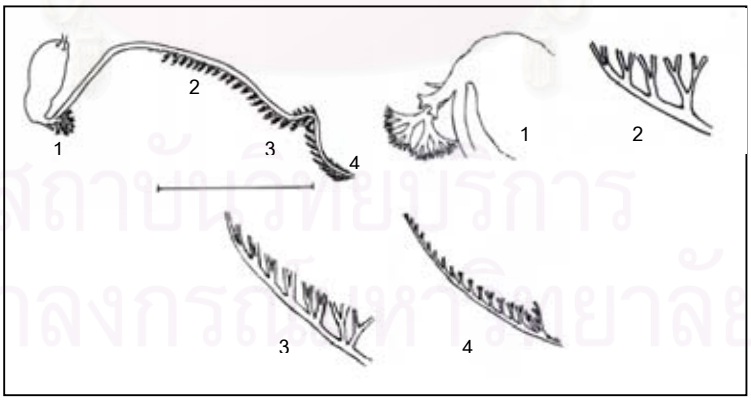
Spermatophore : Spermatophore is spine shaped. It consists of two distinct parts; (1) very long and gutter-like called flum, the first part of it is smooth and the another is generally branches of fine delicate spines on the side. (2) a thin-walled long cylindrical sac (or capsule) which some part was digested by enzyme in spermatheca, and a group of special spines at the base of it. (Fig. 4-4C)

Diagnosis : *M.* sp. 1 should be reclassified as *Sarika* sp. because of the specific genital characteristic which described in the former species. However an investigated spermatophore shows spine characteristic which difference from spermatophore of *Macrochlamys asamura*i and *Syama diadema*. Shell characteristic demonstrates scratched-like transverse striae on the upper surface.

A



B



C

Figure 4-5 (A) Shell morphology of *Macrochlamys* sp 2 (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys* sp 2 (Bar = 1 cm)

(C) Spermatophore morphology of *Macrochlamys* sp 2 (Bar = 1 cm)

Macrochlamys sp. 2

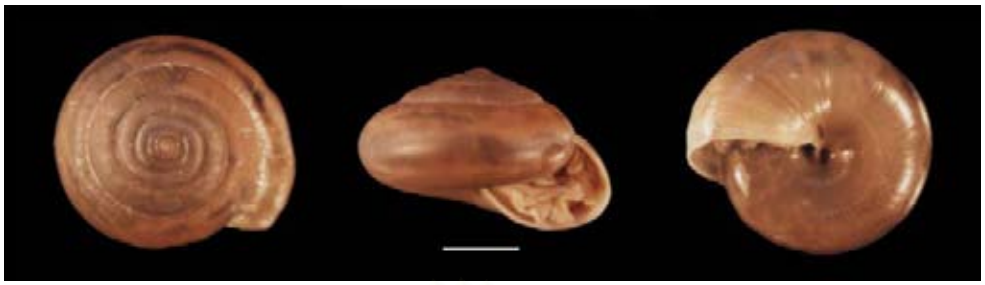
(Fig. 4-5A)

Localities : Plieu Natural Park, Chanthaburi

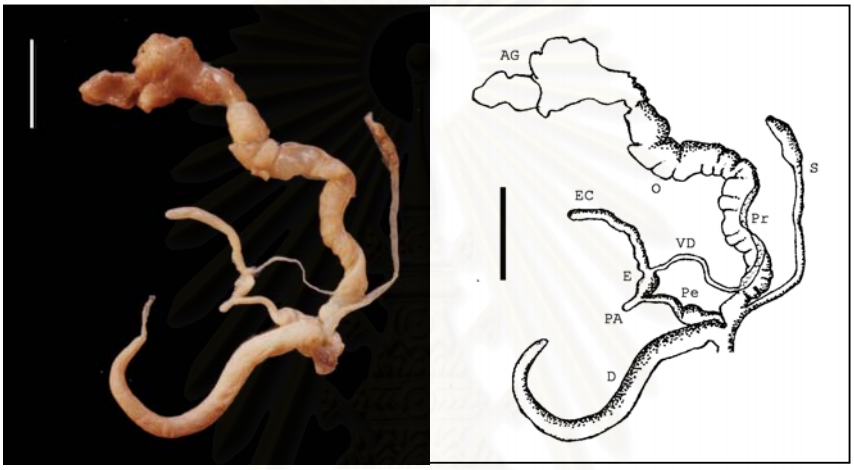
Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate, sometimes with a bulbous termination, containing one perfectly formed spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 4-5B)

Spermatophore : Spermatophore is spine shaped. It consists of two distinct parts ; (1) very long and gutter-like called flum, one-third of its length is smooth and the another is generally branches of fine delicate spines on the side. (2) a thin-walled long cylindrical sac (or capsule), a group of special spines at the base of it and with the usually short gutter-like terminal end. (Fig. 4-5C)

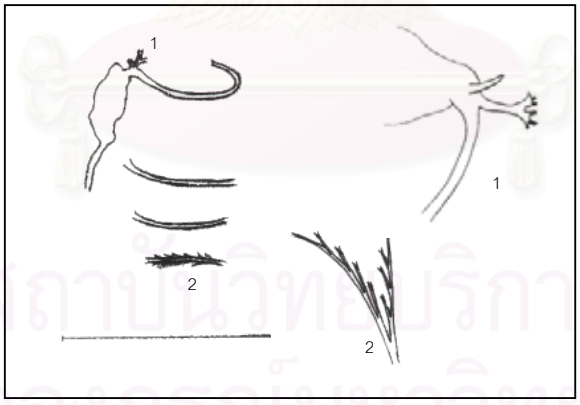
Diagnosis : *M.* sp. 2 should be reclassified as *Sarika* sp. because of the specific genital characteristic which described in the former species. However an investigated spermatophore which look a bit difference at the base of capsule from *M.* sp. 1 shows difference spine characteristic from spermatophore *of Macrochlamys asamurai* and *Syama diadema.*



A



B



C

Figure 4-6 (A) Shell morphology of *Hemiplecta siamensis* (Bar = 1 cm)

(B) Genital morphology of *Hemiplecta siamensis* (Bar = 1 cm)

(C) Spermatophore morphology of *Hemiplecta siamensis* (Bar = 1 cm)

Hemiplecta siamensis (Pfeiffer, 1856)

(Fig. 4-6A)

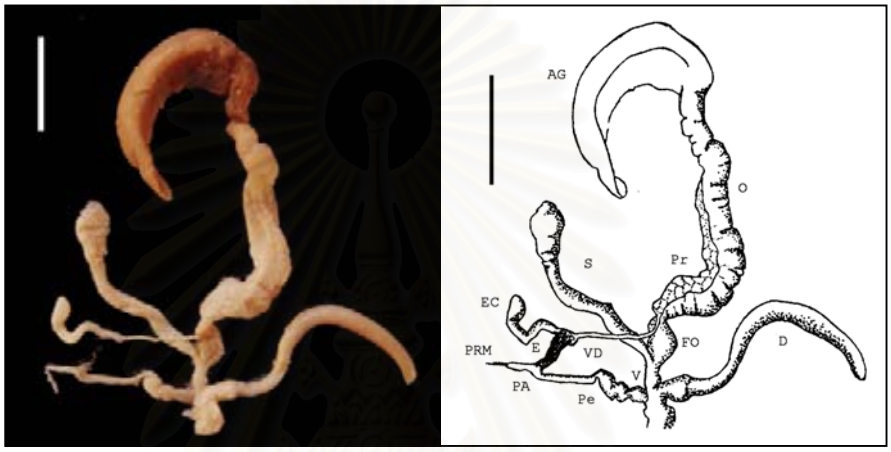
Localities : Pasak Supalai, Saraburi

Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate, sometimes with a bulbous termination, containing one spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 4-6B)

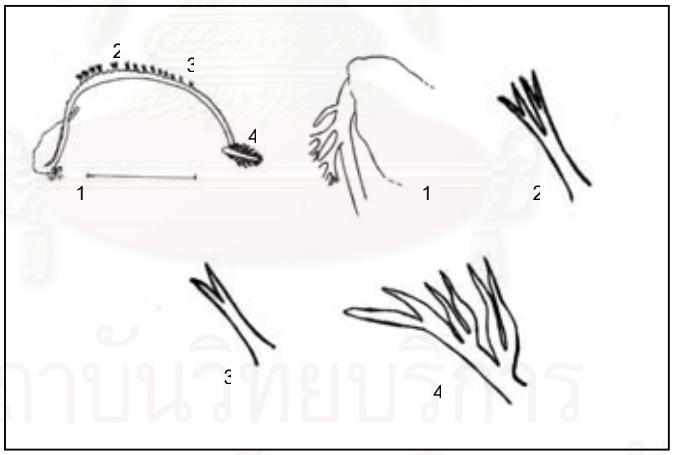
Spermatophore : Spermatophore is spine shaped. It consists of two distinct parts; (1) very long and gutter-like called flum, the first part of it is smooth and the another is generally branches of fine delicate spines on the side. (2) a thin-walled long cylindrical sac (or capsule) which some part was digested by enzyme in spermatheca, and a group of special spines at the base of it. (Fig. 4-6C)

Diagnosis : *H. siamensis* should be reclassified as *Sarika* sp. because of the specific genital characteristic which described in the former species and it exactly difference from *Hemiplecta* in spermatheca and epiphallic caecum characters which Blandford and Godwin-Austen described in 1908. However an investigated spermatophore shows spine characteristic which difference from *Macrochlamys asamurai* and *Syama diadema.*

A



B



C

Figure 4-7 (A) Shell morphology of *Cryptozona siamensis* 1(Bar = 1 cm)

(B) Genital morphology of *Cryptozona siamensis* 1(Bar = 1 cm)

(C) Spermatophore morphology of *Cryptozona siamensis* 1(Bar = 1 cm)

Cryptozona siamensis 1(Tomlin)

(Fig. 4-7A)

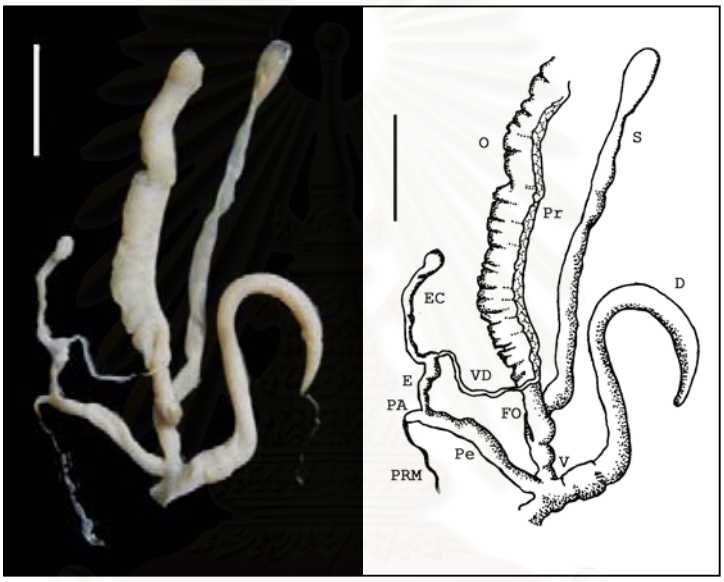
Localities : Phetchabun / Kanchanaburi / Chiang Rai / Chonburi / Chanthaburi / Uthai Thani / Srakaew

Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The epiphllus is blackish colour. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is moderately long, sometimes with a bulbous termination, containing one perfectly formed spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 4-7B)

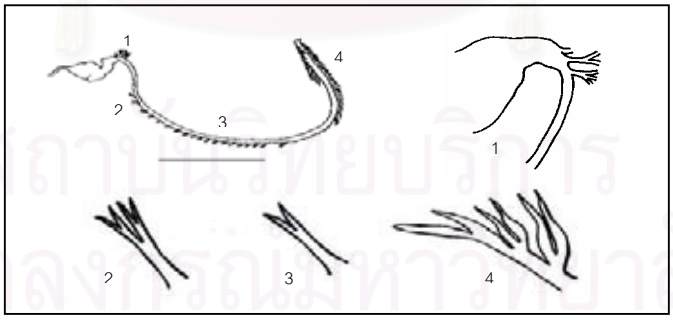
Spermatophore : Spermatophore is spine shaped. It consists of two distinct parts ; (1) very long and gutter-like called flum, one-seventh of its length is smooth and the another is generally branches of fine delicate spines on the side. (2) a thin-walled long cylindrical sac (or capsule), a group of special spines at the base of it and with the usually short gutter-like terminal end. (Fig.4-7C)

Diagnosis : Genital characteristic exhibit : 1) epiphallus presents with blackish colour along its length 2) straight penial appendix 3) long epiphallic caecum. The investigated spermatophore shows spine characteristic, which is specific form of *Cryptozona*.

A



B



C

Figure 4-8 (A) Shell morphology of *Cryptozona siamensis* 2 (Bar = 1 cm)

(B) Genital morphology of *Cryptozona siamensis* 2 (Bar = 1 cm

(C) Spermatophore morphology of *Cryptozona siamensis* 2 (Bar = 1 cm)

Cryptozona siamensis 2 (Tomlin)

(Fig. 4-8A)

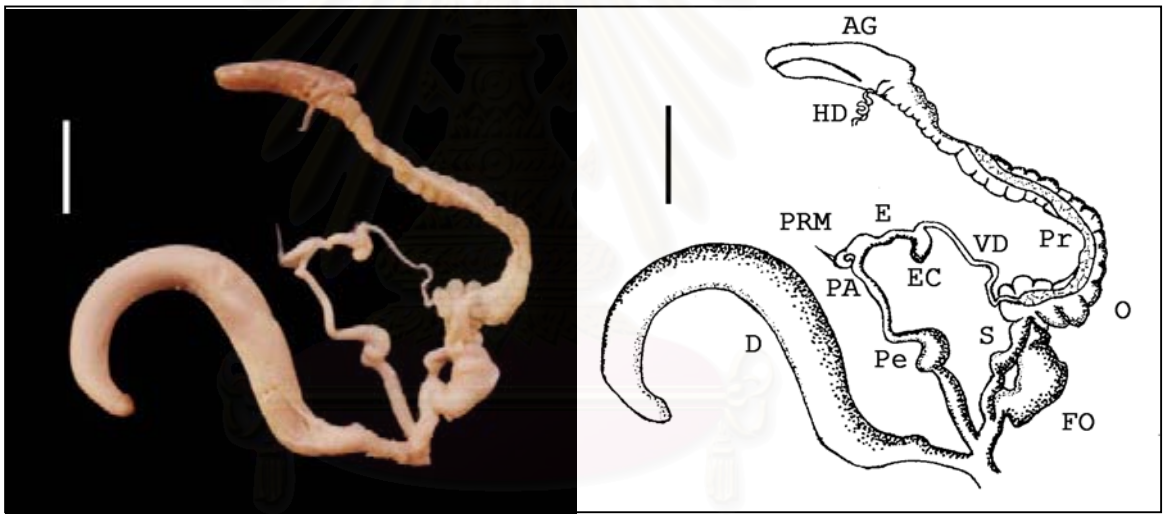
Localities : Manwichai Island, Chonburi

Generative organs : Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The epiphllus is blackish colour. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is moderately long, sometimes with a bulbous termination, containing one perfectly formed spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 4-8B)

Spermatophore : Spermatophore is spine shaped. It consists of two distinct parts ; (1) very long and gutter-like called flum, one-eight of its length is smooth and the another is generally branches of fine delicate spines on the side. (2) a thin-walled long cylindrical sac (or capsule), a group of special spines at the base of it and with the usually short gutter-like terminal end. (Fig.4-8C)

Diagnosis : Genital characteristic exhibit : 1) epiphallus presents with blackish colour near its junction with epiphallic caecum 2) straight penial appendix 3) long epiphallic caecum. The investigated spermatophore shows spine characteristic, which is specific form of *Cryptozona.* Although shell characteristic shows pale colour, whish difference from *C. siamensis* 1.

A



B

Figure 4-9 (A) Shell morphology of *Hemiplecta distincta* (Bar = 1 cm)

(B) Genital morphology of *Hemiplecta distincta* (Bar = 1 cm)

Hemiplecta distincta (Pfeiffer, 1850)

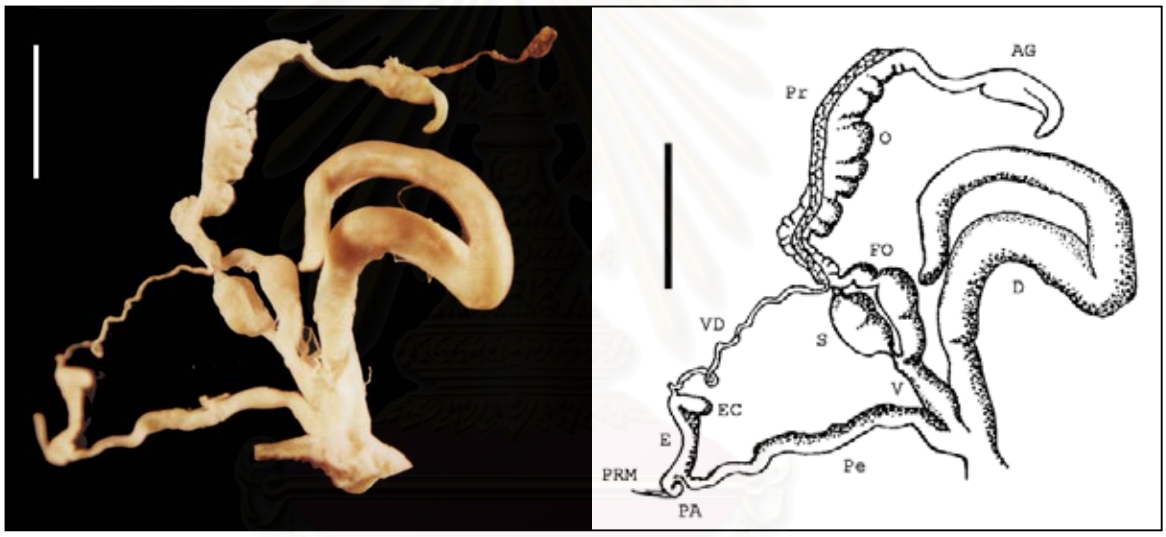
(Fig. 4-9A)

Localities : Samet Island, Rayong / Pa Roi To

Generative organs: Long penis with a short and coiled (sometime straight) penial appendix. The retractor muscle is given off directly at the flexure (sometime at the head) of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The epiphallic caecum is close to the junction with vas deferens, and is a short blunt knob. The spermatheca locating on female side is very short sac. Spermatophore is not found. The dart apparatus is very large, long and thickened. (Fig. 4-9B)

Diagnosis : Genital characteristic exhibit : 1) a short coiled penial appendix (sometime straight) 2) a short blunt knob epiphallic caecum 3) a short spermatheca.

A



B

Figure 4-10 (A) Shell morphology of *Hemiplecta neptunus* (Bar = 1 cm)

(B) Genital morphology of *Hemiplecta neptunus* (Bar = 1 cm)

Hemiplecta neptunus (Pfeiffer, 1861)

(Fig. 4-10A)

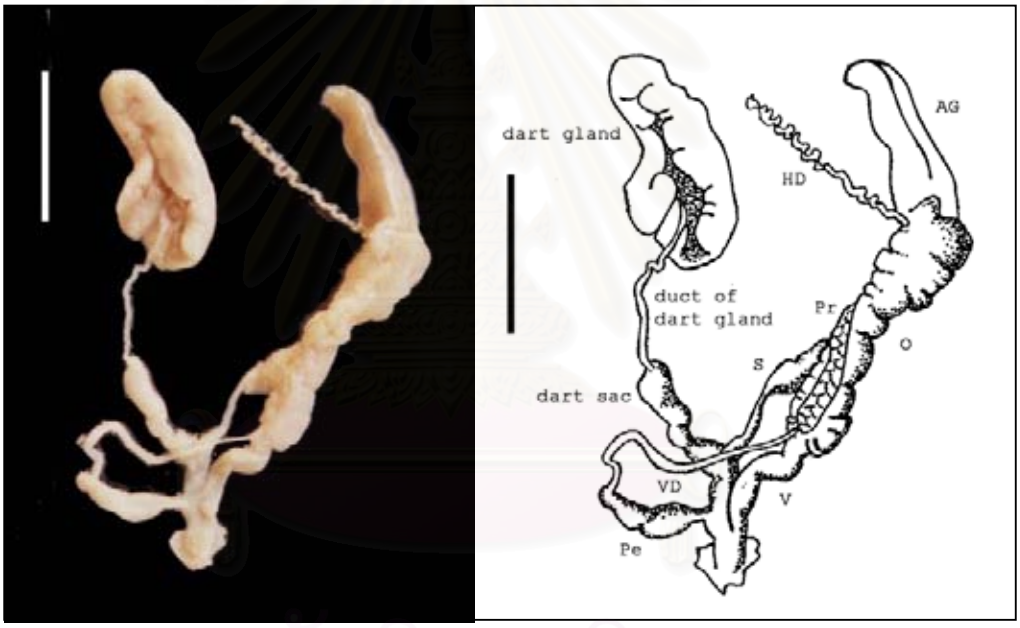
Localities : Pahom, Laos

Generative organs: Long penis with a short and coiled (sometime straight) penial appendix. The retractor muscle is given off directly at the flexure (sometime at the head) of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The epiphallus is short. The epiphallic caecum is close to the junction with vas deferens, and is a short blunt knob. The spermatheca locating on female side is very short sac. Spermatophore is not found. The dart apparatus is very large, long and thickened. (Fig. 4-10B)

Diagnosis : *H. neptunus* shows genital characteristic similar to description of *H. distincta*. However shell characteristic exhibit colour shade which difference from *H. distincta.*

,

A



B

Figure 4-11 (A) Shell morphology of *Hemiplecta weinkauffiana* (Bar = 1 cm)
(B) Genital morphology of *Hemiplecta weinkauffiana* (Bar = 1 cm)

Hemiplecta weinkauffiana Crosse&Fischer, 1863

(Fig. 4-11A)

Localities : Klongsang and Cheawlan, Plieu Natural Park, Surat Thani / Ang Rue Nai, Chanthaburi / Nakhon Nayok / Chachoengsao / Pa Roi To

Generative organs: Penis is a simple tube bent on itself near the short retractor muscle. The spermatheca is moderately long, and on the base of dart sac. The dart sac is short, it having a duct of dart gland at distal end. Spermatophore is not found. (Fig. 4-11B)

Diagnosis : *H. weinkauffiana* should be reclassified as *Diakia weinkauffiana* because of the specific genital characteristic which described in the former species similar to *Dyakia striata* from Singapore and Malaysia. And it exactly differences from *Hemiplecta.*

Extreme genitalia key to genera of *Macrochlamys, Cryptozona* and *Hemiplecta*

1. Genitalia consists of 3 parts ; (1) large , long dart apparatus
(2) male organ (3) female organ with spermatheca at the base
of the free oviduct 2

Genitalia consists of 3 parts ; (1) dart sac with having a duct
of dart gland at the distal end , and spermatheca is on the
base of the dart sac (2) male organ (3) female organ ..... *H. weinkauffiana*
(*Diakia weinkauffiana*)

2. The epiphallus is blackish colour in both fresh and preserved
specimens.....*C. siamensis* 1
C. siamensis 2

The epiphallus is not blackish colour in both fresh and
preserved specimens.....3

3. The spermatheca is very short sac. The epiphallic
caecum is a short blunt knob. ..... *H. distincta*
H. neptunus

The spermatheca is moderately long, sometimes
with a bulbous termination. The epiphallic caecum
is long.....*M. asamurai*
Syama diadema
M. dugasti
M. sp. 1
M. sp. 2
H. siamensis

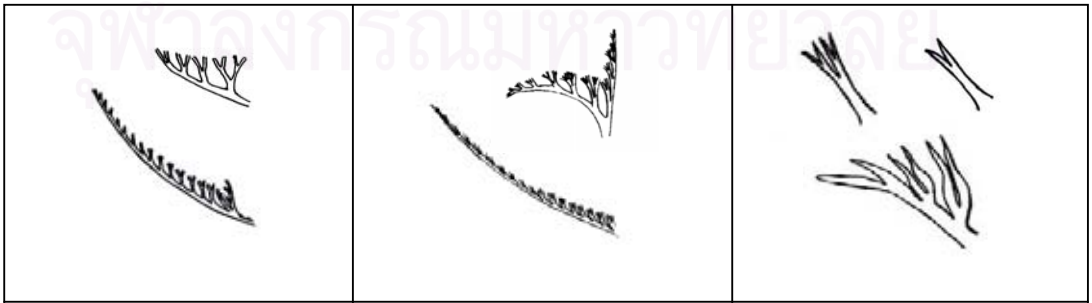
There are four questionable species from different localities for example *M.* sp. 622, *M.* sp. 690/688, *M.* sp. 685, *M.* sp. 699, *M.* sp. 703 and *M.* sp. 711 which present in Appendix IV. Their shell and genital morphology look similar to *M.* sp. 2. Their spermatophore morphological data is very interesting, but there is very rare number in each species. The details about spermatophores in each species that found are shown in Table 4-2. And they could key to species in the genus *Macrochlamys* by using spermatophore characteristic too.

Table 4-2 Spermatophore characteristics in some species

Number of species	Type of spine		Body length (cm.)	Smooth portion/ flume length
	Base of capsule	Along the flume		
M. asamurai	1 knob	-	~2.00	Spineless
S. diadema	1 knob+1spine	-	~2.50	Spineless
M. sp. 1	+1spine	A	**	**
M. sp. 2	+1spine	A	~3.50	1/3
M. sp. 622	+1spine	A	~2.00	1/3-1/4
M. sp. 685	+1spine	A	~2.00	1/3-1/4
M. sp. 711	+1spine	A	~3.00	1/4
M. sp. 690/688	+1spine	B	~2.00	2/3
H. siamensis	+1spine	B	*	*
C. siamensis 1	+1spine	C	~4.50	1/7
C. siamensis 2	+1spine	C	~4.50	1/8

* An investigated spermatophore is broken. Smooth portion may be longer than spine portion.

** An investigated spermatophore is broken. Smooth portion may be shorter than spine portion.

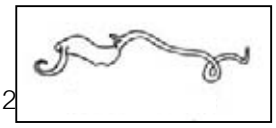


A B C

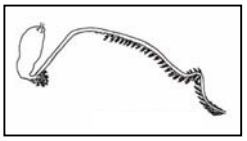
From spermatophore characteristic in Table 4-2, These may be identified with the following key:

Spematophore key to species in the genus *Macrochlamys*

1. Without spines on the side of the flum…...……..2

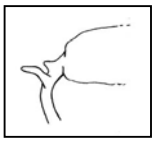


   General branches of fine delicate spine on the side of the flum……..3



2. One knob only at the base of the capsule……*M. asamurai*

   One knob and one spine at the base of the capsule……*S. diadema*



3. Smooth portion longer than spined portion and spine type B on the side of the flum……..4

   Smooth portion shorter than spined portion and spine type A on the side of the flum……..5

4. One branch and one spine at the base of the capsule……*H. siamensis*

   Two branches and one spine at the base of the capsule……*M.* sp. 690/688

5. One branch and one spine at the base of the capsule……*M.* sp. 2

   M. sp. 622

   Two branches and one spine at the base of the capsule……6

6. The base of the two branches confused……..*M.* sp. 1

   The base of the two branches no confused……*M.* sp. 685

   M. sp. 711

Table 4-3 Concluded genital characteristic of all species in the recent study.

System / Species	MALE ORGAN										FEMALE ORGAN					dart apparatus					
		penial appendix		retractor muscle attachment		epiphalus		epiphallic caecum						spermatheca			or dart sac				
	penis	straight	coil	flexure of PA*	head of PA*	black	no black	short	long	vas deferens	prostate	oviduct	free oviduct	short	long	vagina	short	long	carefour	albumen gland	hermaphoditic duct	hermaphoditic gland
M. asamuri	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
S. diadema	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
M. dugasti	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
M. sp 1	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
M. sp 2	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
M. sp 622	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
M. sp 685	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
M. sp 690/688	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
M. sp 699	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
M. sp 703	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
M. sp 711	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
H. siamensis	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
C. siamensis 1	✓	✓			✓	✓			✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
C. siamensis 2	✓	✓			✓	✓			✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
H. distincta	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
H. neptunus	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
H. weinkauffiana	✓	—		✓		✓		—		✓	✓	✓	✓	✓		✓	✓**		✓	✓	✓	✓

* PA means penial appendix

** short with a long cord - like attachment to the dart gland

From the Table 4-3 show genital characteristic of all species in the recent study and each genus is genetically very similar species with complex genital morphological relationships. There is great variation among species in morphology of the reproductive system in each genus. Morphometric analysis should bring to solve this problem. The regression analysis revealed significant linear regression ($p < 0.05$) and correlation coefficient (R) in every pair of genital morphological characters. The results are present in table 4-4. In order to minimize size bias, every morphological character of all specimens were transformed to various parameters in relative to penial appendix length (PAL), epiphallus length (EL), epiphillic caecum length (ECL) and vas deferens length (VDL). One-way analysis of variance (ANOVA) and Duncan's multiple range test were previously made to test for significant different among species and classify them in table 4-5 and 4-6. The present study, only one and two specimens of *M. dugasti* and *H. siamensis* were taken. So they could not bring to test with morphometric analysis.

Table 4-4 shows relationships by using regression analysis. R = correlation coefficient

Relationships	Sig.	R
PAL and PEL	0.000	0.263
EL and PEL	0.000	0.495
ECL and PEL	0.000	-0.270
SL and PEL	0.000	-0.265
VDL and PEL	0.000	0.739
EL and PAL	0.041	0.153
ECL and PAL	0.000	0.481
SL and PAL	0.000	0.499
VDL and PAL	0.005	0.209
ECL and EL	0.877	-0.012
SL and EL	0.487	-0.052
VDL and EL	0.000	0.426
SL and ECL	0.000	0.821
VDL and ECL	0.109	-0.120
VDL and SL	0.028	-0.165

The result of the Regression Analysis shows relationship all pairs of the genital organ length at $p \leq 0.05$ level of significant. From the Table 4-4 shows relation between penial appendix length and penis length (PAL and PeL), epiphallus length and penis length (EL and PeL), epiphallic caecum length and penis length (ECL and PeL), spermatheca length and penis length (SL and PeL), vas deferens length and penis length (VDL and PeL), epiphallus length and penial appendix length (EL and PAL), epiphallic caecum length and penial appendix length (ECL and PAL), spermatheca length and penial appendix length (SL and PAL), vas deferens length and penial appendix length (VDL and PAL), vas deferens length and epiphallus length (VDL and EL), spermatheca length and epiphallic caecum length (SL and ECL), vas deferens length and spermatheca length (VDL and SL) are significant relationships ($p<0.05$), Except epiphallic caecum length and epiphallus length (ECL and EL), spermatheca length and epiphallus length (SL and EL), vas deferens length and epiphallic caecum length (VDL and ECL). And the correlation coefficient (R) shows vas deferens length highly correlate with penis length (VDL and PeL) and spermatheca length highly correlate with epiphallic caecum length (SL and ECL).

The higher length of penial appendix could be related to higher length of penis. The higher length of epiphallus could be related to higher length of penis. The higher length of vas deferens could be related to higher length of penis. The higher length of epiphallus could be related to higher length of penial appendix. The higher length of epiphallic caecum could be related to higher length of penial appendix. The higher length of spermatheca could be related to higher length of penial appendix. The higher length of vas deferens could be related to higher length of penial appendix. The higher length of vas deferens could be related to higher length of epiphallus. The higher length of spermatheca could be related to higher length of epiphallic caecum.

The higher length of epiphallic ceacum could be related to lower length of penis. The higher length of spermatheca could be related to lower length of penis. The higher length of vas deferens could be related to lower length of spermtheca.

Table 4-5 One-way analysis of variance for significant difference in each ratio. The results show significant difference ($p<0.05$) in mean of all ratios among species.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
ECL_PAL	Between Groups	241.878	14	17.277	14.320	.000
	Within Groups	197.859	164	1.206		
	Total	439.737	178			
EL_PAL	Between Groups	299.107	14	21.365	15.774	.000
	Within Groups	222.127	164	1.354		
	Total	521.234	178			
EL_VDL	Between Groups	4.401	14	.314	30.070	.000
	Within Groups	1.714	164	1.045E-02		
	Total	6.115	178			
PAL_ECL	Between Groups	7.643	14	.546	20.666	.000
	Within Groups	4.332	164	2.642E-02		
	Total	11.976	178			
PAL_EL	Between Groups	9.117	14	.651	16.665	.000
	Within Groups	6.409	164	3.908E-02		
	Total	15.526	178			
PAL_VDL	Between Groups	.977	14	6.976E-02	9.465	.000
	Within Groups	1.209	164	7.370E-03		
	Total	2.185	178			
PL_ECL	Between Groups	987.564	14	70.540	116.883	.000
	Within Groups	98.976	164	.604		
	Total	1086.541	178			
PL_EL	Between Groups	149.355	14	10.668	9.465	.000
	Within Groups	184.850	164	1.127		
	Total	334.204	178			
PL_PAL	Between Groups	1402.493	14	100.178	17.904	.000
	Within Groups	917.628	164	5.595		
	Total	2320.121	178			

ANOVA (cont.)

		Sum of Squares	df	Mean Square	F	Sig.
PL_VDL	Between Groups	10.560	14	.754	18.177	.000
	Within Groups	6.805	164	4.150E-02		
	Total	17.365	178			
SL_ECL	Between Groups	42.378	14	3.027	7.371	.000
	Within Groups	67.345	164	.411		
	Total	109.723	178			
SL_PAL	Between Groups	1318.586	14	94.185	12.928	.000
	Within Groups	1194.756	164	7.285		
	Total	2513.342	178			
SL_VDL	Between Groups	94.763	14	6.769	38.917	.000
	Within Groups	28.524	164	.174		
	Total	123.287	178			
VDL_EL	Between Groups	317.539	14	22.681	9.589	.000
	Within Groups	387.937	164	2.365		
	Total	705.476	178			
VDL_PAL	Between Groups	3870.497	14	276.464	22.083	.000
	Within Groups	2053.189	164	12.519		
	Total	5923.686	178			

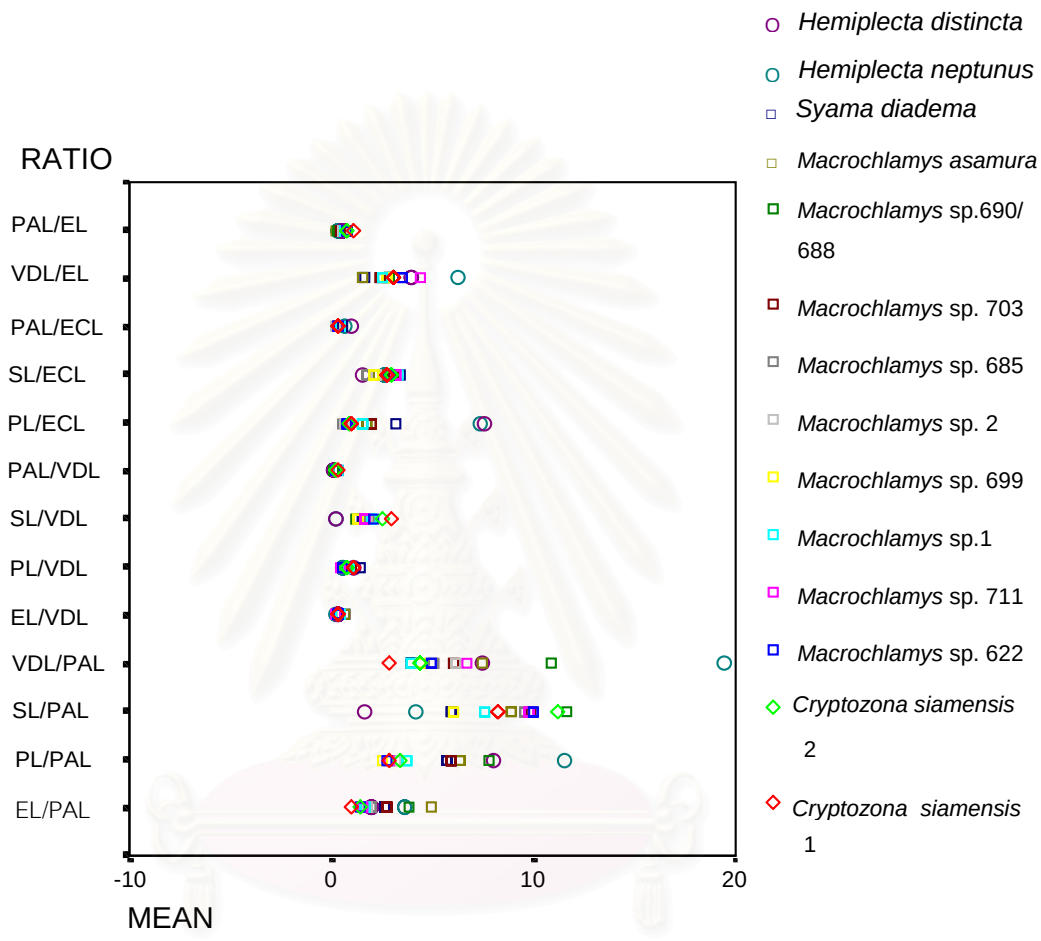
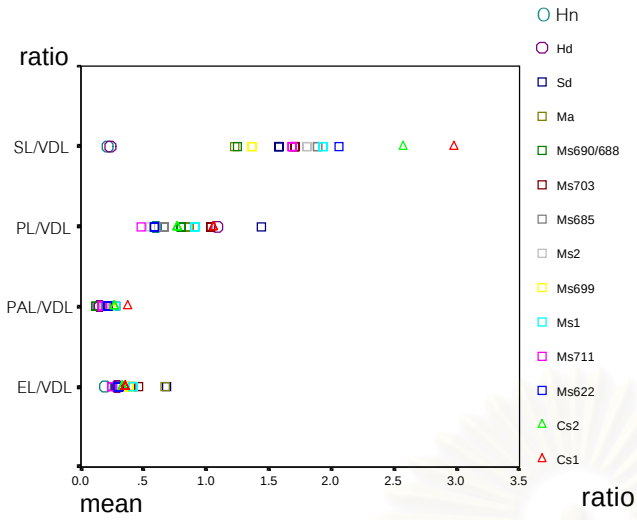
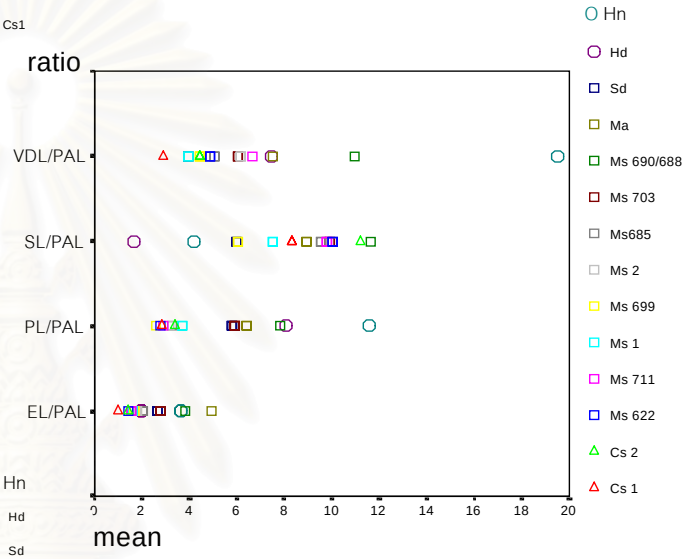


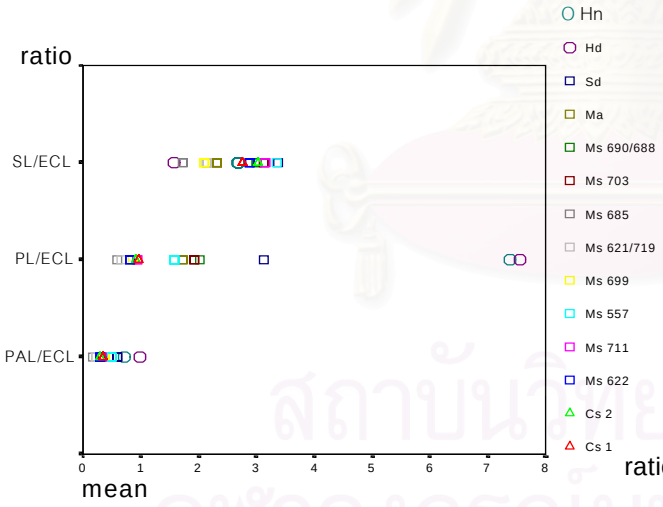
Figure 4-12 Mean of genital organ length ratio for group in each species.



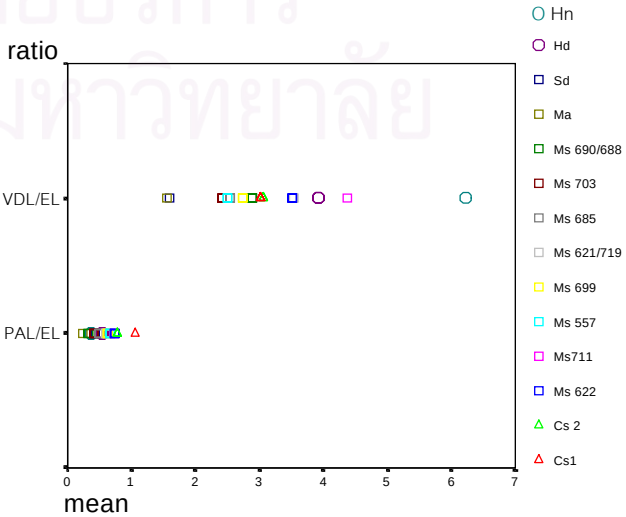
◀ Mean of ratio of epiphallus length, penial appendix length, penis length and spermatheca length to vas deferens length.



▶ Mean of ratio of epiphallus length, penis length, spermatheca length and vas deferens length to penial appendix length.



◀ Mean of ratio of penial appendix length, penis length and spermatheca length to epiphallic caecum length.



▶ Mean of ratio of penial appendix length and vas deferens length to epiphallus length.

Morphometric analysis of reproductive system shows that the ratio of spermatheca length to vas deferens length (SL/VDL) could be use to classified in generic level of *Macrochlamys, Cryptozona* and *Hemiplecta.*

The ratio of epiphallus length to vas deferens length (EL/VDL) could be classsified all terrestrial snails in the recent study into 9 groups from 15 species. The genus *Macrochlamys* could be divided into 9 groups from 10 species. The genus *cryptozona* could be divided into 2 groups from 2 species. The genus *Hemiplecta* could be divided into 2 groups from 2 species. However each group can not be completely separated, because their means overlap.

The ratio of penial appendix length to epiphallus length (PAL/EL) could be classsified all terrestrial snails in the recent study into 9 groups from 15 species. The genus *Macrochlamys* could be divided into 8 groups from 10 species. The genus *cryptozona* could be divided into 2 groups from 2 species. The genus *Hemiplecta* could be divided into 2 groups from 2 species. However each group can not be completely separated, because their means overlap.

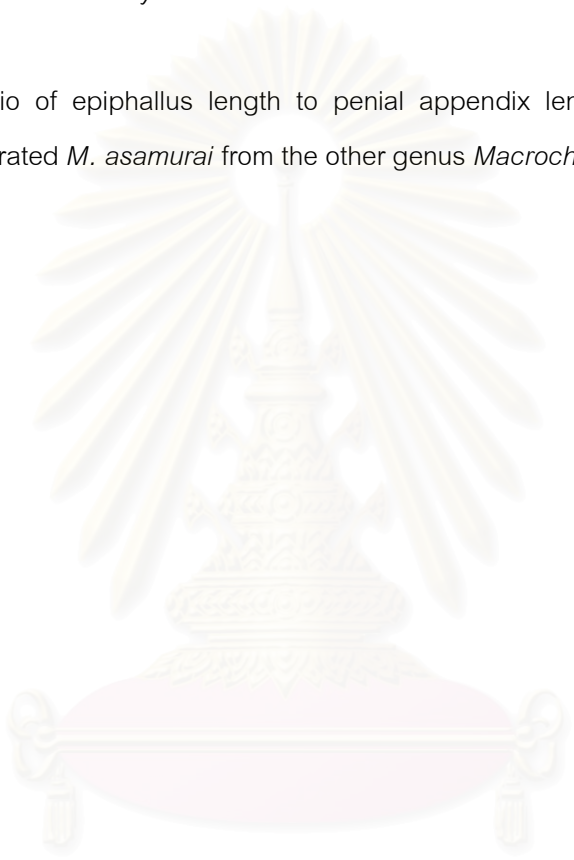
The ratio of spermatheca length to vas deferens length (SL/VDL), penis length to vas deferens length (PL/VDL), penial appendix length to epiphallus length (PAL/EL), spermatheca length to penial appendix length (SL/PAL) and penial appendix length to vas deferens length (PAL/VDL) could be classified snails in the genus *Cryptozona* into 2 groups from 2 species and each group completely separated, their means do not overlap.

The ratio of vas deferens length to epiphallus length (VDL/EL), vas deferens length to penial appendix length (VDL/PAL), spermatheca length to penial appendix length (SL/PAL), spermtheca length to epiphallic caecum length (SL/ECL), penis length to vas deferens length (PeL/VDL), penis length to penial appendix length (PeL/PAL), penial appendix length to vas deferens length (PAL/VDL), penial appendix length to epiphallic caecum length (PAL/ECL) and epiphallus length to penial appendix length

(EL/PAL) could be classified snails in the genus *Hemiplecta* into 2 groups from 2 species and each group completely separated, their means do not overlap.

The ratio of penis length to vas deferens length (PeL/VDL) and penis length to epiphallic caecum length (PeL/ECL) could be completely separated *Syama diadema* from the other genus *Macrochlamys.*

The ratio of epiphallus length to penial appendix length (EL/PAL) could be completely separated *M. asamurai* from the other genus *Macrochlamys.*



Chapter 5

Discussion

Tomiyama (1988) reported that genital structure is very important in systematic studies of pulmonate. In the recent study genital morphology is used to classify genera *Cryptozona*, *Hemiplecta* and *Macrochlamys*. Amatorial organ is a dominant character found in these genera. The main characteristic of the genus *Cryptozona* is blackish epiphallus and long epiphallic caecum. The genus *Hemiplecta* has a very short spermatheca and blunt knob epiphallic caecum. While the genus *Macrochlamys* has a long spermatheca and long epiphallic caecum.

The two endemic Thai crown snails *Syama diadema* (Dall, 1897) and *Macrochlamys asamurai* Panha, 1996 were previously described from Prang, Malaysia and Surat Thani, Thailand respectively. After various later frequent surveys by Panha and his colleagues, the distribution of the two species was clarified only in Southern Thailand (Panha, unpublished information). The general history information of the name “Prang” from Dall’s description in 1897 indicated this particular place in Malaysia, however in Thailand (formerly Siam) has a place name call “Trang”, which is almost the same as “Prang”. There may be some problem on political boundary determine in collecting information, and by many times surveys by Panha and colleagues indicated no sign of crown snails species in Malaysia. The body of *M.asamurai* is very dark color with red posterior trunk, a black caudal foss and caudal horn. In *S. diadema,* the body is only very dark color. The two species look very close by shell morphology, however as from Panha’s description of *M. asamurai* in 1996 the sutural rib numbers different were clarified.

M. asamurai and *S. diadema* anatomical analysis looks very similar in reproductive system but differs in spine number and shape at the capsule’s base of spermatophore. Amatorial organ is a dominant character found in both two species, however this organ is absent in the genus *Syama* (Blanford and Godwin-Austen, 1908).

The straight penial appendix of *M. asamurai* differs from the coiled penial appendix of the genus *Macrochlamys* which Blanford and Godwin-Austen also reported in 1908. After my critical revision,the characteristics of *M. asamurai* and *S. diadema* are definitely belonged to another genus, to the genus *Sarika* in straight penial appendix and retractor muscle is given off directly at the head of it ; amatorial organ has a rounded terminal knob, and spermatophore is spineless shaped (Blanford & Godwin-Austen, 1908 and Solem, 1966). The two species contained the similar spineless shaped characteristics of the genus *Sarika.* They must be reclassified into genus *Sarika.* All specimens of *Macrochlamys* in the present study also contained the similar genital characteristics of the genus *Sarika*, excepts the branches of fine delicate spines on spermatophore's flum. Carefully studied from the literatures and collected specimenscan be concluded that the previous reported *Macrochlamys* from Thailand must be classified into genus *Sarika.* The genital characteristic comparative of the genus *Macrochlamys* by Blandford & Godwin-Austen in 1908*,* the genus *Sarika* by Solem in 1966 and the genus *Macrochlamys* in the recent study are shown in Table 5-1 and Figure 5-1.

The generative organ of *Hemiplecta siamensis* from Saraburi Province has genital description of the genus *Sarika* as *S. hainesii* which Solem (1966) reported in long spermatheca, retractor muscle is given off directly at the head of straight penial appendix, and long epiphallic caecum. It is different from the genus *Hemiplecta* as *Hemiplecta humphreysiana* that distributed in Burma, Siam, The Malay Peninsula and part of Malay Archiplago which Blanford and Godwin-Austen described in 1908. It must be reclassified into *Sarika siamensis.* The comparative genital characteristics of the genus *Hemiplecta* by Blandford & Godwin-Austen in 1908, *H. siamensis* in present study and the genus *Sarika* by Solem in 1966 are presented in Figure 5-2.

The genital characteristics of *Hemiplecta weinkauffiana* in this study look very close to the genus *Dyakia* after carefully revision. All characters are definitely different from of the genus *Hemiplecta* in a short dart sac with having a duct of dart gland at the distal end and spermatheca on the base of dart sac, no penial appendix, and no

epiphallic caecum using *Dyakia striata* from Singapore and Malaysia (Daston and Copeland, 1993). It is different from the genus *Hemiplecta.* It must be reclassified into genus *Dyakia.* The comparative genital characteristics of the genus *Hemiplecta* by Blandford & Godwin-Austen in 1908, *H. weinkauffiana* in the present study and *Dyakia striata* from Singapore and Malaysia are presented in Figure 5-3.

The radula teeth have a relatively simple structure, which is basically the same in all members of the Ariophantidae. Radula of these three genera *Macrochlamys*, *Cryptozona* and *Hemiplecta* are typical each other. The genus *Macrochlamys* has tricuspid central and laterals with bicuspid marginals. The genus *Cryptozona* has central plate of the radula with lateral cusps; lateral teeth with inner and outer cusps ; marginal teeth bicuspid. The genus *Hemiplecta* has triangular central and inner laterals, without distinct lateral cusps. The outer laterals are unicuspid at the first, but gradually become bicuspid and the margins are small and narrow. The SEM photographs of radula in all specimens are given in Appendix V.

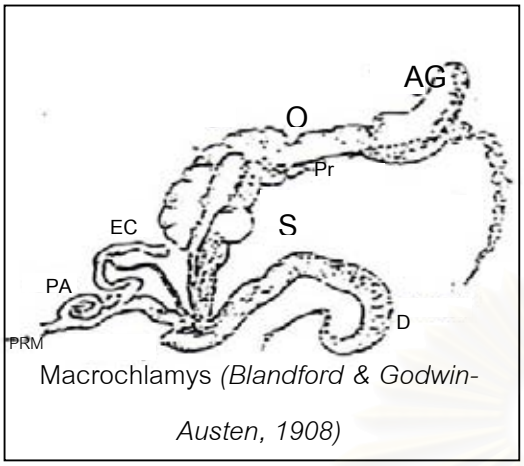
Solem (1966) reported land snails in Thailand on *Cryptozona granulosa* from Chieng Dao and Phu Kradeng ; *H. neptunus* from Kampaengpet ; *H. siamensis* from Sai Yok and Ban Kao ; *H. distincta* from north of Vientiane and Laos. Most specimens were juveniles, some were broken or worn. In this study we used more adult specimens than collection of Solem. The morphometric analysis of genital morphology was used as an important assistance tool for classification. One-way analysis of variance shows significant different ($p<0.05$) in mean of all ratios among species. Regression analysis shows relationship all pair of the genital organ length at $p<0.05$ level of significant, except epiphallic caecum length (ECL) and epiphallus length (EL), spermatheca length (SL) and epiphallus length (EL), vas deferens length (VDL) and epiphallic caecum length (ECL). So the ratio of epiphallic caecum length to epiphallus length (ECL/EL), epiphallus length to epiphallic caecum length (EL/ECL), spermatheca length to epiphallus length (SL/EL), vas deferens length to epiphalic caecum length (VDL/ECL) and epiphalic caecum length to vas deferens length (ECL/VDL) could not bring to test with Duncan's multiple range test. Morphometric analysis of these reproductive systems

shows that the mean ratio of spermatheca length to vas deferens length (SL/VDL) could be used to classify in generic level. The ratio of spermatheca length to vas deferens length (SL/VDL), penis length to vas deferens length (PeL/VDL), penial appendix length to epiphallus length (PAL/EL), spermatheca length to penial appendix length (SL/PAL) and penial appendix length to vas deferens length (PAL/VDL) could be classified in specific level of *Cryptozona siamensis* 1 and *Cryptozona siamensis* 2. Other ratio of vas deferens length to epiphallus length (VDL/EL), vas deferens length to penial appendix length (VDL/PAL), spermatheca length to penial appendix length (SL/PAL), spermatheca length to epiphallic caecum length (SL/ECL), penis length to vas deferens length (PeL/VDL), penis length to penial appendix length (PeL/PAL), penial appendix length to vas deferens length (PAL/VDL), penial appendix length to epiphallic caecum length (PAL/ECL) and epiphallus length to penial appendix length (EL/PAL) could be used to classify in specific level of *Hemiplecta distincta* and *Hemiplecta neptunus*.

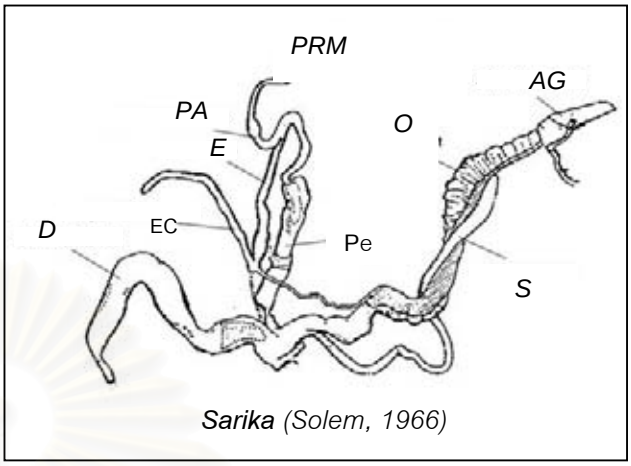
Table 5-1 Comparative genital characteristic of the genus *Macrochlamys* by Blandford&Godwin-Austen in 1908, *Sarika* by Solem, 1966 and *Macrochlamys* in the recent study.

System / Genus	MALE ORGAN									FEMALE ORGAN									reference
	penis	penial appendix		retractor muscle attachment		epiphallus	epiphallic caecum	vas deferens	prostate	oviduct	free oviduct	spermatheca	vagina	dart apparatus	carefour	albumem gland	hermaphroditic duct	hermaphroditic gland	
		straight	coil	base of PA*	head of PA*														
Macrochlamys	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Blanford and Godwin-Austen, 1908
Sarika	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Solem, 1966
Macrochlamys	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	present study

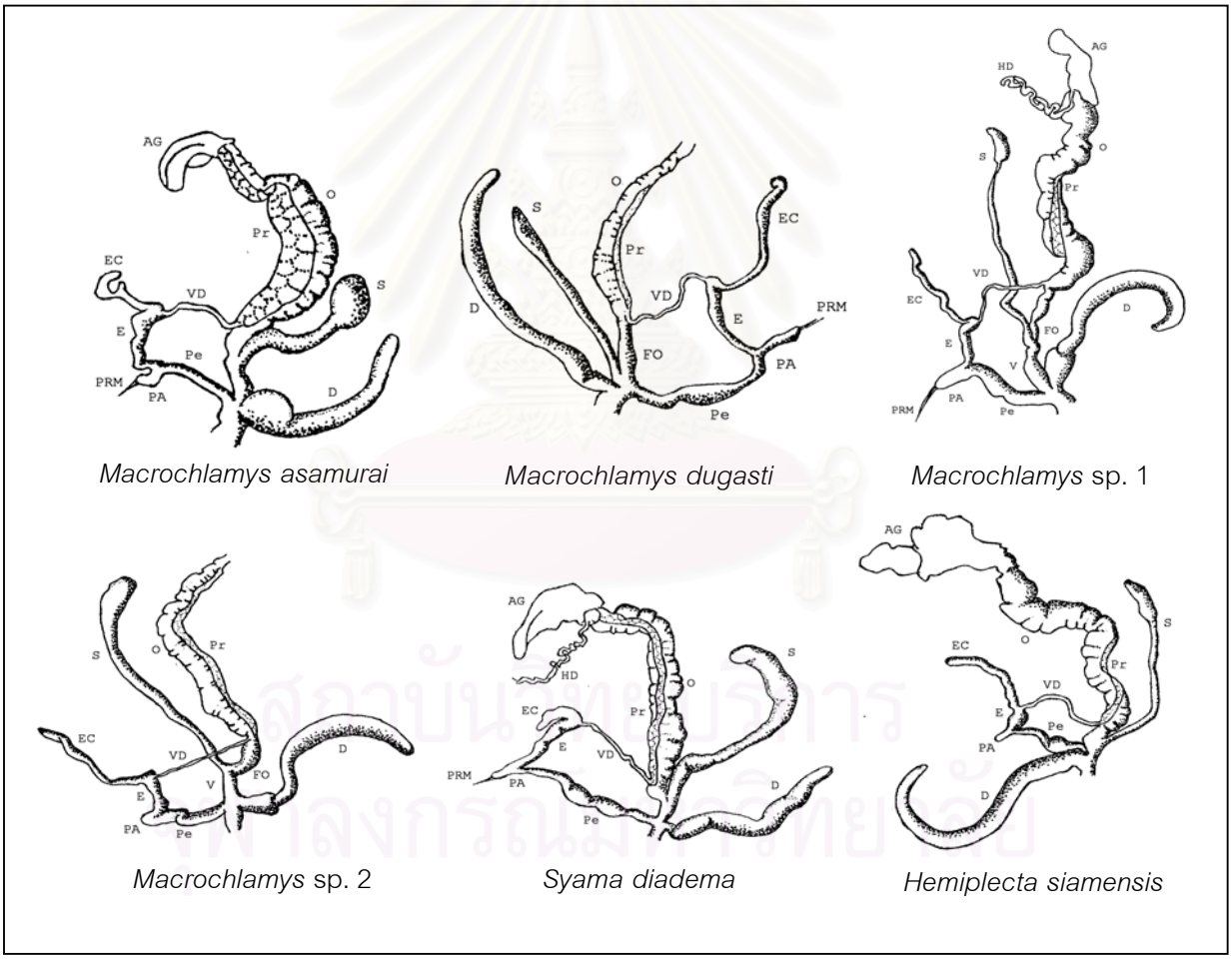
* PA means penial appendix



Macrochlamys *(Blandford & Godwin-Austen, 1908)*



Sarika *(Solem, 1966)*



Macrochlamys asamurai

Macrochlamys dugasti

Macrochlamys sp. 1

Macrochlamys sp. 2

Syama diadema

Hemiplecta siamensis

Figure 5-1 Comparptive genital characteristic of genus *Macrochlamys*, genus *Sarika* and other species contain the genital characteristic of genus *Sarika.*

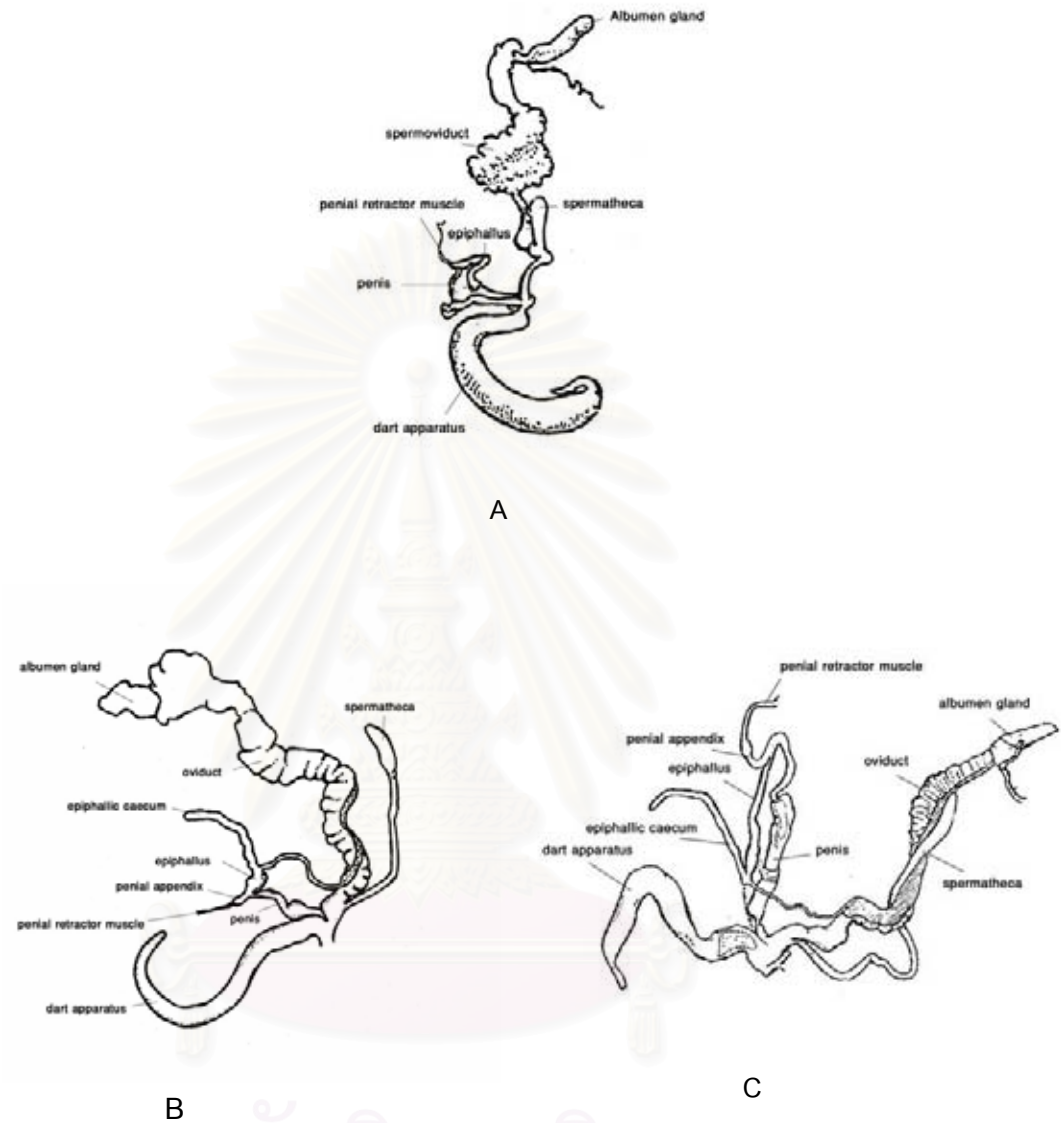


Figure 5-2 Comparative morphology of genitalia between (A) the genus *Hemiplecta* (*H. humphreysiana*) by Blandford & Godwin-Austen in 1908 and (B) *Hemiplecta siamensis* and (C) the genus *Sarika* (*S. hainesii*) by Solem in 1966.

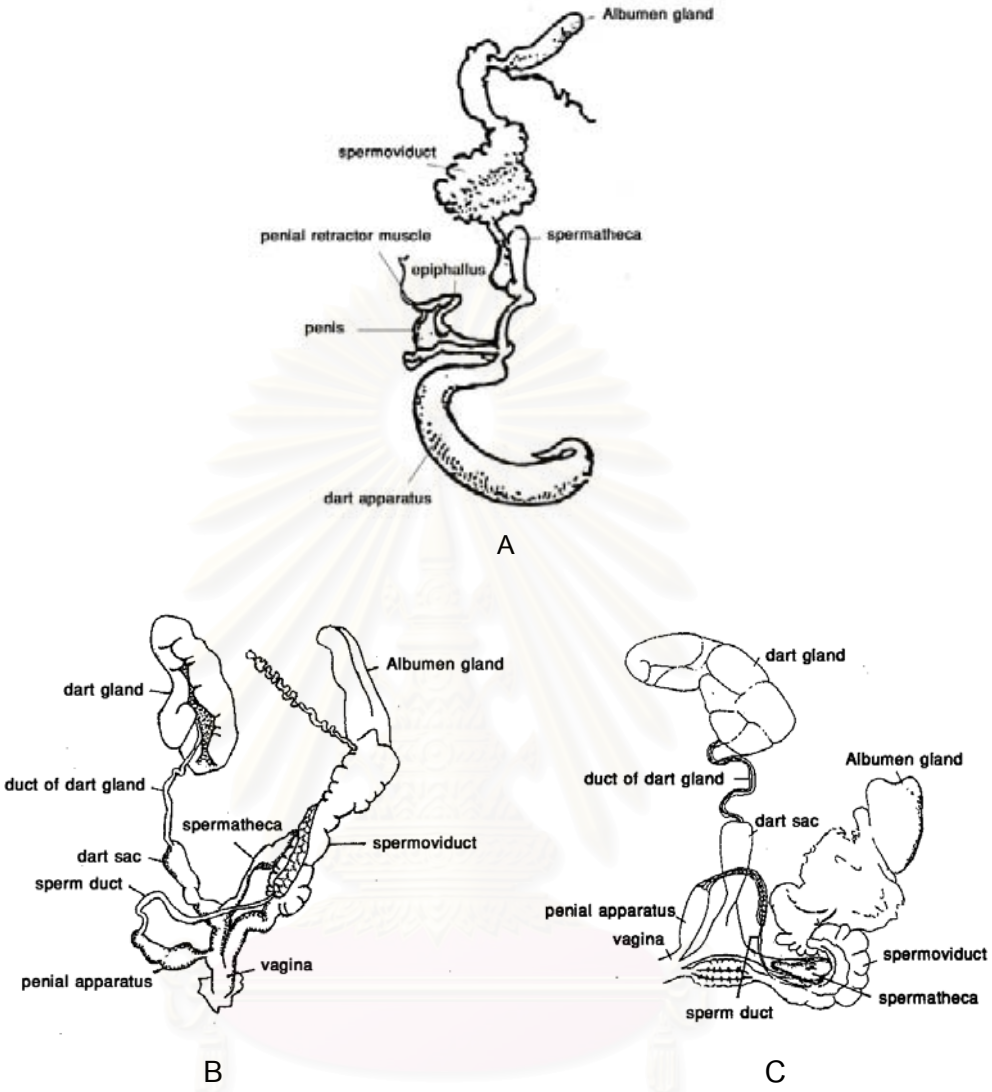


Figure 5-3 Comparative morphology of genitalia between (A) the genus *Hemiplecta* (*H. humphreysiana*) by Blandford & Godwin-Austen in 1908 (B) *Hemiplecta weinkauffiana* and (C) *Dyakia striata* (Daston and Copeland, 1993).

Chapter 6

Conclusion

- All specimens of *Macrochlamys* in recent study must be reclassified as the genus *Sarika* because contain the main genital characteristics as this genus in having long spermatheca, straight penial appendix and retracter muscle is given off directly at the head of it.

- The main genital characteristic of the genus Cryptozona is long spermatheca, blackish colour in epiphallus and long epiphallic caecum. Spermatophore shows spine characteristic, which specific form of this genus.

- The main genital characteristic of the genus *Hemiplecta* is very short spermatheca and blunt knob epiphallic caecum.

- *H. siamensis* in the recent must be reclassified as the genus *Sarika* because it contains the similar genital characteristics as the genus *Sarika.*

- *H. weinkauffiana* in the recent study looks very similar to genital characters of the genus *Dyakia* in dart sac with having a duct of dart gland at the distal end, spermatheca located on the base of dart sac, no penial appendix and no epiphallic caecum. It must be reclassified as the genus *Dyakia*.

- Spermatophore characteristics of *M. asamurai* and *S. diadema* look similar in spineless shaped to the genus *Sarika.*

- Spermatophore in each species is very important data because it is a characteristic of the species. The spermatophore morphological data will be of useful for clarify snails classification when there are much more samples in the further study.

- Morphometric analysis shows genital length could be completely classified in the genera *Cryptozona* and *Hemiplecta.* But the genus *Macrochlamys* shows complex genital morphological relationships. The ratio of spermatheca length to vas deferens length (SL/VDL) could be use to classified in generic level. And the ratio of spermatheca length to vas deferens length (SL/VDL), penis length to vas deferens length (PeL/VDL), penial appendix length to epiphallus length (PAL/EL), spermatheca length to penial appendix length (SL/PAL) and penial appendix length to vas deferens length (PAL/VDL) could be classified in species level of genus *Cryptozona* during *Cryptozona siamensis* 1 and *Cryptozona siamensis* 2. There are many ratios such as the ratio of vas deferens length to epiphallus length (VDL/EL), vas deferens length to penial appendix length (VDL/PAL), spermatheca length to penial appendix length (SL/PAL), spermatheca length to epiphallic caecum length (SL/ECL), penis length to vas deferens length (PeL/VDL), penis length to penial appendix length (PeL/PAL), penial appendix length to vas deferens length (PAL/VDL), penial appendix length to epiphallic caecum length (PAL/ECL) and epiphallus length to penial appendix length (EL/PAL) could be use to classified in species level of genus *Hemiplecta* during *Hemiplecta distincta* and *Hemiplecta neptunus.*

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APPENDICES

APPENDIX I

SHELL MORPHOLOGICAL DATA

Data of shell morphology in the land snails genus Macrochlamys, Cryptozona and Hemiplecta.

See text for explanation of variables.

	Collection number	No.	Major diameter	Minor diameter	Shell height	Spire height	Aperture height	Aperture width
Marcochlamys								
M. asamurai	620	620.1	1.434	1.315	0.840	-	0.662	0.768
M. asamurai	620	620.2	1.960	1.882	0.944	0.672	0.736	0.826
M. asamurai	620	620.3	1.546	1.392	0.932	0.654	0.764	0.840
M. asamurai	620	620.4	1.558	1.420	0.966	0.692	0.768	0.884
M. asamurai	620	620.5	1.416	1.312	0.858	0.628	0.750	0.800
M. asamurai	567	567.6	1.504	1.372	0.882	0.582	0.684	0.820
M. asamurai	567	567.7	1.548	1.410	0.850	0.624	0.664	0.822
M. asamurai	567	567.8	1.404	1.274	0.804	0.540	0.650	0.782
M. asamurai	567	567.9	1.710	1.506	1.050	0.756	0.758	0.940
M. asamurai	567	567.10	1.446	1.268	0.868	0.590	0.690	0.780
M. asamurai	620	620.11	1.500	1.366	0.866	0.586	0.636	0.716
M. asamurai	620	620.12	1.488	1.336	0.840	0.568	0.692	0.818
M. asamurai	14R.1	14R.1	1.586	1.408	-	-	0.676	0.870
M. asamurai	14R.2	14R.2	1.504	1.374	-	-	0.646	0.824
M. asamurai	14P.1	14P.1	1.542	1.414	-	-	0.694	0.870
M. asamurai	14P.2	14P.2	1.622	1.444	-	-	0.702	0.898
M. asamurai	14P.3	14P.3	1.570	1.388	-	-	0.706	0.876
M. asamurai	731	731.1	1.940	1.654	1.060	0.736	0.860	1.070
M. asamurai	731	731.2	1.912	1.710	1.114	0.756	0.864	1.042
M. asamurai	731	731.3	2.044	1.834	1.160	0.782	0.940	1.134
M. asamurai	731	731.4	1.816	1.666	1.000	0.690	0.772	0.984
M. asamurai	731	731.5	1.894	1.664	0.980	0.694	0.830	1.040
M. asamurai	731	731.6	1.876	1.710	1.072	0.744	0.850	1.020
M. asamurai	731	731.7	1.786	1.552	1.054	0.712	0.780	0.988
M. asamurai	731	731.8	1.576	1.386	0.942	0.630	0.752	0.916
M. asamurai	731	731.9	1.820	1.642	1.054	0.750	0.806	0.986
M. asamurai	731	731.10	1.808	1.566	1.058	0.702	0.840	0.980
M. sp 2	719	719.1	2.820	2.534	1.534	1.004	1.164	1.556
M. sp 2	719	719.2	2.594	2.398	1.372	1.012	1.058	1.424
M. sp 2	719	719.3	2.746	2.458	1.314	0.956	1.190	1.518
M. sp 2	719	719.4	2.844	2.546	1.504	1.000	1.192	1.534
M. sp 2	719	719.5	2.642	2.372	1.430	0.986	1.124	1.446

	Collecttion number	No.	Major diameter	Minor diameter	Shell height	Spire height	Aperture height	Aperture width
M. sp 2	719	719.6	2.884	2.570	1.514	0.986	1.158	1.536
M. sp 2	719	719.7	1.984	2.544	1.542	1.030	1.250	1.586
M. sp 2	719	719.8	2.668	2.422	1.438	0.994	1.148	1.340
M. sp 2	719	719.9	2.760	2.496	1.424	0.928	1.162	1.548
M. sp 2	719	719.10	2.526	2.242	1.356	0.902	1.044	1.374
M. sp 2	719	719.11	2.586	2.322	1.362	0.918	1.096	1.404
M. sp 2	719	719.12	2.438	2.208	1.256	0.878	0.984	1.292
M. sp 2	719	719.13	2.462	2.194	1.184	0.842	1.036	1.334
M. sp 2	719	719.14	2.630	2.436	1.316	0.928	1.126	1.430
M. sp 2	719	719.15	2.766	2.540	1.452	0.992	1.182	1.510
M. sp 2	719	719.16	2.620	2.338	1.446	0.976	1.090	1.422
M. sp 2	719	719.17	2.798	2.550	1.448	0.950	1.230	1.540
M. sp 2	719	719.18	2.644	2.342	1.408	0.964	1.114	1.478
M. sp 2	719	719.19	2.940	2.654	1.546	1.068	1.194	1.608
M. sp 2	719	719.20	2.486	2.272	1.248	0.870	1.050	1.352
M. dugasti	632	632.1	1.424	1.340	1.058	0.840	0.658	0.670
M. sp 685	685	685.1	1.958	1.864	1.170	0.862	0.696	1.082
M. sp 685	685	685.2	1.754	1.506	1.014	0.734	0.676	0.980
M. sp 685	685	685.3	2.054	1.872	1.122	0.822	0.838	1.140
M. sp 685	685	685.4	1.964	1.824	1.200	0.914	0.848	1.034
M. sp 685	685	685.5	1.994	1.766	1.130	0.776	0.808	0.976
M. sp 690	690	690.1	1.768	1.626	0.936	0.684	0.736	0.940
M. sp 690	690	690.2	1.920	1.794	1.020	0.724	0.824	1.020
M. sp 690	690	690.3	1.694	1.500	0.914	0.634	0.734	0.930
M. sp 690	690	690.4	1.920	1.766	1.046	0.740	0.774	1.038
M. sp 690	690	690.5	1.700	1.556	0.900	0.638	0.746	0.908
M. sp 690	690	690.6	1.806	1.692	0.986	0.692	0.740	0.960
M. sp 690	690	690.7	1.470	1.322	0.764	0.508	0.612	0.822
M. sp 690	690	690.8	1.870	1.704	1.034	0.724	0.778	1.042
M. sp 690	690	690.9	1.874	1.714	1.016	0.738	0.806	1.016
M. sp 690	690	690.10	1.810	1.620	0.954	0.636	0.758	0.916
M. sp 690	690	690.11	1.790	1.626	0.954	0.644	0.734	0.978
M. sp 688	688	688.2	1.798	1.694	0.936	0.656	0.780	1.006
M. sp 688	688	688.3	1.888	1.758	0.948	0.664	0.786	0.928
M. sp 688	688	688.4	1.772	1.582	0.894	0.644	0.756	0.910

	Collection number	No.	Major diameter	Minor diameter	Shell height	Spire height	Aperture height	Aperture width
M. sp 688	688	688.6	1.722	1.590	0.952	0.660	0.734	0.944
M. sp 688	688	688.7	1.942	1.760	0.994	0.686	0.808	1.040
M. sp 703	703	703.1	1.924	1.746	0.914	0.630	0.796	1.112
M. sp 703	703	703.2	2.540	2.310	1.180	0.844	1.010	1.410
M. sp 703	703	703.3	2.224	2.080	1.078	0.760	0.930	1.210
M. sp 703	703	703.4	2.242	2.120	1.074	0.784	0.916	1.250
M. sp 703	703	703.5	1.850	1.672	0.956	0.650	0.834	1.010
M. sp 703	703	703.6	1.734	1.616	0.886	0.634	0.708	0.944
M. sp 703	703	703.7	1.828	1.646	0.962	0.652	0.782	1.014
M. sp 703	703	703.8	0.734	1.548	0.928	0.624	0.764	0.954
M. sp 703	703	703.9	1.700	1.622	0.886	0.616	0.692	0.932
M. sp 703	703	703.10	1.880	1.660	0.908	0.622	0.800	1.038
M. sp 699	699	699.1	1.788	1.638	1.006	0.720	0.766	0.986
M. sp 699	699	699.2	1.854	1.654	1.000	0.710	0.826	1.022
M. sp 699	699	699.3	1.972	1.790	1.136	0.780	0.822	1.080
M. sp 699	699	699.4	1.918	1.784	1.110	0.800	0.854	1.050
M. sp 699	699	699.5	2.040	1.820	1.190	0.844	0.884	0.968
M. sp 699	699	699.6	1.810	1.598	0.962	0.668	0.764	0.918
M. sp 699	699	699.7	1.972	1.754	1.042	0.744	0.760	1.044
M. sp 699	699	699.8	2.150	1.896	1.170	0.818	0.900	1.182
M. sp 699	699	699.9	2.162	2.000	1.138	0.794	0.922	1.170
M. sp 699	699	699.10	2.032	1.800	1.200	0.822	0.878	1.092
M. sp 622	622	622.1	1.936	1.832	1.200	0.806	0.834	1.062
M. sp 622	622	622.2	1.902	1.752	1.040	0.716	0.710	1.042
M. sp 622	622	622.3	2.044	1.862	1.132	0.784	0.834	1.110
M. sp 622	622	622.4	2.002	1.790	1.654	1.786	0.782	1.074
M. sp 622	622	622.5	2.028	2.010	1.092	0.935	0.833	0.979
M. sp 622	622	622.6	1.884	1.730	0.992	0.712	0.782	1.006
M. sp 622	622	622.7	1.666	1.530	1.028	0.682	0.734	0.898
M. sp 622	622	622.8	-	-	-	-	-	-
M. sp 622	622	622.9	1.664	1.540	0.930	0.630	0.664	0.934
M. sp 622	622	622.10	1.500	1.310	0.842	0.594	0.670	0.802
M. sp 711	711	711.1	2.420	2.194	1.268	0.882	0.956	1.330
M. sp 711	711	711.2	2.616	2.348	1.352	0.894	1.014	1.444
M. sp 711	711	711.3	2.500	2.232	1.364	0.940	1.002	1.374

	Collection number	No.	Major diameter	Minor diameter	Shell height	Spire height	Aperture height	Aperture width
M. sp 711	711	711.4	2.554	2.314	1.358	0.962	1.022	1.406
M. sp 711	711	711.5	2.504	2.288	1.330	0.932	0.988	1.358
M. sp 711	711	711.6	2.472	2.240	1.292	0.938	0.966	1.352
M. sp 711	711	711.7	2.432	2.240	1.264	0.886	0.826	1.336
M. sp 711	711	711.8	2.386	2.146	1.280	0.896	0.982	1.312
M. sp 711	711	711.9	2.752	2.486	1.486	1.030	1.114	1.532
M. sp 711	711	711.10	2.394	2.214	1.364	0.994	0.974	1.292
Syama								
S. diadema	624	624.1OLD	1.834	1.110	-	-	0.806	0.910
S. diadema	624	624.2OLD	1.748	1.606	-	-	0.770	0.869
S. diadema	624	624.1	1.660	1.580	-	-	0.754	0.850
S. diadema	624	624.2	-	-	-	-	-	-
S. diadema	624	624.3	1.750	1.626	-	-	0.766	0.888
S. diadema	624	624.4	1.688	1.572	-	-	0.720	0.840
S. diadema	624	624.5	1.841	1.674	-	-	0.790	0.970
S. diadema	624	624.6	1.734	1.624	-	-	0.786	0.880
S. diadema	624	624.7	1.632	1.526	-	-	0.766	0.800
S. diadema	624	624.9	1.760	1.680	-	-	0.822	0.966
Cryptozona								
C. siamensis 1	177	177.1	3.182	2.820	1.788	1.360	1.320	1.702
C. siamensis 1	205	205.1	2.698	2.530	1.422	1.152	1.042	1.166
C. siamensis 1	224	224.1	2.575	2.392	1.458	1.140	1.280	1.330
C. siamensis 1	633	633.2	3.076	2.748	1.708	1.250	1.332	1.572
C. siamensis 1	633	633.3	2.768	2.678	1.526	1.114	1.234	1.470
C. siamensis 1	633	633.4	2.790	2.690	1.716	1.250	1.196	1.440
C. siamensis 1	633	633.5	2.642	2.424	1.442	1.030	1.148	1.390
C. siamensis 1	633	633.6	2.660	2.532	1.570	1.100	1.180	1.410
C. siamensis 1	637	637.7	-	-	-	-	-	-
C. siamensis 1	637	637.8	2.640	2.576	1.650	1.230	1.246	1.390
C. siamensis 1	637	637.9	2.970	2.720	1.748	1.302	1.300	1.624
C. siamensis 1	637	637.10	2.582	2.410	1.640	1.220	1.100	1.356
C. siamensis 1	637	637.11	2.764	2.560	1.678	1.228	1.208	1.500
C. siamensis	686	686.1	3.068	2.938	2.138	1.490	1.214	1.720
C. siamensis	686	686.2	3.516	3.142	2.328	1.692	1.464	1.848
C. siamensis	686	686.3	3.544	3.082	2.156	1.488	1.346	1.862

	Collecttion number	No.	Major diameter	Minor diameter	Shell height	Spire height	Aperture height	Aperture width
C. siamensis	686	686.4	3.138	2.854	2.004	1.530	1.262	1.684
C. siamensis	686	686.5	2.712	2.508	1.784	1.246	1.142	1.464
C. siamensis	686	686.6	2.496	2.350	1.636	1.116	1.100	1.350
C. siamensis	686	686.7	3.328	3.066	-	-	1.346	1.770
C. siamensis	686	686.8	2.998	2.694	-	-	1.220	1.610
C. siamensis	686	686.9	3.236	2.986	-	-	1.284	1.788
C. siamensis	686	686.10	3.276	3.004	-	-	1.356	1.780
C. siamensis 2	709	709.1	3.414	3.162	2.254	1.654	1.430	1.896
C. siamensis 2	709	709.2	3.512	3.226	2.250	1.584	1.362	1.880
C. siamensis 2	709	709.3	3.484	3.190	2.170	1.522	1.478	1.890
C. siamensis 2	709	709.4	2.892	2.608	1.880	1.282	1.192	1.554.
C. siamensis 2	709	709.5	3.026	2.736	1.912	1.326	1.312	1.652
C. siamensis 2	709	709.6	3.158	2.856	2.006	1.414	1.388	1.760
C. siamensis 2	709	709.7	3.414	3.148	2.336	1.628	1.388	1.822
C. siamensis 2	709	709.8	3.280	3.000	2.154	1.514	1.378	1.802
C. siamensis 2	709	709.9	3.470	3.200	2.234	1.556	1.390	1.862
Hemiplecta								
H. distincta	344	344.1	4.622	4.022	3.976	2.310	2.460	2.500
H. distincta	344	344.3	5.950	5.164	4.326	2.984	2.904	3.014
H. distincta	344	344.4	5.384	4.620	3.662	2.450	2.760	2.822
H. distincta	344	344.5	4.228	3.712	3.372	2.000	2.386	2.152
H. distincta	344	344.6	5.728	4.590	3.780	2.286	2.680	2.920
H. distincta	344	344.7	4.848	4.224	3.518	2.100	2.498	2.472
H. distincta	345	345.2	5.010	4.308	3.686	2.270	2.676	2.550
H. distincta	566	566.8	-	-	-	-	-	-
H. distincta	566	566.9	5.808	5.100	4.068	2.692	3.004	2.960
H. distincta	566	566.10	4.610	4.222	3.550	2.200	2.792	2.562
H. siamensis	226	226.1	3.000	2.688	1.700	1.236	1.246	1.424
H. siamensis	226	226.2	2.996	2.724	1.824	1.490	1.228	1.456
H. weinkauffiana	165	-	3.012	2.486	1.500	1.200	1.000	1.584
H. weinkauffiana	165	-	2.634	2.362	1.390	1.046	1.042	1.300
H. weinkauffiana	197	-	2.692	23578	1.034	1.266	1.160	1.434
H. weinkauffiana	179	-	2.860	2.690	1.460	1.054	0.980	1.394
H. weinkauffiana	179	-	2.540	2.266	1.446	1.090	0.862	1.332
H. weinkauffiana	179	-	2.546	2.268	1.520	1.132	0.922	1.340

	Collecttion number	No.	Major diameter	Minor diameter	Shell height	Spire height	Aperture height	Aperture width
H. neptunus	635	635.1	4.168	3.544	2.572	1.720	1.920	2.200
H. neptunus	635	635.2	4.124	3.538	2.520	1.688	2.040	2.200
H. neptunus	635	635.6	4.618	3.956	2.960	1.980	2.234	2.434
H. neptunus	635	635.3	4.818	4.150	2.730	1.844	2.234	2.534
H. neptunus	635	635.7	4.474	3.870	2.888	2.028	2.074	2.370
H. neptunus	635	635.4	4.350	3.814	2.882	1.960	2.156	2.342
H. neptunus	635	635.5	4.110	3.628	2.610	1.754	1.948	2.234
H. neptunus	635	635.9	4.142	3.622	2.610	1.776	2.040	2.288
H. neptunus	635	635.8	4.990	4.298	3.106	2.126	2.372	2.530
H. neptunus	635	635.10	4.280	3.910	2.660	1.850	1.970	2.226
H. neptunus	635	635.11	4.694	4.180	3.354	2.300	2.156	2.534
H. neptunus	635	635.12	4.474	3.822	3.024	1.262	2.044	2.450
H. neptunus	635	635.13	4.146	3.568	2.686	1.732	2.134	2.314
H. neptunus	635	635.14	4.502	3.900	2.850	1.902	2.204	2.458
H. neptunus	635	635.15	4.864	4.172	2.996	2.044	2.158	2.640
H. neptunus	635	635.16	4.296	3.644	2.704	1.752	2.000	2.368
H. neptunus	635	635.17	3.968	3.404	2.448	1.662	1.820	2.154
H. neptunus	635	635.18	4.320	3.732	2.836	1.876	2.000	2.340
H. neptunus	635	635.19	3.984	3.360	2.764	1.732	1.816	2.130
H. neptunus	635	635.20	4.072	3.552	2.560	1.800	1.774	2.190

APPENDIX II

GENITAL MORPHOLOGICAL DATA

Data for analysis of genital morphology in the land snails genus Macrochlamys, Cryptozona and Hemiplecta.

See text for explanation of variables.

	NO.	Penis Length	Penial appendix Length	Epiphallus Length	Epiphallic caecum Length	Spermatheca Length	Vas deferens Length
C. siamensis 1	633.2	0.710	0.294	0.318	0.994	2.100	0.868
	633.3	0.686	0.264	0.294	0.804	2.298	0.726
	633.4	0.774	0.328	0.300	1.100	2.530	0.838
	633.5	0.820	0.273	0.286	0.966	2.200	0.866
	633.6	0.934	0.331	0.248	0.900	2.294	0.842
	637.7	0.810	0.248	0.234	0.684	1.840	0.422
	637.8	0.852	0.254	0.216	0.922	2.286	1.006
	637.9	0.720	0.258	0.228	0.920	2.140	0.718
	637.10	0.524	0.180	0.200	0.540	2.090	0.740
	637.11	0.772	0.300	0.232	0.470	1.990	0.578
	mean	0.760	0.273	0.256	0.830	2.176	0.760
C. siamensis	686.1	1.272	0.244	0.386	1.348	3.500	1.316
	686.2	1.074	0.222	0.300	0.990	3.140	1.218
	686.3	1.342	0.224	0.462	0.874	3.452	1.242
	686.4	1.438	0.444	0.460	0.936	3.064	1.704
	686.5	0.902	0.230	0.262	1.036	2.068	1.150
	686.6	0.862	0.226	0.290	0.956	1.912	1.130
	686.7	1.342	0.302	0.256	1.042	1.900	1.108
	686.8	0.960	0.360	0.242	0.784	1.886	0.938
	686.9	1.016	0.206	0.254	0.948	1.990	1.024
	686.10	1.132	0.160	0.184	0.762	1.494	0.982
	mean	1.134	0.256	0.310	0.968	2.441	1.181
C. siamensis 2	709.1	1.638	0.382	0.536	1.170	5.226	1.562
	709.2	1.090	0.285	0.444	1.368	4.494	1.866
	709.3	1.666	0.378	0.712	1.880	3.278	2.222
	709.4	1.618	0.660	0.664	1.384	4.060	1.756
	709.5	0.982	0.536	0.588	1.502	4.938	1.598
	709.6	0.898	0.636	0.484	1.392	3.522	1.396
	709.7	1.312	0.364	0.532	1.494	4.184	1.770
	709.8	1.274	0.356	0.444	1.182	3.038	1.382
	709.9	1.092	0.216	0.538	1.340	4.722	1.464
	mean	1.149	0.381	0.494	1.271	3.746	1.493

	NO	Penis	Penial appendix	Epiphallus	Epiphallic caecum	Spermatheca	Vas deferens
		Length	Length	Length	Length	Length	Length
H.distincta	344.1	3.132	0.312	0.964	0.404	0.392	3.000
	345.2	1.502	0.342	0.650	0.220	0.428	1.382
	344.3	3.860	0.410	0.600	0.382	0.706	3.676
	344.4	3.030	0.400	0.700	0.480	0.432	2.714
	344.5	2.752	0.342	0.748	0.384	0.914	2.402
	344.6	2.990	0.308	0.662	0.442	0.572	2.388
	344.7	2.914	0.512	0.904	0.384	0.408	2.180
	566.8	3.336	0.330	0.710	0.480	0.952	3.572
	566.9	3.862	0.482	0.872	0.460	0.894	3.842
	566.10	3.222	0.466	0.654	0.476	0.704	3.490
	mean	3.060	0.390	0.746	0.411	0.640	2.595
S. diadema	624.1OLD	1.440	0.334	0.462	0.380	1.262	0.942
	624.2OLD	1.392	0.204	0.610	0.300	1.032	0.996
	624.1	0.938	0.186	0.374	0.334	1.360	.0740
	624.2	1.244	0.224	0.660	0.402	1.122	0.890
	624.3	1.062	0.240	0.392	0.412	1.440	0.954
	624.4	0.888	0.230	0.498	0.380	1.296	0.640
	624.5	0.824	0.200	0.624	0.350	0.962	0.566
	624.6	1.740	0.124	0.742	0.504	1.236	0.870
	624.7	1.118	0.226	0.492	0.336	1.540	0.628
	624.9	1.122	0.252	0.572	0.380	1.302	1.090
	mean	1.177	0.222	0.543	0.378	1.284	0.832
I. neptunus	635.1	1.810	0.114	0.540	0.322	0.542	2.712
	635.2	1.900	0.110	0.500	0.234	0.600	3.242
	635.3	1.654	0.122	0.630	0.264	0.684	3.070
	635.4	1.672	0.144	0.410	0.290	0.800	3.460
	635.5	2.070	0.156	0.570	0.300	0.760	3.490
	635.6	2.090	0.140	0.720	0.316	0.705	3.524
	635.7	2.312	0.162	0.480	0.300	0.850	3.212
	635.8	1.720	0.120	0.324	0.254	0.608	1.984
	635.9	0.936	0.114	0.390	0.272	0.366	2.322
	635.10	1.552	0.106	0.386	0.230	0.578	2.718
	635.11	2.172	0.222	0.760	0.264	0.808	3.572
	635.12	2.270	0.228	0.840	0.280	0.716	3.538
	635.13	2.056	0.206	0.618	0.202	0.778	3.484
	635.14	0.938	0.264	0.542	0.240	0.764	3.616

	NO.	Penis Length	Penial appendix Length	Epiphallus Length	Epiphallic caecum Length	Spermatheca Length	Vas deferens Length
	635.15	2.412	0.168	0.714	0.308	0.828	3.308
	635.16	2.188	0.316	0.162	0.250	0.724	3.412
	635.17	2.276	0.172	1.194	0.260	0.802	4.024
	635.18	2.028	0.250	1.010	0.206	0.532	3.382
	635.19	1.796	0.202	0.704	0.216	0.466	2.940
	635.20	2.326	0.270	0.706	0.236	1.000	3.610
	mean	1.909	0.179	0.563	0.263	0.693	3.231
M.asamurai	620.1	0.462	0.088	0.462	0.432	0.884	0.864
	620.2	0.180	0.152	0.610	0.572	0.980	0.822
	620.3	0.342	0.120	0.758	0.498	0.865	0.894
	620.4	0.710	0.094	0.532	0.418	0.870	0.930
	620.5	0.740	0.126	0.588	0.444	0.980	0.726
	567.8	0.794	0.098	0.616	0.570	0.832	0.720
	567.9	0.874	0.100	0.654	0.672	1.070	0.844
	567.10	0.784	0.082	0.522	0.392	0.704	0.888
	620.11	0.882	0.098	0.490	0.392	0.634	0.778
	620.12	0.460	0.140	0.480	0.406	0.680	0.718
	14R.1	1.342	0.430	0.776	0.660	1.254	1.250
	14R.2	0.938	0.208	0.794	0.730	1.142	1.102
	14P.1	1.088	0.236	0.632	0.430	1.156	1.166
	14P.2	1.082	0.252	0.582	0.442	1.198	1.698
	14P.3	1.176	0.318	0.810	0.492	1.304	1.006
	731.1	1.590	0.176	1.258	0.584	2.140	1.916
	731.2	1.520	0.158	0.916	0.846	2.172	1.196
	731.3	1.902	0.192	1.104	0.706	2.180	1.882
	731.4	1.088	0.170	0.720	0.738	1.862	1.436
	731.5	1.306	0.166	1.106	0.670	2.404	1.430
	731.6	1.280	0.138	0.932	0.748	2.234	1.326
	731.7	1.132	0.132	0.880	0.664	1.720	1.316
	731.8	1.048	0.170	0.744	0.468	1.826	1.182
	731.9	0.490	0.148	0.734	0.532	0.916	1.152
	731.10	1.146	0.138	0.658	0.774	1.580	0.896
	mean	0.972	0.165	0.734	0.571	1.344	1.126
M. sp 685	685.1	0.806	0.228	0.473	1.242	1.870	1.020
	685.2	0.696	0.188	0.360	1.044	1.886	0.906
	685.3	0.682	0.214	0.480	1.214	2.206	1.016

	NO.	Penis	Penial appendix	Epiphallus	Epiphallic caecum	Spermatheca	Vas deferens
		Length	Length	Length	Length	Length	Length
	685.4	0.582	0.184	0.400	0.914	1.878	1.080
	685.5	0.700	0.250	0.414	1.492	2.216	1.350
	mean	0.693	0.213	0.425	1.181	2.011	1.074
M. sp 1	557.1	1.460	0.494	0.672	1.434	3.570	1.440
	557.2	1.612	0.292	0.590	0 942	3.040	1.514
	557.3	0.732	0.470	0.614	0.520	2.020	1.168
	557.4	1.842	0.552	0.600	1.082	3.832	2.190
	557.5	1.712	0.336	0.770	0.836	2.956	1.732
	mean	1.472	0.429	0.649	0.963	3.084	1.609
M. sp 690	690.1	1.220	0.108	0.456	0.354	1.610	1.082
	690.2	1.192	0.132	0.406	0.508	1.800	1.158
	690.3	0.698	0.030	0.374	0.212	0.590	1.172
	690.4	1.024	0.132	0.564	0.694	1.330	0.920
	690.5	0.714	0.178	0.446	0.344	0.842	0.938
	690.6	0.796	0.146	0.552	0.640	2.072	1.086
	690.8	1.242	0.158	0.610	1.184	2.446	2 198
	690.9	1.138	0.168	0.404	0.496	1.682	1.432
	690.10	1.142	0.134	0.520	0.560	1.554	1.290
	690.11	1.062	0.148	0.502	0.556	1.886	1.006
M. sp 688	688.2	1.132	0.160	0.316	0.452	1.376	1.808
	688.3	1.130	0.264	0.460	0.598	1.544	1.332
	688.4	1.164	0.244	0.652	0.530	1.758	1.148
	688.6	1.068	0.196	0.570	0.580	1.892	1.614
	688.7	1.624	0.126	0.524	0.738	2.050	2.292
	mean	1.090	0.155	0.490	0.563	1.617	1.365
M. sp 703	703.1	1.460	0.168	0.760	0.752	2.254	1.166
	703.2	1.690	0.262	1.134	1.192	2.652	1.820
	703.3	1.488	0.362	0.600	0.640	2.482	1.966
	703.4	1.234	0.226	0.362	0.608	2.222	1.312
	703.5	1.274	0.220	0.478	0.674	2.794	0.970
	703.6	0.876	0.180	0.432	0.390	1.670	0.720
	703.7	1.410	0.192	0.660	0.804	2.104	1.216
	703.8	0.810	0.158	0.290	0.348	0.688	1.036
	703.9	1.018	0.126	0.484	0.658	1.668	1.080
	703.10	1.106	0.240	0.440	0.692	1.994	1.230

	NO.	Penis Length	Penial appendix Length	Epiphallus Length	Epiphallic caecum Length	Spermatheca Length	Vas deferens Length
	mean	1.257	0.213	0.564	0.675	2.053	1.252
M. sp 699	699.1	0.752	0.376	0.504	1.054	2.062	1.328
	699.2	0.584	0.216	0.276	0.856	1.244	1.010
	699.3	0.840	0.324	0.660	1.182	1.950	1.690
	699.4	0.960	0.332	0.610	1.180	2.320	1.288
	699.5	0.840	0.346	0.606	1.146	2.380	1.706
	699.6	0.986	0.320	0.588	1.096	2.108	1.768
	699.7	0.946	0.260	0.632	1.082	2.066	1.346
	699.8	0.766	0.400	0.486	0.580	2.068	1.366
	699.9	1.004	0.492	0.736	1.042	2.244	1.504
	699.10	0.920	0.396	0.520	0.916	2.044	1.838
	mean	0.860	0.346	0.562	1.013	2.049	1.484
M. resplendens 622	622.1	0.420	0.184	0.246	0.572	1.298	0.628
	622.2	0.386	0.150	0.236	0.572	1.768	0.836
	622.3	0.456	0.174	0.194	0.600	1.766	0.878
	622.4	0.470	0.152	0.224	0.626	1.788	0.848
	622.5	0.270	0.126	0.250	0.556	1.582	0.738
	622.6	0.448	0.152	0.206	0.456	1.506	0.710
	622.7	0.420	0.178	0.246	0.474	1.350	0.818
	622.8	0.568	0.150	0.222	0.506	1.440	0.670
	622.9	0.470	0.156	0.228	0.596	1.978	0.704
	622.10	0.422	0.138	0.148	0.424	1.000	0.716
	mean	0.433	0.156	0.220	0.538	1.547	0.755
M. sp 711	711.1	0.846	0.332	0.288	0.780	2.334	1.224
	711.2	0.816	0.248	0.594	1.082	2.996	1.998
	711.3	0.756	0.326	0.384	0.770	2.470	1.162
	711.4	0.784	0.288	0.370	0.736	3.514	1.500
	711.5	0.552	0.304	0.330	0.834	3.178	1.656
	711.6	1.040	0.262	0.450	0.904	1.948	1.674
	711.7	0.746	0.246	0.298	0.936	2.090	1.404
	711.8	0.736	0.176	0.366	0.592	1.350	2.778
	711.9	0.864	0.326	0.462	1.036	3.830	2.196
	711.10	0.462	0.188	0.356	0.690	2.522	1.164
	mean	0.760	0.270	0.390	0.836	1.557	1.674

	NO.	Penis Length	Penial appendix Length	Epiphallus Length	Epiphallic caecum Length	Spermatheca Length	Vas deferens Length
M. sp 2	719.1	1.100	0.396	0.654	1.930	3.516	1.820
	719.2	0.684	0.168	0.304	1.054	1.688	0.850
	719.3	0.850	0.382	0.470	1.380	3.878	1.674
	719.4	0.870	0.320	0.500	1.522	2.760	1.704
	719.5	1.140	0.308	0.668	1.266	3.048	1.920
	719.6	0.802	0.460	0.638	1.582	3.598	2.578
	719.7	0.232	0.318	0.768	1.760	3.230	2.138
	719.8	0.986	0.424	0.672	1.620	3.600	1.748
	719.9	1.128	0.454	0.636	1.472	3.798	2.282
	719.10	0.700	0.248	0.354	0.986	2.058	1.054
	719.11	0.912	0.220	0.570	1.396	2.616	1.866
	719.12	0.726	0.238	0.322	0.866	2.232	0.658
	719.13	0.840	0.228	0.384	1.250	1.876	1.238
	719.14	0.964	0.290	0.696	1.530	3.720	1.996
	719.15	1.080	0.302	0.528	1.508	3.492	1.692
	719.16	0.948	0.362	0.646	1.222	3.794	1.576
	719.17	1.204	0.290	0.366	1.414	3.332	1.796
	719.18	1.132	0.296	0.500	1.562	3.838	2.028
	719.19	1.048	0.350	0.674	2.444	3.278	1.950
	719.20	0.640	0.242	0.492	1.720	2.732	1.862
	mean	0.891	0.289	0.542	1.474	3.104	1.722
H. siamensis	226.1	1.350	0.112	0.298	0.904	2.616	1.190
	226.2	1.680	0.220	0.252	1.336	3.042	1.234
	mean	1.515	0.166	0.275	1.120	2.829	1.212
M. dugasti	632.1	0.846	0.274	0.416	0.970	1.036	0.726

APPENDIX III

RATIO DATA

Ratios data for analysis of genital morphology in the land snails genus *Macrochlamys*, *Cryptozona* and *Hemiplecta*. See text for explanation of variables.

SPECIES	PeL/PAL	EL/PAL	ECL/PAL	SL/PAL	VDL/PAL	PeL/EL	PAL/EL	ECL/EL	SL/EL	VDL/EL	PeL/ECL	PAL/ECL	EL/ECL	SL/ECL	VDL/ECL	PeL/VDL	PAL/VDL	EL/VDL	ECL/VDL	SL/VDL
C. siamensis1	2.91	1.303	4.074	8.607	3.557	2.233	0.767	3.126	6.604	2.73	0.714	0.296	0.32	2.113	0.873	0.818	0.281	0.366	1.145	2.419
C. siamensis1	2.598	1.114	3.045	8.705	2.75	2.333	0.898	2.735	7.816	2.469	0.853	0.328	0.366	2.734	0.903	0.945	0.364	0.405	1.107	3.165
C. siamensis1	2.36	0.915	3.354	7.713	2.555	2.58	1.093	3.667	8.433	2.793	0.704	0.298	0.273	2.3	0.762	0.924	0.391	0.358	1.313	3.019
C. siamensis1	3.004	1.048	3.538	8.059	3.172	2.867	0.955	3.378	7.692	3.028	0.849	0.283	0.296	2.277	0.896	0.947	0.315	0.33	1.115	2.54
C. siamensis1	2.822	0.749	2.719	6.931	2.544	3.766	1.335	3.629	9.25	3.395	1.038	0.368	0.276	2.549	0.936	1.109	0.393	0.295	1.069	2.724
C. siamensis1	3.266	0.944	2.758	7.419	1.702	3.462	1.06	2.923	7.863	1.803	1.184	0.363	0.342	2.69	0.617	1.919	0.588	0.555	1.621	4.36
C. siamensis1	3.354	0.85	3.63	9	3.961	3.944	1.176	4.269	10.583	4.657	0.924	0.275	0.234	2.479	1.091	0.847	0.252	0.215	0.917	2.272
C. siamensis1	2.791	0.884	3.566	8.295	2.783	3.158	1.132	4.035	9.386	3.149	0.783	0.28	0.248	2.326	0.78	1.003	0.359	0.318	1.281	2.981
C. siamensis1	2.911	1.111	3	11.611	4.111	2.62	0.9	2.7	10.45	3.7	0.97	0.333	0.37	3.87	1.37	0.708	0.243	0.27	0.73	2.824
C. siamensis1	2.573	0.767	1.567	6.6	1.927	3.357	1.304	2.043	8.609	2.513	1.643	0.638	0.494	4.213	1.23	1.336	0.519	0.398	0.813	3.426
C. siamensis	1.213	1.582	6.018	14.344	5.393	3.295	0.632	3.492	9.067	3.409	0.944	0.181	0.286	2.596	0.976	0.967	0.185	0.293	1.024	2.66
C. siamensis	4.838	1.351	4.459	14.144	5.486	3.58	0.74	3.3	10.467	4.06	1.085	0.224	0.303	3.172	1.23	0.882	0.182	0.246	0.813	2.578
C. siamensis	5.991	2.063	3.902	15.411	5.545	2.905	0.485	1.892	7.472	2.688	1.535	0.256	0.529	3.95	1.421	1.081	0.18	0.372	0.704	2.779
C. siamensis	3.239	1.036	2.108	6.901	3.838	3.126	0.965	2.035	6.661	3.704	1.536	0.474	0.491	3.274	1.821	0.844	0.261	0.27	0.549	1.798
C. siamensis	3.922	1.139	4.504	8.991	5	3.443	0.878	3.954	7.893	4.389	0.871	0.222	0.253	1.996	1.11	0.784	0.2	0.228	0.901	1.798
C. siamensis	3.814	1.283	4.23	8.46	5	2.972	0.779	3.297	6.593	3.897	0.902	0.236	0.303	2	1.182	0.763	0.2	0.257	0.846	1.692
C. siamensis	4.444	0.848	3.45	6.291	3.669	5.242	1.18	4.07	7.422	4.328	1.288	0.29	0.246	1.823	1.063	1.211	0.273	0.231	0.94	1.715
C. siamensis	3.2	0.807	2.613	6.287	3.127	3.967	1.24	3.24	7.793	3.876	1.224	0.383	0.309	2.406	1.196	1.023	0.32	0.258	0.836	2.011
C. siamensis	4.932	1.233	4.602	9.66	4.971	4	0.811	3.732	7.835	4.031	1.072	0.217	0.268	2.099	1.08	0.992	0.201	0.248	0.926	1.943
C. siamensis	7.075	1.15	4.763	9.338	6.138	6.152	0.87	4.141	8.12	5.337	1.486	0.21	0.241	1.961	1.289	1.153	0.163	0.187	0.776	1.521
H. distincta	10.038	3.09	1.295	1.256	9.615	3.249	0.324	0.419	0.407	3.112	7.752	0.772	2.386	0.97	7.426	1.044	0.104	0.321	0.135	0.131
H. distincta	4.814	1.901	0.643	1.251	4.041	2.311	0.528	0.338	0.658	2.126	6.827	1.555	2.955	1.945	6.282	1.087	0.247	0.47	0.159	0.31
H. distincta	9.415	1.463	0.932	1.722	8.966	6.433	0.683	0.637	1.177	6.127	10.105	1.073	1.571	1.848	9.623	1.05	0.112	0.163	0.104	0.192
H. distincta	7.575	1.75	1.2	1.08	6.785	4.329	0.571	0.686	0.617	3.877	6.313	0.833	1.458	0.9	5.654	1.116	0.147	0.258	0.177	0.159
H. distincta	8.047	2.187	1.223	2.673	7.023	3.679	0.457	0.513	1.222	3.211	7.167	0.891	1.948	2.38	6.255	1.146	0.142	0.311	0.16	0.381
H. distincta	9.708	2.149	1.435	1.857	7.753	4.517	0.465	0.668	0.864	3.607	7.765	0.697	1.496	1.294	5.403	1.252	0.129	0.277	0.185	0.24
H. distincta	5.691	1.766	0.75	0.797	4.258	3.223	0.566	0.425	0.451	2.412	7.589	1.333	2.354	1.063	5.677	1.337	0.235	0.415	0.176	0.187
H. distincta	10.109	2.152	1.455	2.885	10.824	4.699	0.465	0.676	1.341	5.031	6.95	0.688	1.479	1.983	7.442	0.934	0.092	0.199	0.134	0.267
H. distincta	8.012	1.809	0.954	1.855	7.971	4.429	0.553	0.528	1.025	4.406	8.396	1.048	1.896	1.943	8.352	1.005	0.125	0.227	0.12	0.233

SPECIES	PeL/PAL	EL/PAL	ECL/PAL	SL/PAL	VDL/PAL	PeL/EL	PAL/EL	ECL/EL	SL/EL	VDL/EL	PeL/ECL	PAL/ECL	EL/ECL	SL/ECL	VDL/ECL	PeL/VDL	PAL/VDL	EL/VDL	ECL/VDL	SL/VDL
H. dislincta	6.914	1.403	1.021	1.021	7.489	6.914	0.713	0.728	1.076	5.336	6.769	0.979	1.374	1.479	7.332	0.923	0.134	0.187	0.136	0.202
S. diadema	4.311	1.383	1.138	3.778	2.82	3.117	0.723	0.823	2.732	2.039	3.789	0.879	1.216	3.321	2.479	1.529	0.355	0.49	0.403	1.34
S. diadema	6.824	2.99	1.471	5.059	4.882	2.282	0.334	0.492	1.692	1.633	4.64	0.68	2.033	3.44	3.32	1.398	0.205	0.612	0.301	1.036
S. diadema	5.043	2.011	1.796	7.312	3.978	2.508	0.497	0.893	3.636	1.979	2.808	0.557	1.12	4.072	2.216	1.268	0.251	0.505	0.451	1.838
S. diadema	5.554	2.946	1.795	5.009	3.973	1.885	0.339	0.609	1.7	1.348	3.095	0.557	1.642	2.791	2.214	1.398	0.252	0.742	0.452	1.261
S. diadema	4.425	1.633	1.717	6	3.975	2.709	0.612	1.051	3.673	2.434	2.578	0.583	0.951	3.495	2.316	1.113	0.252	0.411	0.432	1.509
S. diadema	3.861	2.165	1.652	5.635	2.783	1.783	0.462	0.763	2.602	1.285	2.337	0.605	1.311	3.411	1.684	1.388	0.359	0.778	0.594	2.025
S. diadema	4.12	3.12	1.75	4.81	2.83	1.321	0.321	0.561	1.542	0.907	2.354	0.571	1.783	2.749	1.617	1.456	0.353	1.102	0.618	1.7
S. diadema	14.032	5.984	4.065	9.968	7.016	2.345	0.167	0.679	1.666	1.173	3.452	0.246	1.472	2.452	1.726	2	0.143	0.853	0.579	1.421
S. diadema	4.947	2.177	1.487	6.814	2.779	2.272	0.459	0.683	3.13	1.276	3.327	0.673	1.464	4.583	1.869	1.78	0.36	0.783	0.535	2.452
S. diadema	4.452	2.27	1.508	5.167	4.325	1.962	0.441	0.664	2.276	1.906	2.953	0.663	1.505	3.426	2.868	1.029	0.231	0.525	0.349	1.194
H. neptunus	15.877	4.737	2.825	4.754	23.789	3.352	0.211	0.596	1.004	5.022	5.621	0.354	1.677	1.683	8.422	0.667	0.042	0.199	0.119	0.2
H. neptunus	17.273	4.545	2.127	5.455	29.473	3.8	0.22	0.468	1.2	6.484	8.119	0.47	2.137	2.564	13.855	0.586	0.034	0.154	0.072	0.185
H. neptunus	13.557	5.164	2.164	5.607	25.164	2.625	0.194	0.419	1.086	4.873	6.265	0.462	2.386	2.591	11.629	0.539	0.04	0.205	0.086	0.223
H. neptunus	11.611	2.847	2.014	5.556	24.028	4.078	0.351	0.707	1.951	8.439	5.766	0.497	1.414	2.759	11.931	0.483	0.042	0.118	0.084	0.231
H. neptunus	13.269	3.654	1.923	4.487	22.372	3.632	0.274	0.526	1.228	6.123	6.9	0.52	1.9	2.333	11.633	0.593	0.045	0.163	0.086	0.201
H. neptunus	14.929	5.143	2.257	5.043	25.171	2.903	0.194	0.439	0.981	4.894	6.614	0.443	2.278	2.234	11.152	0.593	0.04	0.204	0.09	0.201
H. neptunus	14.272	2.963	1.852	5.247	19.827	4.817	0.338	0.625	1.771	6.692	7.707	0.54	1.6	2.833	10.707	0.72	0.05	0.149	0.093	0.265
H. neptunus	14.333	2.7	2.117	5.067	16.533	5.309	0.37	0.784	1.877	6.123	6.772	0.472	1.276	2.394	7.811	0.867	0.06	0.163	0.128	0.306
H. neptunus	8.211	3.421	2.386	3.211	20.368	2.4	0.292	0.697	0.938	5.954	3.441	0.419	1.434	1.346	8.537	0.403	0.049	0.168	0.117	0.158
H. neptunus	14.642	3.642	2.17	5.453	25.642	3.943	0.275	0.596	1.497	7.042	6.748	0.461	1.678	2.513	11.817	0.571	0.039	0.142	0.085	0.213
H. neptunus	9.784	3.45	1.189	3.64	16.09	2.836	0.29	0.345	1.055	4.663	8.227	0.841	2.902	3.061	13.53	0.608	0.062	0.214	0.074	0.226
H. neptunus	9.956	3.684	1.272	3.14	15.518	2.702	0.271	0.345	0.852	4.212	7.828	0.786	2.897	2.469	12.2	0.642	0.064	0.237	0.082	0.202
H. neptunus	9.981	3	0.901	3.777	16.813	3.327	0.333	0.327	1.259	5.638	10.178	1.02	3.059	3.851	17.248	0.59	0.059	0.177	0.058	0.223
H. neptunus	3.553	2.053	0.909	2.894	13.697	1.731	0.487	0.443	1.41	6.672	3.908	1.1	2.258	3.183	15.067	0.259	0.073	0.15	0.066	0.211
H. neptunus	14.357	4.25	1.833	4.929	19.69	3.378	0.235	0.431	1.16	4.633	7.831	0.545	2.318	2.688	10.74	0.729	0.051	0.216	0.093	0.25
H. neptunus	6.924	0.513	0.791	2.291	10.797	13.506	1.951	1.543	4.469	21.062	8.752	1.264	0.048	2.896	13.648	0.641	0.093	0.047	0.073	0.212
H. neptunus	13.236	6.942	1.512	4.663	23.395	1.906	0.144	0.218	0.672	3.37	8.754	0.662	4.592	3.085	15.477	0.566	0.043	0.297	0.065	0.199
H. neptunus	8.112	4.04	0.824	2.128	13.528	2.008	0.248	0.204	0.527	3.349	9.845	1.214	4.903	2.583	16.417	0.6	0.074	0.299	0.061	0.157
H. neptunus	8.891	3.485	1.069	2.307	14.554	2.551	0.287	0.207	0.662	4.176	8.315	0.935	3.259	2.157	13.611	0.611	0.069	0.239	0.073	0.159

SPECIES	PeL/PAL	EL/PAL	ECL/PAL	SL/PAL	VDL/PAL	PeL/EL	PAL/EL	ECL/EL	SL/EL	VDL/EL	PeL/ECL	PAL/ECL	EL/ECL	SL/ECL	VDL/ECL	PeL/VDL	PAL/VDL	EL/VDL	ECL/VDL	SL/VDL
H. neptunus	8.615	2.615	0.874	3.704	13.37	3.295	0.382	0.334	1.416	5.113	9.856	1.144	2.992	4.237	15.297	0.644	0.075	0.196	0.069	0.277
M. asamurai	5.25	5.25	4.909	10.045	9.818	1	0.19	0.935	1.913	1.87	1.074	0.204	1.069	2.046	2	0.535	0.102	0.535	0.5	1.023
M. asamurai	1.184	4.013	3.763	6.461	5.408	0.295	0.249	0.938	1.61	1.348	0.315	0.211	1.066	1.717	1.437	0.219	0.185	0.742	0.696	1.195
M. asamurai	2.85	6.317	4.15	7.217	7.45	0.451	0.158	0.657	1.142	1.179	0.687	0.241	1.522	1.739	1.795	0.383	0.134	0.848	0.557	0.969
M. asamurai	7.553	5.66	4.447	9.255	9.894	1.335	0.177	0.786	1.635	1.748	1.699	0.225	1.273	2.081	2.225	0.763	0.101	0.572	0.449	0.935
M. asamurai	5.873	4.667	3.524	7.778	5.762	1.259	0.214	0.755	1.667	1.235	1.667	0.284	1.324	2.207	1.635	1.019	0.174	0.81	0.612	1.35
M. asamurai	8.102	6.286	5.816	8.49	7.347	1.289	0.159	0.925	1.351	1.169	1.393	0.172	1.081	1.46	1.263	1.103	0.136	0.856	0.792	1.156
M. asamurai	8.74	6.54	6.72	10.7	8.44	1.336	0.153	1.028	1.636	1.291	1.301	0.149	0.973	1.592	1.256	1.036	0.118	0.775	0.796	1.268
M. asamurai	9.561	6.366	4.78	8.585	10.829	1.502	0.157	0.751	1.349	1.701	2	0.209	1.332	1.796	2.265	0.883	0.923	0.588	0.441	1.793
M. asamurai	9	5	4	6.469	7.939	1.8	0.2	0.8	1.294	1.588	2.25	0.25	1.25	1.617	1.985	1.134	0.126	0.63	0.504	0.815
M. asamurai	3.286	3.429	2.9	4.857	5.129	0.958	0.292	0.846	1.417	1.496	1.133	0.345	1.182	1.675	1.768	0.641	0.195	0.669	0.565	0.947
M. asamurai	3.121	1.805	1.535	2.916	2.907	1.729	0.554	0.851	1.616	1.611	2.033	0.652	1.176	1.9	1.894	1.074	0.344	0.621	0.528	1.003
M. asamurai	4.365	3.817	3.51	5.49	5.298	1.144	0.262	0.919	1.438	1.388	1.244	0.285	1.088	1.564	1.51	0.824	0.199	0.721	0.662	1.036
M. asamurai	4.525	2.676	1.822	4.898	4.941	1.69	0.373	0.68	1.829	1.845	2.484	0.549	1.47	2.688	2.712	0.916	0.202	0.542	0.369	0.991
M. asamurai	4.294	2.31	1.754	4.754	6.738	1.859	0.433	0.759	2.058	2.918	2.448	0.57	1.317	2.71	3.842	0.637	0.148	0.343	0.26	0.706
M. asamurai	3.698	2.547	1.547	4.101	3.164	1.452	0.393	0.607	1.61	1.242	2.39	0.646	1.646	2.65	2.045	1.169	0.316	0.805	0.489	1.296
M. asamurai	9.034	7.148	3.318	12.159	10.886	1.264	0.14	0.464	1.701	1.523	2.723	0.301	2.154	3.664	3.218	0.83	0.092	0.657	0.305	1.117
M. asamurai	9.62	5.797	5.354	13.747	7.57	1.659	0.172	0.924	2.371	1.306	1.797	0.187	1.083	2.567	1.414	1.271	0.132	0.766	0.707	1.816
M. asamurai	9.906	5.75	3.677	11.354	9.802	1.723	0.174	0.639	1.975	1.705	2.694	0.174	1.564	3.088	2.666	1.011	0.102	0.587	0.375	1.158
M. asamurai	6.4	4.235	4.341	10.953	8.447	1.511	0.236	1.025	2.586	1.994	1.474	0.23	0.976	2.523	1.946	0.758	0.118	0.501	0.514	1.297
M. asamurai	7.867	6.663	4.036	14.482	8.614	1.181	0.15	0.606	2.174	1.293	1.949	0.248	1.651	3.588	2.134	0.913	0.116	0.773	0.469	1.681
M. asamurai	9.275	6.754	5.42	16.188	9.609	1.373	0.148	0.803	2.397	1.423	1.711	0.184	1.246	2.987	1.773	0.965	0.104	0.703	0.564	1.685
M. asamurai	8.576	6.667	5.03	13.03	9.97	1.286	0.15	0.755	1.955	1.495	1.705	0.199	1.325	2.59	1.982	0.86	0.1	0.669	0.505	1.307
M. asamurai	6.165	4.376	2.753	10.741	6.953	1.409	0.228	0.629	2.454	1.589	2.239	0.363	1.59	3.902	2.526	0.887	0.144	0.629	0.396	1.545
M. asamurai	3.311	4.96	3.595	6.189	7.784	0.668	0.202	0.725	1.248	1.569	0.921	0.278	1.38	1.722	2.165	0.425	0.128	0.637	0.462	0.795
M. asamurai	8.304	4.768	5.609	11.449	6.493	1.742	0.21	1.176	2.401	1.362	1.481	0.178	0.85	2.041	1.158	1.279	0.154	0.734	0.864	1.763
M. sp. 685	3.531	2.075	5.447	8.202	4.474	1.704	0.482	2.626	3.953	2.156	0.649	0.184	0.381	1.506	0.821	0.79	0.224	0.464	1.218	1.833
M. sp. 685	3.702	1.915	5.553	10.032	4.619	1.933	0.522	2.9	5.239	2.517	0.667	0.18	0.345	1.807	0.868	0.768	0.208	0.397	1.152	2.082
M. sp. 685	3.187	2.243	5.673	10.308	4.748	1.421	0.446	2.529	4.596	2.117	0.562	0.176	0.395	1.817	0.837	0.671	0.211	0.472	1.195	2.171
M. sp. 685	3.163	2.174	4.967	10.207	5.87	1.455	0.46	2.285	4.695	2.7	0.637	0.201	0.438	2.055	1.182	0.539	0.17	0.37	0.846	1.739

SPECIES	PeL/PAL	EL/PAL	ECL/PAL	SL/PAL	VDL/PAL	PeL/EL	PAL/EL	ECL/EL	SL/EL	VDL/EL	PeL/ECL	PAL/ECL	EL/ECL	SL/ECL	VDL/ECL	PeL/VDL	PAL/VDL	EL/VDL	ECL/VDL	SL/VDL
M. sp. 685	2.8	1.656	5.966	8.864	5.4	1.691	0.604	3.604	5.353	3.261	0.469	0.168	0.277	1.485	0.905	0.519	0.185	0.307	1.105	1.641
M. sp. 1	2.955	1.36	2.903	7.227	2.915	2.173	0.735	2.134	5.313	2.143	1.018	0.344	0.469	2.49	1.004	1.014	0.343	0.467	0.996	2.479
M. sp. 1	5.521	2.021	3.226	10.411	5.185	5.521	0.495	1.597	5.153	2.566	1.711	0.31	0.626	3.227	1.607	1.069	0.193	0.39	0.622	2.008
M. sp. 1	1.557	1.306	1.106	4.298	2.485	1.192	0.765	0.847	3.29	1.902	1.408	0.904	1.181	3.885	2.246	0.627	0.402	0.526	0.445	1.729
M. sp. 1	3.337	1.087	1.96	6.942	3.967	3.07	0.92	1.803	6.387	3.65	1.702	0.51	0.555	3.542	2.024	0.841	0.252	0.274	0.494	1.75
M. sp. 1	5.095	2.292	2.488	8.798	5.155	2.223	0.436	1.086	3.839	2.249	2.048	0.402	0.921	3.536	2.072	0.988	0.194	0.445	0.483	1.707
M. sp. 690/68	11.296	4.222	3.278	14.907	10.019	2.675	0.237	0.776	3.531	2.373	3.446	0.305	1.288	4.548	3.056	1.128	0.1	0.421	0.327	1.486
M. sp. 690/68	9.03	3.076	3.848	13.636	8.773	2.936	0.325	1.251	4.433	2.852	2.346	0.26	0.799	3.543	2.28	1.029	0.114	0.351	0.439	1.554
M. sp. 690/68	23.267	12.467	7.067	19.667	39.067	1.866	0.08	0.567	1.578	3.134	3.292	0.142	1.764	2.783	5.528	0.596	0.026	0.319	0.181	0.503
M. sp. 690/68	7.758	4.273	5.258	10.076	6.97	1.816	0.234	1.23	2.358	1.631	1.476	0.19	0.813	1.916	1.326	1.113	0.143	0.613	0.754	1.446
M. sp. 690/68	4.011	2.506	1.933	4.73	5.27	1.601	0.399	0.771	1.886	2.103	2.076	0.517	1.297	2.448	2.727	0.761	0.19	0.475	0.367	0.898
M. sp. 690/68	5.267	3.781	4.384	14.192	7.438	1.442	0.264	1.159	3.754	1.967	1.244	0.228	0.863	3.238	1.697	0.733	0.134	0.508	0.589	1.908
M. sp. 690/68	7.861	3.861	7.494	15.481	13.911	2.036	0.259	1.941	4.01	3.603	1.049	0.133	0.515	2.066	1.856	0.565	0.072	0.278	0.539	1.113
M. sp. 690/68	6.774	2.405	2.952	10.012	8.524	2.817	0.416	1.228	4.163	3.545	2.294	0.339	0.815	3.391	2.887	0.795	0.117	0.282	0.346	1.175
M. sp. 690/68	8.522	3.881	4.179	11.597	9.627	2.196	0.258	1.077	2.988	2.481	2.039	0.239	0.929	2.775	2.304	0.885	0.104	0.403	0.434	1.205
M. sp. 690/68	7.176	3.307	3.757	12.743	6.797	2.116	0.295	1.108	3.757	2.004	1.91	0.266	0.903	3.392	1.809	1.056	0.147	0.499	0.553	1.875
M. sp. 690/68	7.075	1.975	2.825	8.6	11.3	3.582	0.506	1.43	4.354	5.722	2.504	0.354	0.699	3.044	4	0.626	0.088	0.175	0.25	0.761
M. sp. 690/68	4.28	1.742	2.265	5.848	5.045	2.457	0.574	1.3	3.357	2.896	1.89	0.441	0.769	2.582	2.227	0.848	0.198	0.345	0.449	1.159
M. sp. 690/68	4.77	2.612	2.172	7.205	4.705	1.785	0.374	0.813	2.696	1.761	2.196	0.46	1.23	3.317	2.166	1.014	0.213	0.568	0.462	1.531
M. sp. 690/68	5.449	2.908	2.959	9.653	8.235	1.874	0.344	1.018	3.319	2.832	1.841	0.338	0.983	3.262	2.783	0.662	0.121	0.353	0.359	1.172
M. sp. 690/68	4.952	4.159	5.857	16.27	18.19	1.191	0.24	1.408	3.912	4.374	0.846	0.171	0.71	2.778	3.106	0.272	0.055	0.229	0.322	0.894
M. sp. 703	8.69	4.524	4.476	13.417	6.94	1.921	0.221	0.989	2.966	1.534	1.941	0.223	1.011	2.997	1.551	1.252	0.144	0.652	0.645	1.933
M. sp. 703	7.214	4.328	4.55	10.122	6.947	1.667	0.231	1.051	2.339	1.605	1.586	0.22	0.951	2.225	1.527	1.038	0.144	0.623	0.655	1.457
M. sp. 703	4.11	1.657	1.768	6.856	5.431	2.48	0.603	1.067	4.137	3.277	2.325	0.566	0.938	3.878	3.072	0.757	0.184	0.305	0.326	1.262
M. sp. 703	5.46	1.602	2.69	9.832	5.805	3.409	0.624	1.68	6.138	3.624	2.03	0.372	0.595	3.655	2.158	0.941	0.172	0.276	0.463	1.694
M. sp. 703	5.791	2.173	3.064	12.7	4.409	2.665	0.46	1.41	5.845	2.029	1.89	0.326	0.709	4.145	1.439	1.313	0.227	0.493	0.695	2.65
M. sp. 703	4.867	2.4	2.167	9.278	4	2.028	0.417	0.903	3.866	1.657	2.246	0.462	1.108	4.282	1.846	1.217	0.25	0.6	0.542	2.319
M. sp. 703	7.344	3.438	4.188	10.958	6.333	2.136	0.291	1.218	3.188	1.842	1.754	0.239	0.821	2.617	1.512	1.16	0.158	0.543	0.661	1.73
M. sp. 703	5.127	1.835	2.203	4.354	6.557	2.793	0.545	1.2	2.372	3.572	2.328	0.454	0.833	1.977	2.977	0.782	0.153	0.28	0.336	0.664
M. sp. 703	8.079	3.841	5.222	13.238	8.571	2.103	0.26	1.36	3.446	2.231	1.547	0.191	0.736	2.535	1.641	0.943	0.117	0.448	0.609	1.544

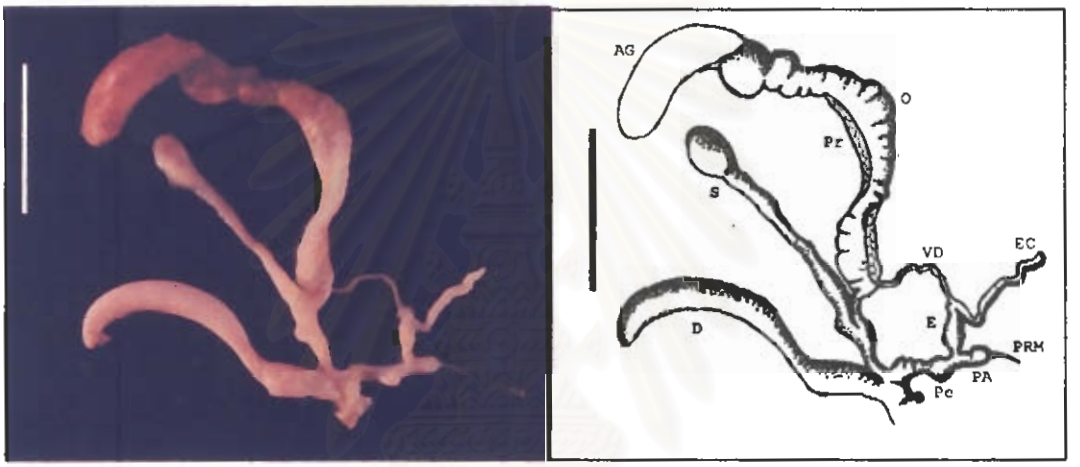
SPECIES	PeL/PAL	EL/PAL	ECL/PAL	SL/PAL	VDL/PAL	PeL/EL	PAL/EL	ECL/EL	SL/EL	VDL/EL	PeL/ECL	PAL/ECL	EL/ECL	SL/ECL	VDL/ECL	PeL/VDL	PAL/VDL	EL/VDL	ECL/VDL	SL/VDL
M. sp. 703	2.514	1.833	2.842	8.308	5.125	2.514	0.545	1.55	4.532	2.795	1.622	0.352	0.645	2.924	1.804	0.899	0.195	0.358	0.554	1.621
M. sp. 699	2	1.34	2.803	5.484	3.532	1.492	0.746	2.091	4.091	2.635	0.713	0.357	0.478	1.956	1.26	0.566	0.283	0.38	0.794	1.553
M. sp. 699	2.704	1.278	3.963	5.759	4.676	2.116	0.783	3.101	4.507	3.695	0.682	0.252	0.322	1.453	1.18	0.578	0.214	0.273	0.848	0.9
M. sp. 699	2.593	2.037	3.648	6.019	5.216	1.273	0.491	1.791	2.955	2.561	0.711	0.274	0.558	1.65	1.43	0.497	0.192	0.391	0.699	1.154
M. sp. 699	2.892	1.837	3.554	6.988	3.88	1.574	0.544	1.934	3.803	2.111	0.814	0.281	0.517	1.966	1.092	0.745	0.258	0.474	0.916	1.801
M. sp. 699	2.428	1.751	3.312	6.879	4.931	1.386	0.571	1.891	3.927	2.815	0.733	0.302	0.529	2.077	1.489	0.492	0.203	0.355	0.672	1.395
M. sp. 699	3.081	1.838	3.425	6.588	5.525	1.677	0.544	1.864	3.585	3.007	0.9	0.292	0.536	1.923	1.613	0.558	0.181	0.333	0.62	1.192
M. sp. 699	3.638	2.431	4.162	7.946	5.177	1.497	0.411	1.72	3.269	2.13	0.874	0.24	0.584	1.909	1.244	0.703	0.193	0.47	0.804	1.535
M. sp. 699	1.915	1.215	1.45	5.17	3.415	1.576	0.823	1.193	4.255	2.811	1.321	0.69	0.838	3.566	2.355	0.561	0.293	0.356	0.425	1.514
M. sp. 699	2.041	1.496	2.118	4.561	3.057	1.364	0.668	1.416	3.049	2.043	0.964	0.472	0.706	2.154	1.443	0.668	0.327	0.489	0.693	1.492
M. sp. 699	2.323	1.313	2.313	5.162	4.641	1.769	0.762	1.762	3.931	3.535	1.004	0.432	0.568	2.231	2.007	0.501	0.215	0.283	0.498	1.112
M. sp. 622	2.283	1.337	3.109	7.054	3.413	1.707	0.748	2.325	5.276	2.553	0.734	0.322	0.43	2.269	1.098	0.669	0.293	0.392	0.911	2.067
M. sp. 622	2.573	1.573	3.813	11.787	5.573	1.636	0.636	2.424	7.492	3.542	0.675	0.262	0.413	3.091	1.462	0.462	0.179	0.282	0.684	2.115
M. sp. 622	2.621	1.115	3.448	10.149	5.046	2.351	0.897	3.093	9.103	4.526	0.76	0.29	0.323	2.943	1.463	0.519	0.198	0.221	0.683	2.011
M. sp. 622	3.092	1.474	4.116	11.763	5.579	2.098	0.679	2.795	7.982	3.786	0.751	0.243	0.368	2.856	1.355	0.554	0.179	0.264	0.738	2.108
M. sp. 622	2.143	1.984	4.413	12.556	5.857	1.08	0.504	2.224	6.328	2.952	0.486	0.227	0.45	2.845	1.327	0.366	0.171	0.339	0.753	2.144
M. sp. 622	2.947	1.355	3	9.908	4.671	2.175	0.738	2.214	7.311	3.447	0.982	0.333	0.452	3.303	1.557	0.631	0.214	0.29	0.642	2.121
M. sp. 622	2.36	1.382	2.663	7.584	4.596	1.707	0.724	1.927	5.488	3.325	0.886	0.376	0.519	2.848	1.726	0.513	0.218	0.301	0.579	1.65
M. sp. 622	3.787	1.48	3.373	9.6	4.467	2.559	0.676	2.505	6.486	3.018	1.123	0.296	0.439	2.846	1.324	0.848	0.224	0.331	0.755	2.149
M. sp. 622	3.013	1.462	3.821	12.679	4.513	2.061	0.684	2.614	8.675	3.088	0.789	0.262	0.383	3.319	1.161	0.668	0.222	0.324	0.847	2.81
M. sp. 622	3.058	1.072	3.072	7.246	5.188	2.851	0.932	2.865	6.757	4.838	0.995	0.325	0.349	2.356	1.689	0.589	0.193	0.207	0.592	1.397
C. siamensis2	4.288	1.403	3.063	13.681	4.089	3.056	0.713	2.183	9.75	2.914	1.4	0.326	0.458	4.467	1.335	1.049	0.245	0.343	0.749	3.346
C. siamensis2	3.811	1.552	4.783	15.713	6.524	2.455	0.644	3.081	10.122	4.203	0.797	0.209	0.325	3.265	1.364	0.584	0.153	0.238	0.733	2.408
C. siamensis2	4.407	1.884	4.974	8.672	5.878	2.34	0.531	2.64	4.604	3.121	0.886	0.201	0.379	1.744	1.182	0.75	0.17	0.32	0.846	1.475
C. siamensis2	2.452	1.006	2.097	6.152	2.661	2.437	0.994	2.084	6.114	2.645	1.169	0.477	0.48	2.934	1.269	0.921	0.376	0.378	0.788	2.312
C. siamensis2	1.683	1.097	2.802	9.213	2.813	1.534	0.912	2.554	8.398	2.565	0.601	0.357	0.391	3.288	1.004	0.598	0.355	0.39	0.996	3.275
C. siamensis2	1.412	0.761	2.189	5.538	2.195	1.855	1.314	2.876	7.277	2.884	0.645	0.457	0.348	2.53	1.003	0.643	0.456	0.347	0.997	2.523
C. siamensis2	3.604	1.462	4.104	11.495	4.863	2.466	0.684	2.808	7.865	3.327	0.878	0.244	0.356	2.801	1.185	0.741	0.206	0.301	0.844	2.364
C. siamensis2	3.579	1.247	3.32	8.534	3.882	2.869	0.802	2.662	6.842	3.113	1.078	0.301	0.376	2.57	1.169	0.922	0.258	0.321	0.855	2.198
C. siamensis2	5.056	2.491	6.204	21.861	6.778	2.03	0.401	2.491	8.777	2.721	0.815	0.161	0.401	3.524	1.093	0.746	0.148	0.367	0.915	3.225

SPECIES	PeL/PAL	EL/PAL	ECL/PAL	SL/PAL	VDL/PAL	PeL/EL	PAL/EL	ECL/EL	SL/EL	VDL/EL	PeL/ECL	PAL/ECL	EL/ECL	SL/ECL	VDL/ECL	PeL/VDL	PAL/VDL	EL/VDL	ECL/VDL	SL/VDL
M. sp. 711	2.548	0.867	2.349	7.03	3.687	2.938	1.153	2.708	8.104	4.25	1.085	0.426	0.369	2.992	1.569	0.691	0.271	0.235	0.637	1.907
M. sp. 711	3.29	2.385	4.363	12.081	8.056	1.374	0.418	1.822	5.044	3.364	0.754	0.229	0.549	2.769	1.847	0.408	0.124	0.297	0.542	1.499
M. sp. 711	2.319	1.178	2.362	7.577	3.564	1.969	0.849	2.005	6.432	3.026	0.982	0.423	0.499	3.208	1.509	0.651	0.281	0.33	0.663	2.126
M. sp. 711	2.722	1.285	2.556	12.201	5.208	2.119	0.778	1.989	9.497	4.054	1.065	0.391	0.503	4.774	2.038	0.523	0.192	0.247	0.491	2.343
M. sp. 711	1.816	1.086	2.743	10.454	5.447	1.673	0.921	2.527	9.63	5.018	0.662	0.365	0.396	3.811	1.986	0.333	0.184	0.199	0.504	1.919
M. sp. 711	3.969	1.718	3.45	7.435	6.389	2.311	0.582	2.009	4.329	3.72	1.15	0.29	0.498	2.155	1.852	0.621	0.157	0.269	0.54	1.164
M. sp. 711	3.033	1.211	3.805	8.496	5.707	2.503	0.826	3.141	7.013	4.711	0.797	0.263	0.318	2.233	1.5	0.531	0.175	0.212	0.667	1.489
M. sp. 711	4.182	2.08	3.364	7.67	15.784	2.011	0.481	1.617	3.689	7.59	.243	0.297	0.618	2.28	4.693	0.265	0.063	0.132	0.213	0.486
M. sp. 711	2.65	1.417	3.178	11.748	6.736	1.87	0.706	2.242	8.29	4.753	0.834	0.315	0.446	3.697	2.12	0.393	0.148	0.21	0.472	1.744
M. sp. 711	2.457	1.894	3.67	13.415	6.191	1.289	0.528	1.938	7.084	3.27	0.67	0.272	0.516	3.655	1.687	0.397	0.162	0.306	0.593	2.167
M. sp. 2	2.778	1.654	4.874	8.879	4.596	1.682	0.606	2.951	5.376	2.783	0.57	0.205	0.339	1.822	0.943	0.604	0.218	0.359	1.06	1.932
M. sp. 2	4.071	1.81	6.274	10.048	16.964	2.25	0.553	3.467	5.553	9.375	0.649	0.159	0.288	1.602	2.704	0.24	0.059	0.107	0.37	0.592
M. sp. 2	2.225	1.23	3.613	10.152	4.382	1.809	0.613	2.936	8.251	3.562	0.616	0.277	0.341	2.81	1.213	0.508	0.228	0.281	0.824	2.317
M. sp. 2	2.719	1.563	4.756	8.625	5.325	1.74	0.64	3.044	5.52	3.408	0.572	0.21	0.329	1.813	1.12	0.511	0.188	0.293	0.893	1.62
M. sp. 2	3.701	2.169	4.11	9.896	6.234	1.707	0.461	1.895	4.563	2.874	0.9	0.243	0.528	2.408	1.517	0.594	0.16	0.348	0.659	1.588
M. sp. 2	1.743	1.387	3.439	7.822	5.604	1.257	0.721	2.48	5.639	4.041	0.507	0.291	0.403	2.274	1.63	0.311	0.178	0.247	0.614	1.392
M. sp. 2	3.874	2.415	5.535	10.157	6.723	1.604	0.414	2.292	4.206	2.784	0.7	0.181	0.436	1.835	1.215	0.576	0.149	0.359	0.823	1.511
M. sp. 2	2.325	1.585	8.058	8.491	4.123	1.467	0.631	2.411	5.357	2.601	0.609	0.262	0.415	2.222	1.079	0.564	0.243	0.384	0.927	2.059
M. sp. 2	2.485	1.401	3.242	8.366	5.026	1.774	0.714	2.314	5.972	3.588	0.766	0.308	0.432	2.58	1.55	0.494	0.199	0.279	0.645	1.664
M. sp. 2	2.823	1.427	3.968	8.298	4.25	1.977	0.701	2.78	5.814	2.977	0.711	0.252	0.36	2.091	1.071	0.664	0.235	0.336	0.934	1.953
M. sp. 2	4.145	2.591	6.345	11.891	8.482	1.6	0.386	2.449	4.589	3.274	0.653	0.158	0.408	1.874	1.337	0.489	0.118	0.355	0.748	1.402
M. sp. 2	3.05	1.353	3.639	9.378	2.765	2.255	0.739	2.689	6.932	2.043	0.838	0.275	0.372	2.577	0.759	1.103	0.362	0.489	1.316	3.391
M. sp. 2	3.684	1.684	5.482	8.228	5.43	2.188	0.594	2.265	4.885	3.224	0.672	0.182	0.307	1.501	0.99	0.679	0.184	0.31	1.01	1.515
M. sp. 2	3.324	2.4	5.276	12.828	6.88	1.385	0.417	2.196	5.345	2.868	0.63	0.19	0.455	2.431	1.305	0.483	0.145	0.349	0.787	1.864
M. sp. 2	3.576	1.748	4.993	11.563	5.603	2.045	0.572	2.856	6.614	3.205	0.719	0.2	0.35	2.316	1.122	0.638	0.178	0.312	0.891	2.064
M. sp. 2	2.619	1.785	3.376	10.481	4.354	1.467	0.56	1.892	5.873	2.44	0.776	0.296	0.529	3.105	1.29	0.602	0.23	0.41	0.775	2.407
M. sp. 2	4.152	1.262	4.876	11.49	6.193	3.29	0.792	3.863	9.104	4.907	0.834	0.205	0.259	2.356	1.27	0.67	0.161	0.24	0.787	1.855
M. sp. 2	3.824	1.689	5.277	12.968	6.851	2.264	0.592	3.124	7.676	4.056	0.725	0.19	0.32	2.457	1.295	0.558	0.146	0.247	0.77	1.893
M. sp. 2	2.994	1.926	6.983	9.366	5.571	1.555	0.519	3.626	4.864	2.893	0.429	0.143	0.276	1.341	1.798	0.537	0.179	0.346	1.253	1.681
M. sp. 2	2.645	2.033	7.107	11.289	7.694	1.301	0.492	3.496	5.553	3.785	0.372	0.141	0.286	1.588	1.083	0.344	0.13	0.264	0.924	1.467

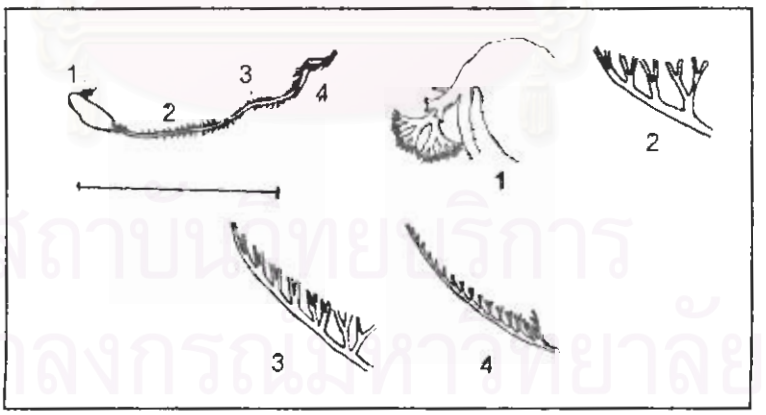
APPENDIX IV

QUESTIONABLE SPECIES

A



B



C

Figure 1 (A) Shell morphology of *Macrochlamys* sp. 622 (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys* sp. 622 (Bar = 1 cm)

(C) Spermatophore morphology of *Macrochlamys* sp. 622 (Bar = 1 cm)

Macrochlamys sp. 622

(Fig. 1A)

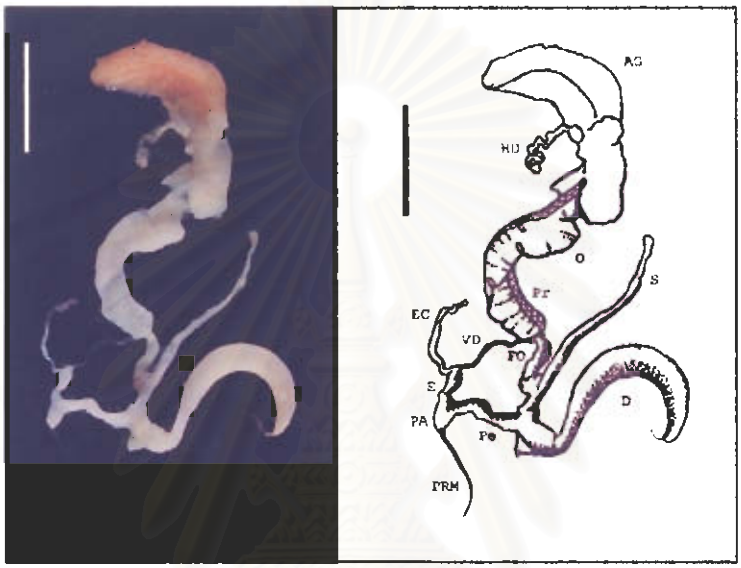
localities : Smaesarn Island, Chonburi

Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate, sometimes with a bulbous termination, containing one perfectly formed spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 1B)

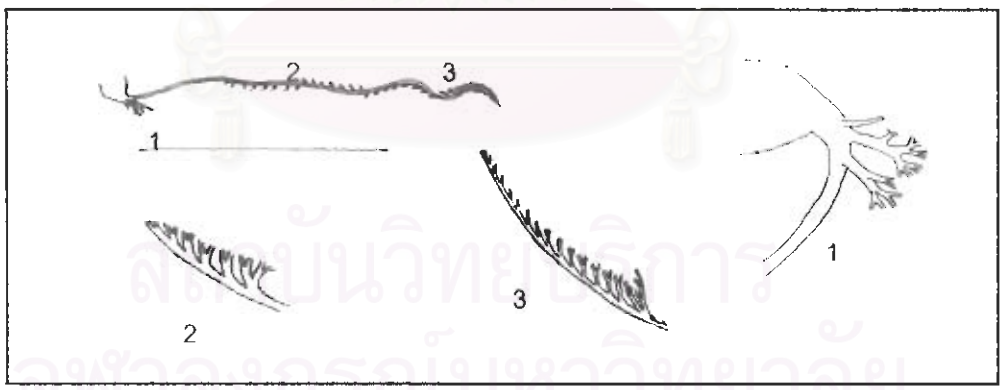
Spermatophore : Spermatophore is spine shaped. It consists of two distinct parts ; (1) very long and gutter-like called flum, one-fourth of its length is smooth and the another is generally branches of fine delicate spines on the side. (2) a thin-walled long cylindrical sac (or capsule), a group of special spines at the base of it and with the usually short gutter-like terminal end. (Fig. 1C)

Diagnosis : *M.* sp. 622 should be reclassified as *Sarika* sp. because of the specific genital characteristic which described in the former species. The investigated spermatophore shows spine characteristic which looks similar to *M.* sp. 2. However shell looks a bit difference from *M.* sp. 2.

A



B



C

Figure 2 (A) Shell morphology of *Macrochlamys* sp. 685 (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys* sp. 685 (Bar = 1 cm)

(C) Spermatophore morphology of *Macrochlamys* sp. 685 (Bar = 1 cm)

Macrochlamys sp. 685

(Fig. 2A)

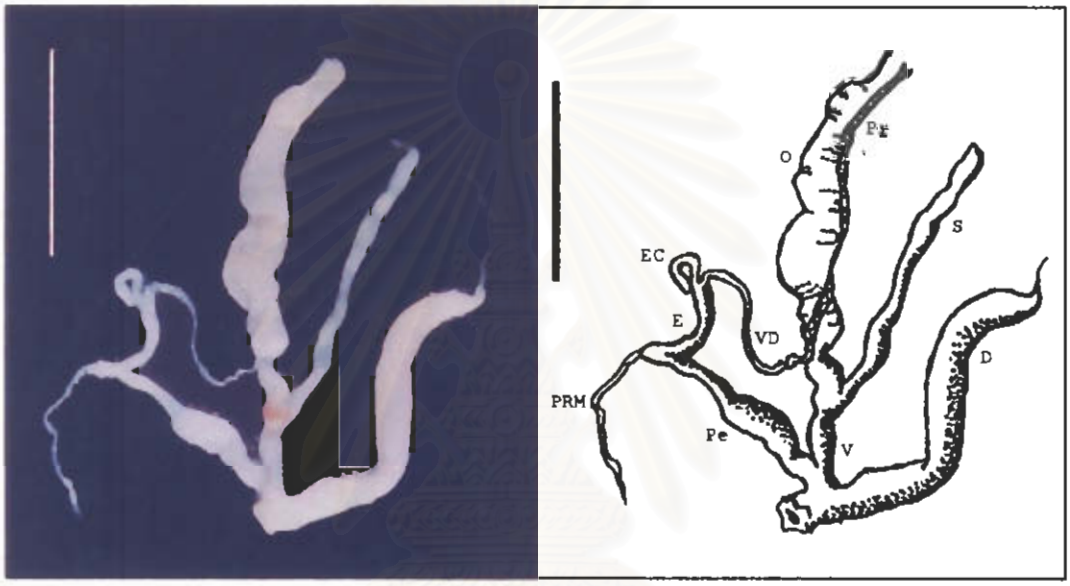
Localities : Chonburi

Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate, sometimes with a bulbous termination, containing one spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 2B)

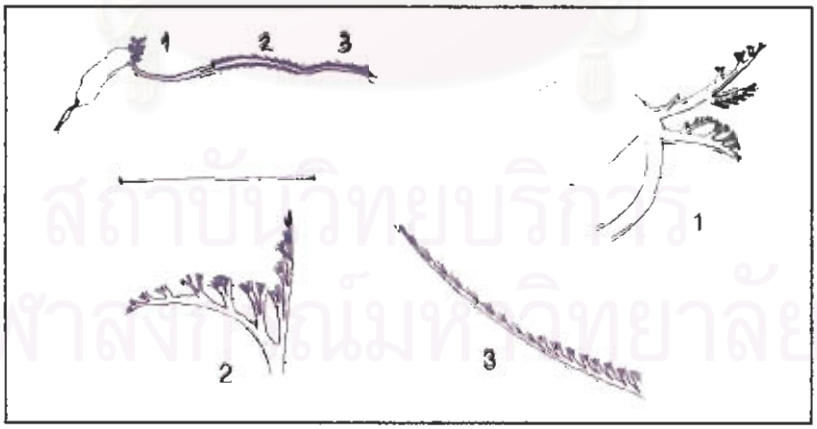
Spermatophore : Spermatophore is spine shaped. It consists of two distinct parts; (1) very long and gutter-like called flum, the first part of it is smooth and the another is generally branches of fine delicate spines on the side. (2) a thin-walled long cylindrical sac (or capsule) which some part was digested by enzyme in spermatheca, and a group of special spines at the base of it. (Fig. 2C)

Diagnosis : *M.* sp. 685 should be reclassified as *Sarika* sp. because of the specific genital characteristic which described in the former species. The shell, genitalia and investigated spermatophore look similar to *M.* sp. 2. However spine characteristic at the base of capsule shows a bit difference from spermatophore of *M.* sp. 2.

A



B



C

Figure 3 (A) Shell morphology of *Macrochlamys* sp. 690/688 (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys* sp. 690/688 (Bar = 1 cm)

(C) Spermatophore morphology of *Macrochlamys* sp. 690/688 (Bar = 1 cm)

Macrochlamys sp. 690/688

(Fig. 3A)

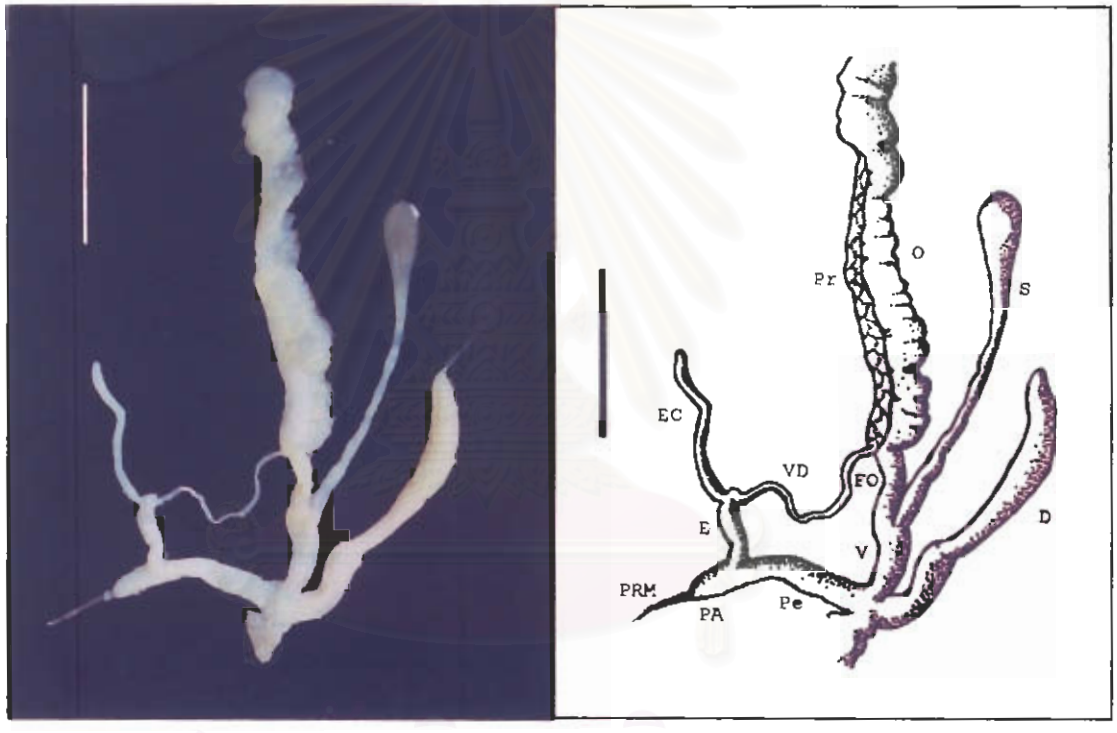
Localities : Prachuap Khirikhan

Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate, sometimes with a bulbous termination, containing one perfectly formed spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 3B)

Spermatophore : Spermatophore is spine shaped. It consists of two distinct parts ; (1) very long and gutter-like called flum, two-third of its length is smooth and the another is generally branches of fine delicate spines on the side. (2) a thin-walled long cylindrical sac (or capsule), a group of special spines at the base of it and with the usually short gutter-like terminal end. (Fig. 3C)

Diagnosis : *M.* sp. 690/688 should be reclassified as *Sarika* sp. because of the specific genital characteristic which described in the former species. The shell and genitalia look similar to *M.* sp. 2. However an investigated spermatophore shows spine characteristic which look a bit difference from *M.* sp. 2.

A



B

Figure 4 (A) Shell morphology of *Macrochlamys* sp. 699 (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys* sp. 699 (Bar = 1 cm)

Macrochlamys sp. 699

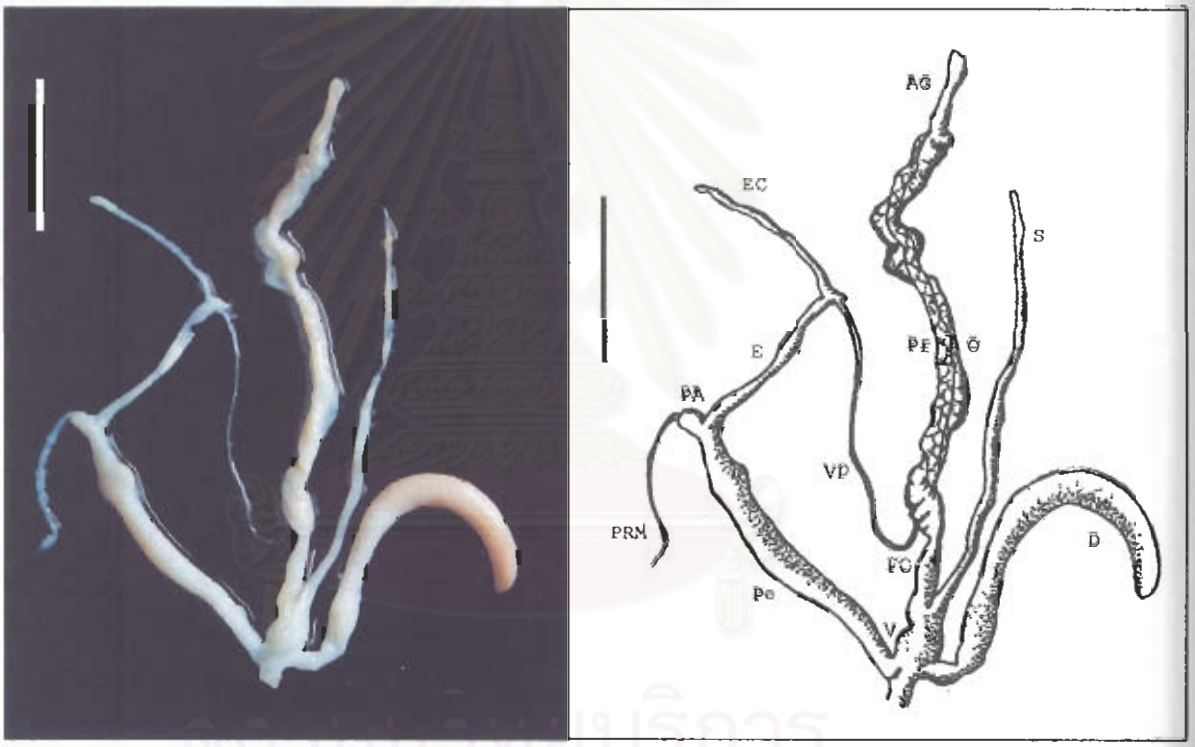
(Fig. 4A)

Localities : Nakhon Si Thammarat

Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate, sometime with a bulbous termination. Spermatophore is not found. The dart apparatus is large, long and cylindrical. (Fig. 4B)

Diagnosis : *M.* sp. 699 should be reclassified as *Sarika* sp. because of the specific genital characteristic which described in the former species. The shell and genitalia look similar to *M.* sp. 2.

A



B

Figure 5 (A) Shell morphology of *Macrochlamys* sp 703 (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys* sp 703 (Bar = 1 cm)

Macrochlamys sp. 703

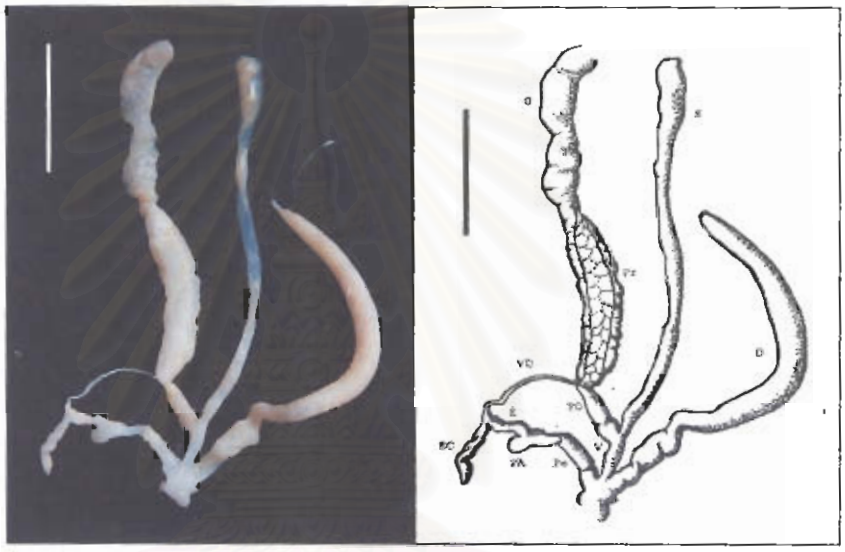
(Fig. 5A)

Localities : Kanchanaburi

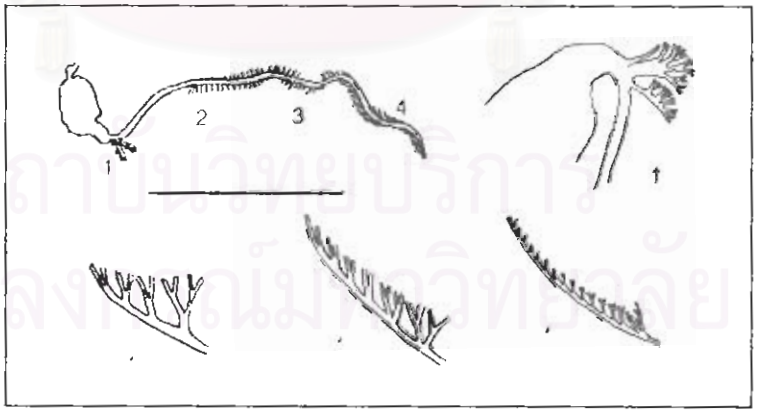
Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate, sometime with a bulbous termination. Spermatophore is not found. The dart apparatus is large, long and cylindrical. (Fig. 5B)

Diagnosis : *M.* sp. 703 should be reclassified as *Sarika* sp. because of the specific genital characteristic which described in the former species. The shell and genitalia look similar to *M.* sp. 2.

A



B



C

Figure 6 (A) Shell morphology of *Macrochlamys* sp 711 (Bar = 1 cm)

(B) Genital morphology of *Macrochlamys* sp 711 (Bar = 1 cm)

(C) Spermatophore morphology of *Macrochlamys* sp 711 (Bar = 1 cm)

Macrochlamys sp. 711

(Fig. 6A)

Localities : Khoa Kaew, Chonburi

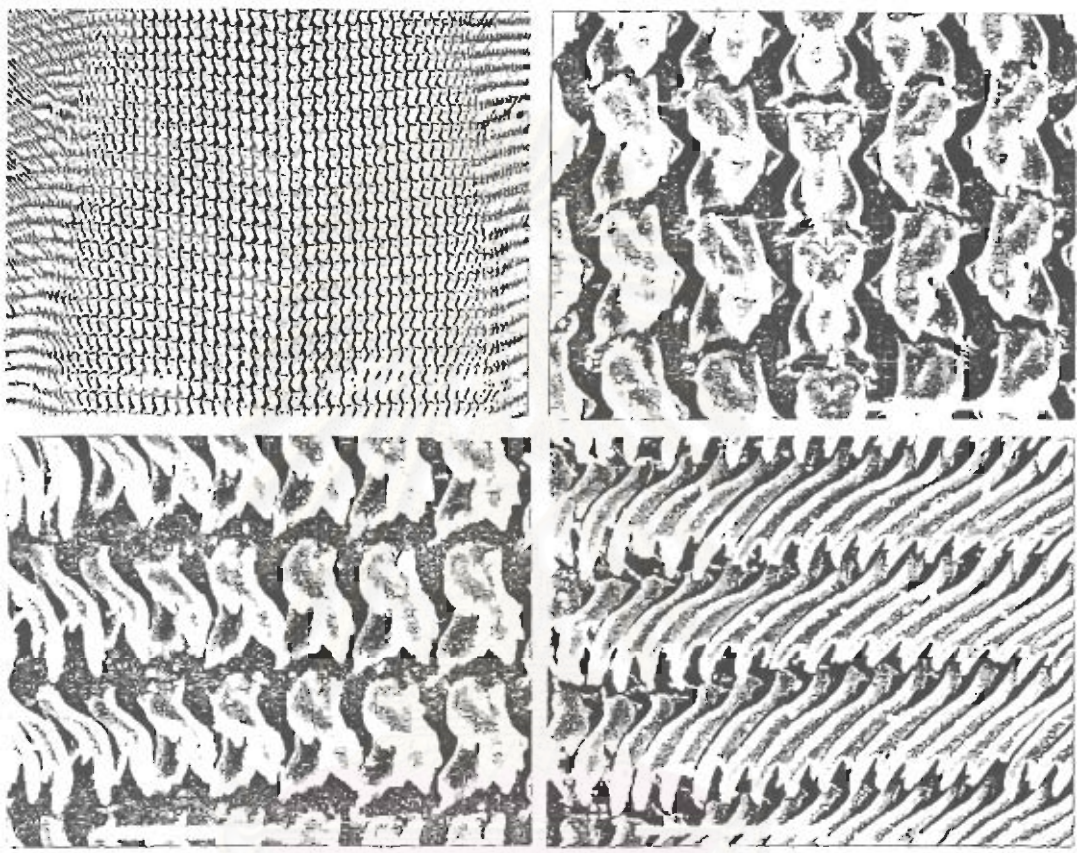
Generative organs: Penis with a short and uncoiled penial appendix. The retractor muscle is given off directly at the head of penial appendix. The epiphallus meeting the head of penis close to and on side of penial appendix. The long finger-like epiphallic caecum is close to the junction with vas deferens. The spermatheca locating on female side is elongate, sometimes with a bulbous termination, containing one perfectly formed spermatophore. The dart apparatus is large, long and cylindrical. (Fig. 6B)

Spermatophore : Spermatophore is spine shaped. It consists of two distinct parts ; (1) very long and gutter-like called flum, one-fourth of its length is smooth and the another is generally branches of fine delicate spines on the side. (2) a thin-walled long cylindrical sac (or capsule), a group of special spines at the base of it and with the usually short gutter-like terminal end. (Fig. 6C)

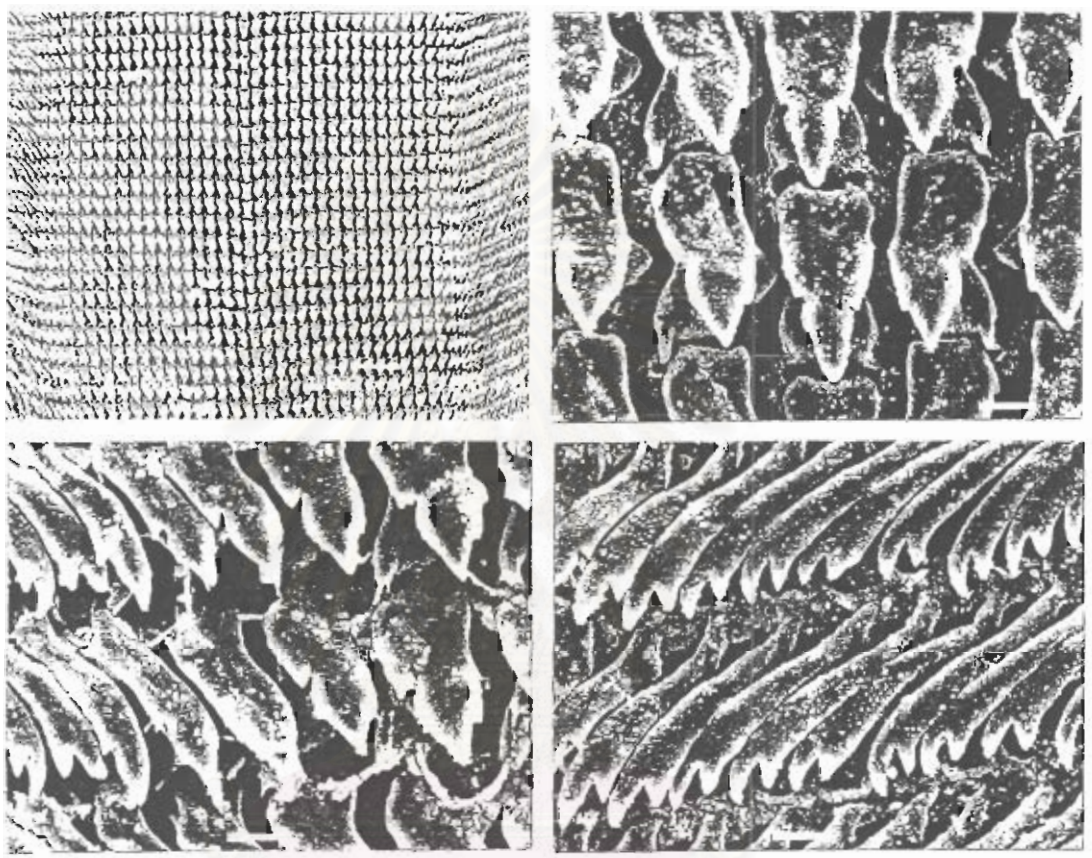
Diagnosis : *M.* sp. 711 should be reclassified as *Sarika* sp. because of the specific genital characteristic which described in the former species. The shell, genitalia and investigated spermatophore look similar to *M.* sp. 2. However spine characteristic at the base of capsule shows a bit difference from spermatophore of *M.* sp. 2.

APPENDIX V

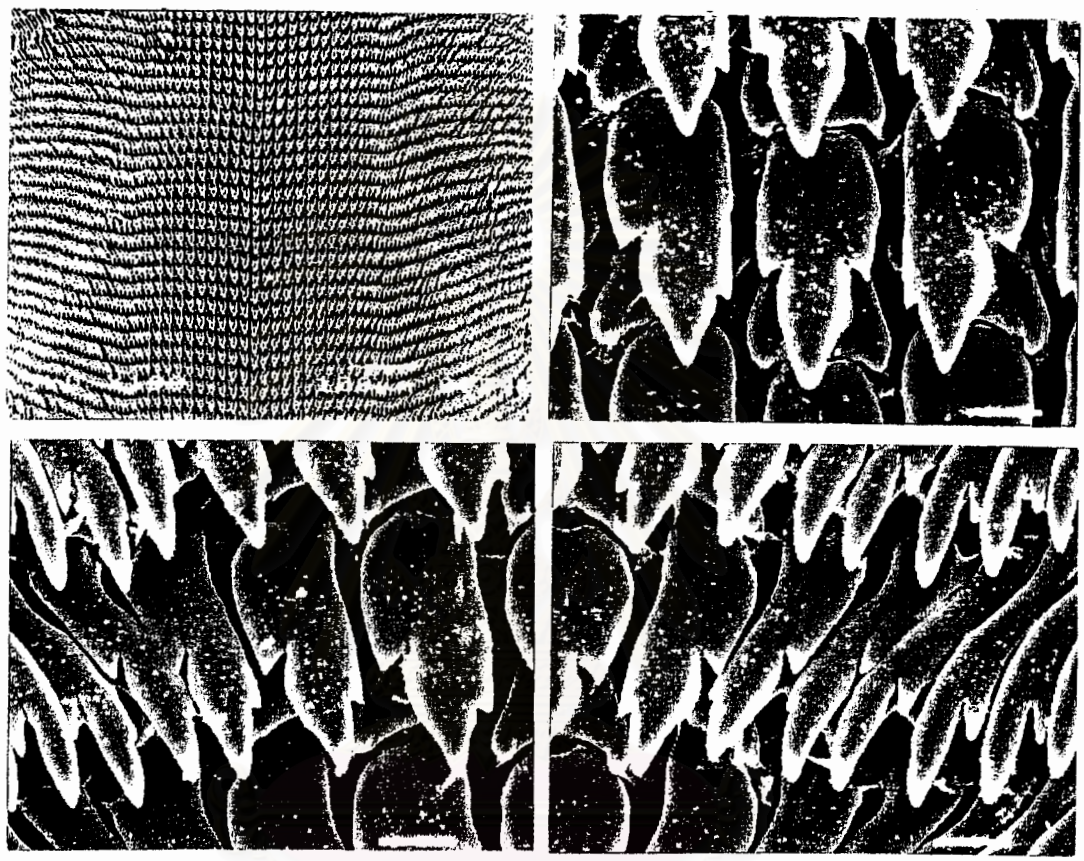
SEM PHOTOGRAPHS OF RADULA



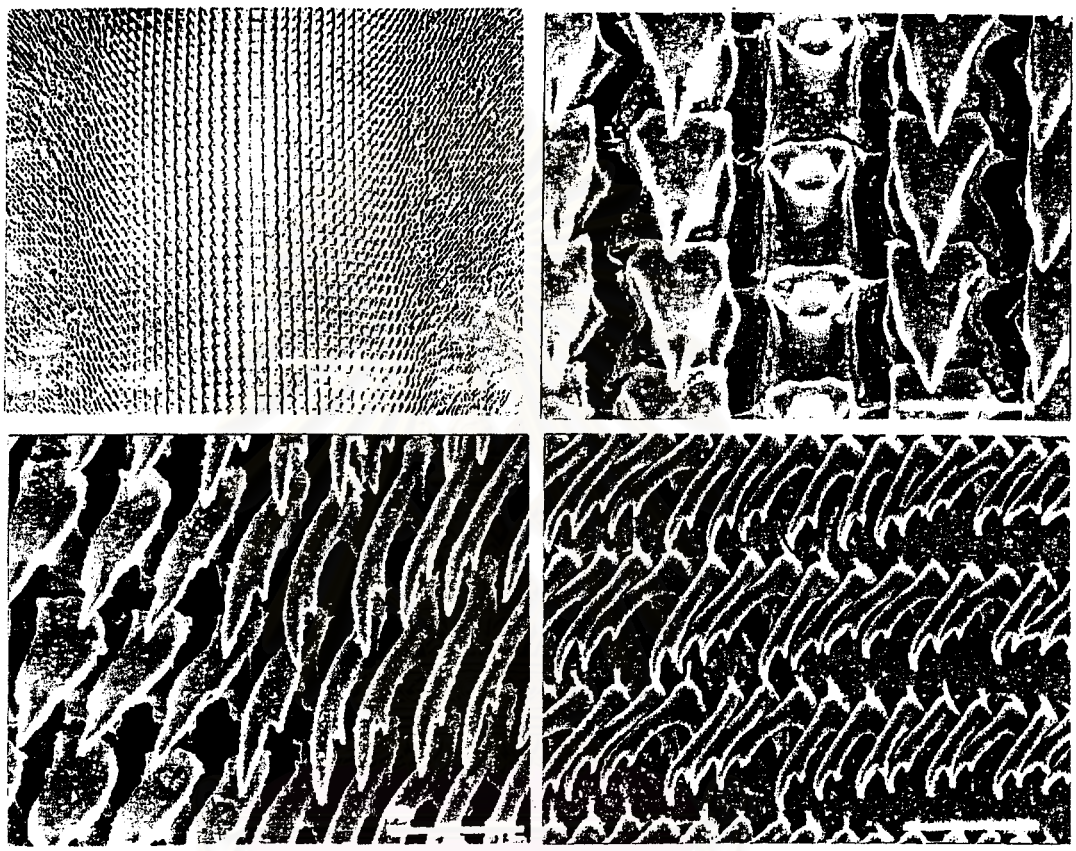
Radula teeth of *Macrochlamys asamurai* : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 50 μm)



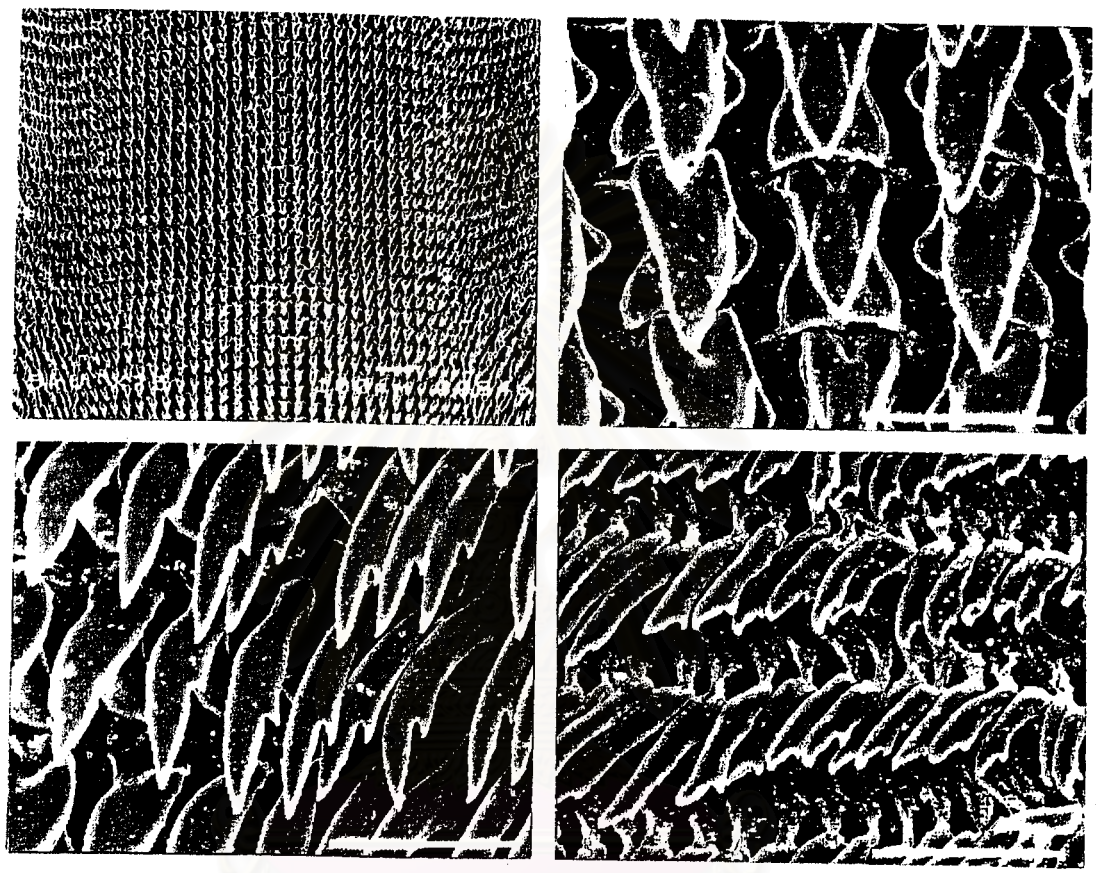
Radula teeth of *Syama diadema* : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 10 μm)



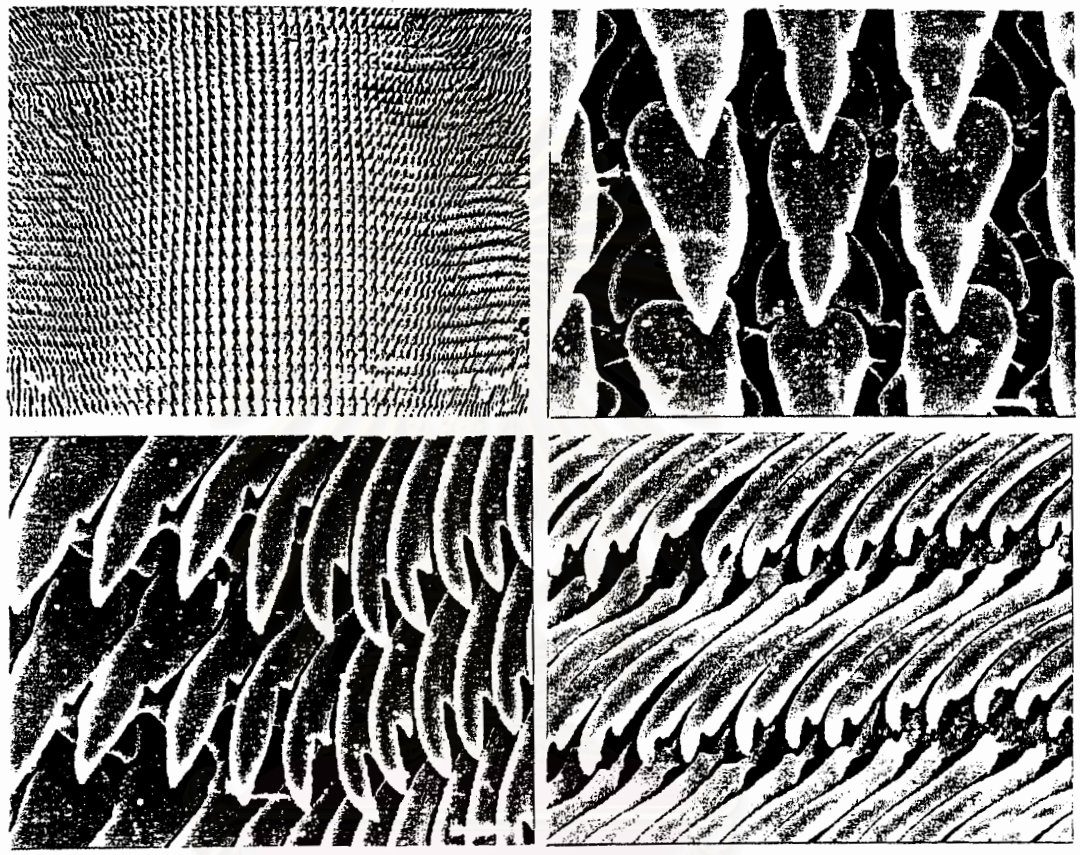
Radula teeth of *Macrochlamys dugasti* : a) radula rows b) central and lateral teeth c) and d) lateral teeth and marginal teeth (Bar = 10 μm)



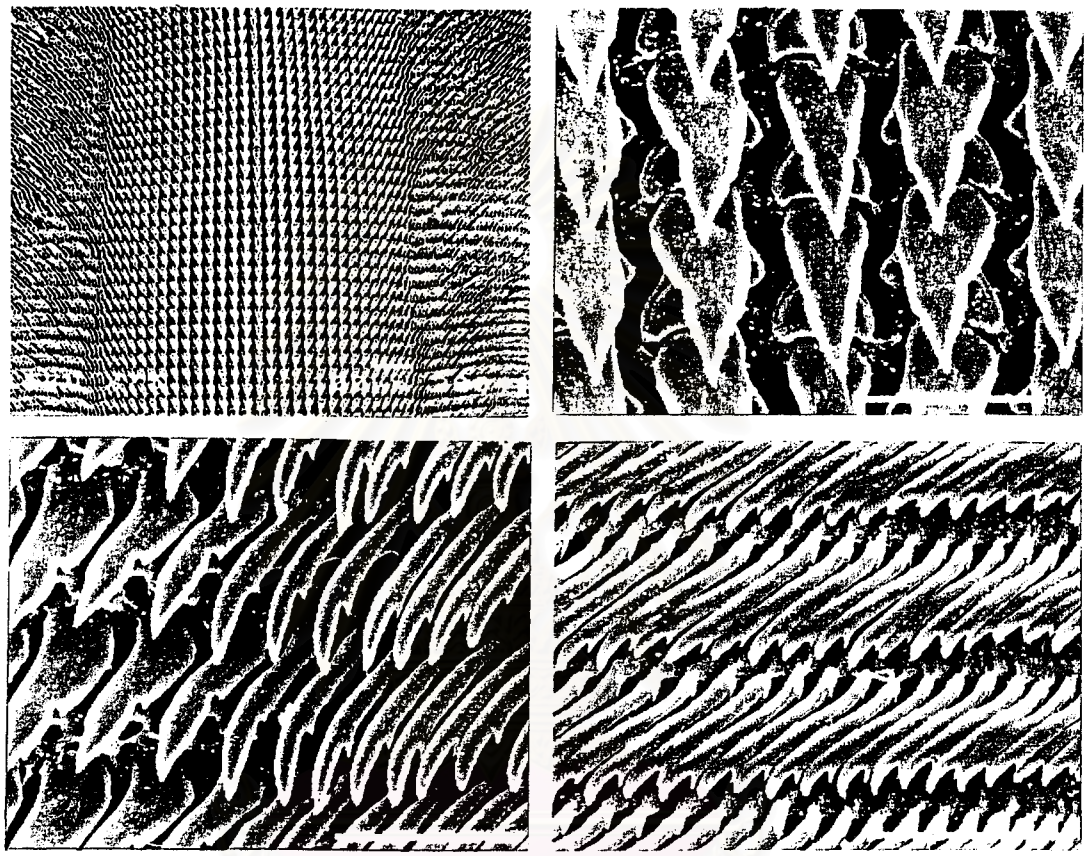
Radula teeth of *Macrochlamys* sp. 1 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 50 µm)



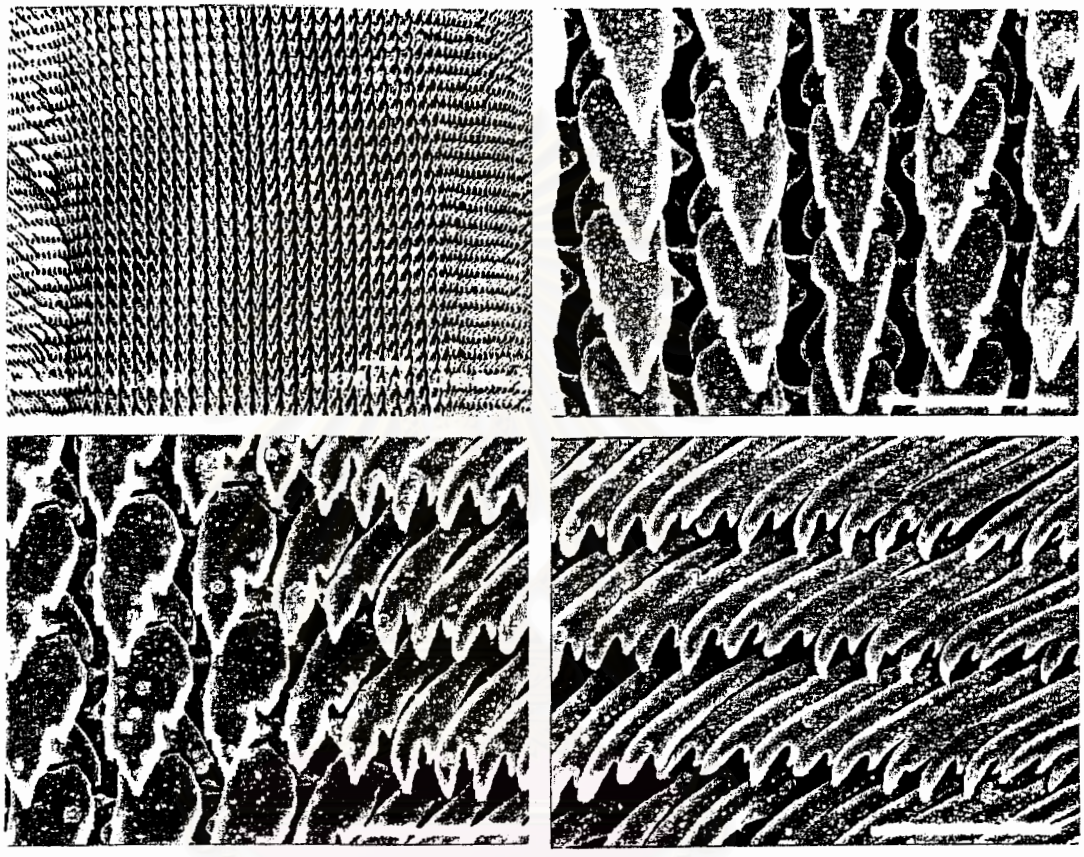
Radula teeth of *Macrochlamys* sp. 2 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 50 µm)



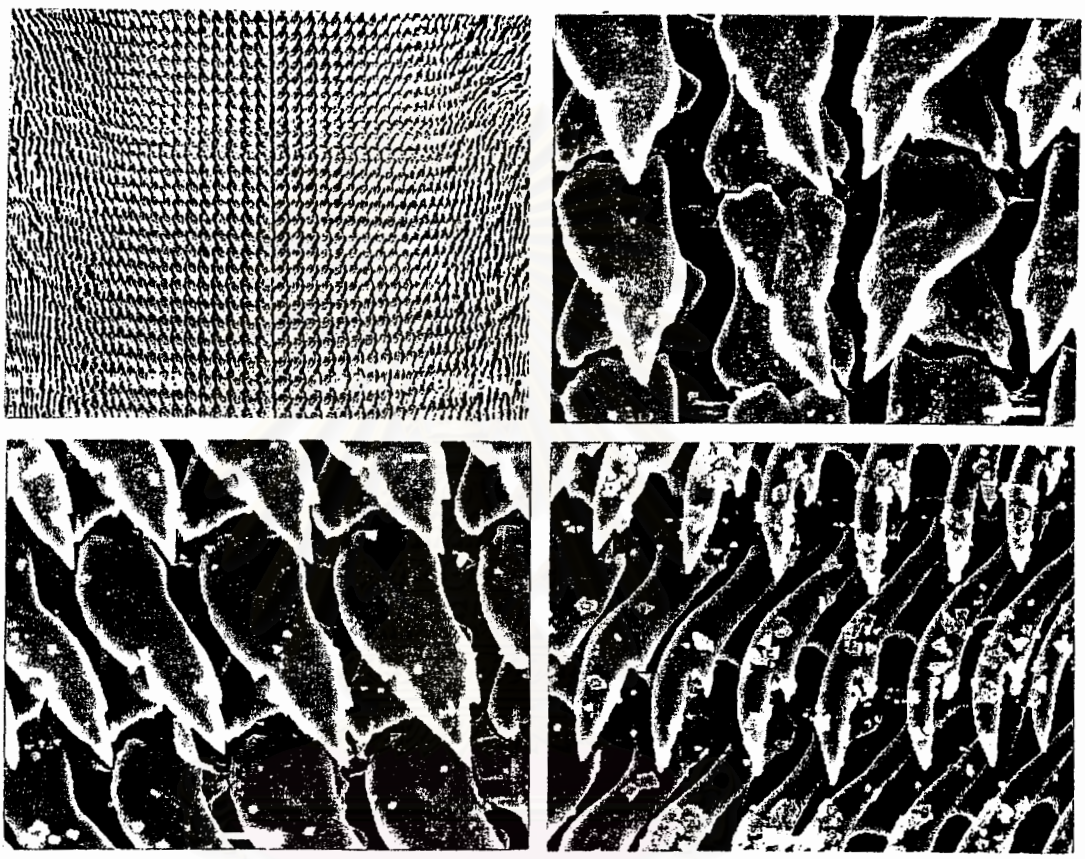
Radula teeth of *Macrochlamys* sp 622 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 10 μm)



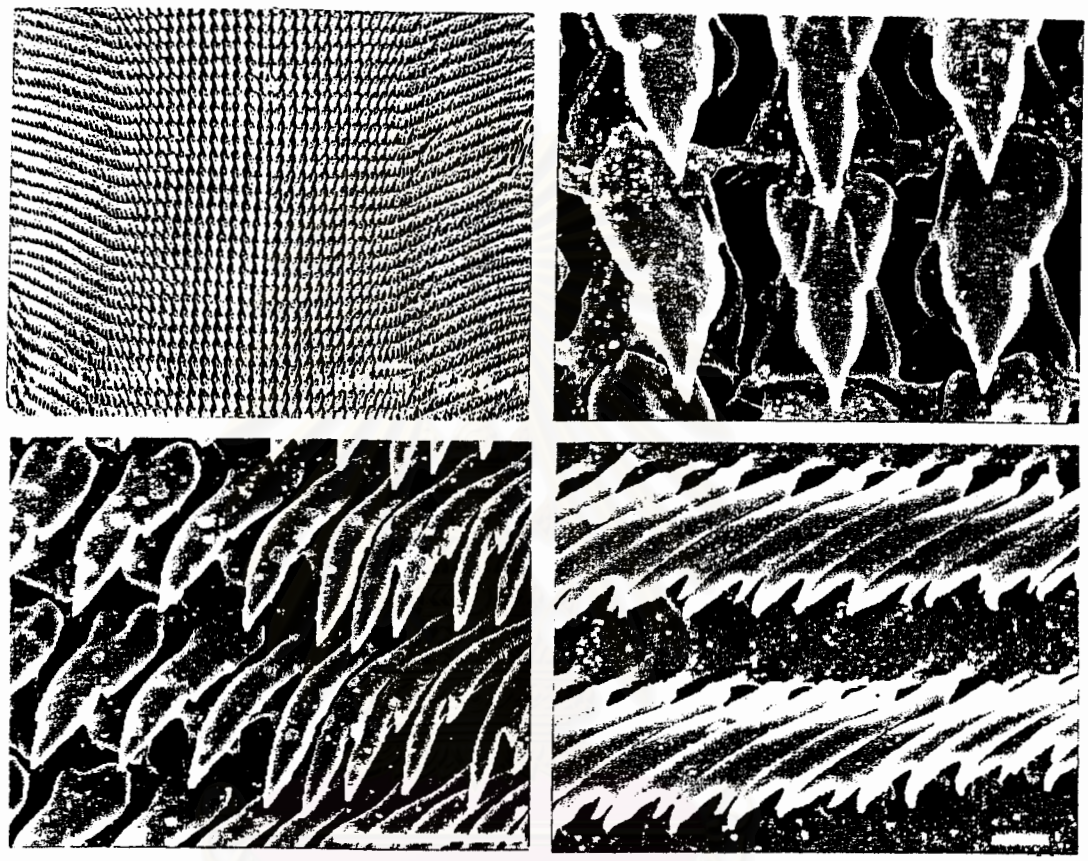
Radula teeth of *Macrochlamys* sp 685 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 50 μm)



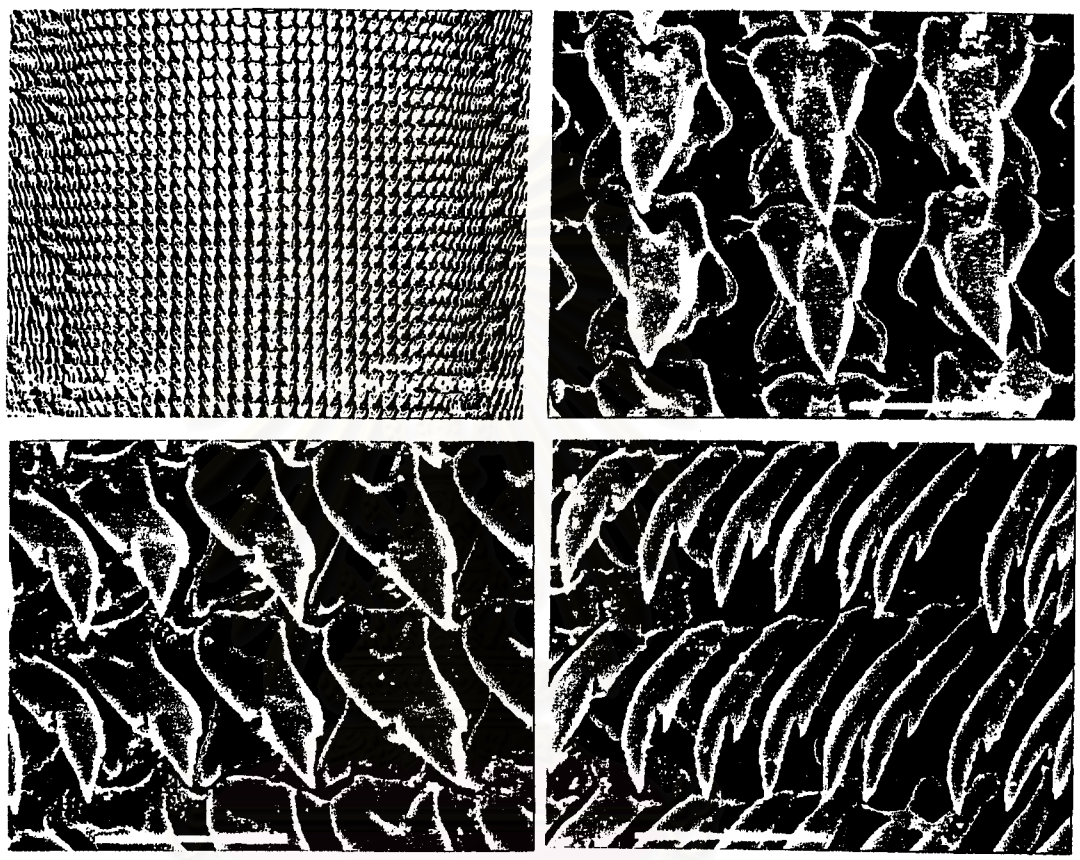
Radula teeth of *Macrochlamys* sp 690/688 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 50 μm)



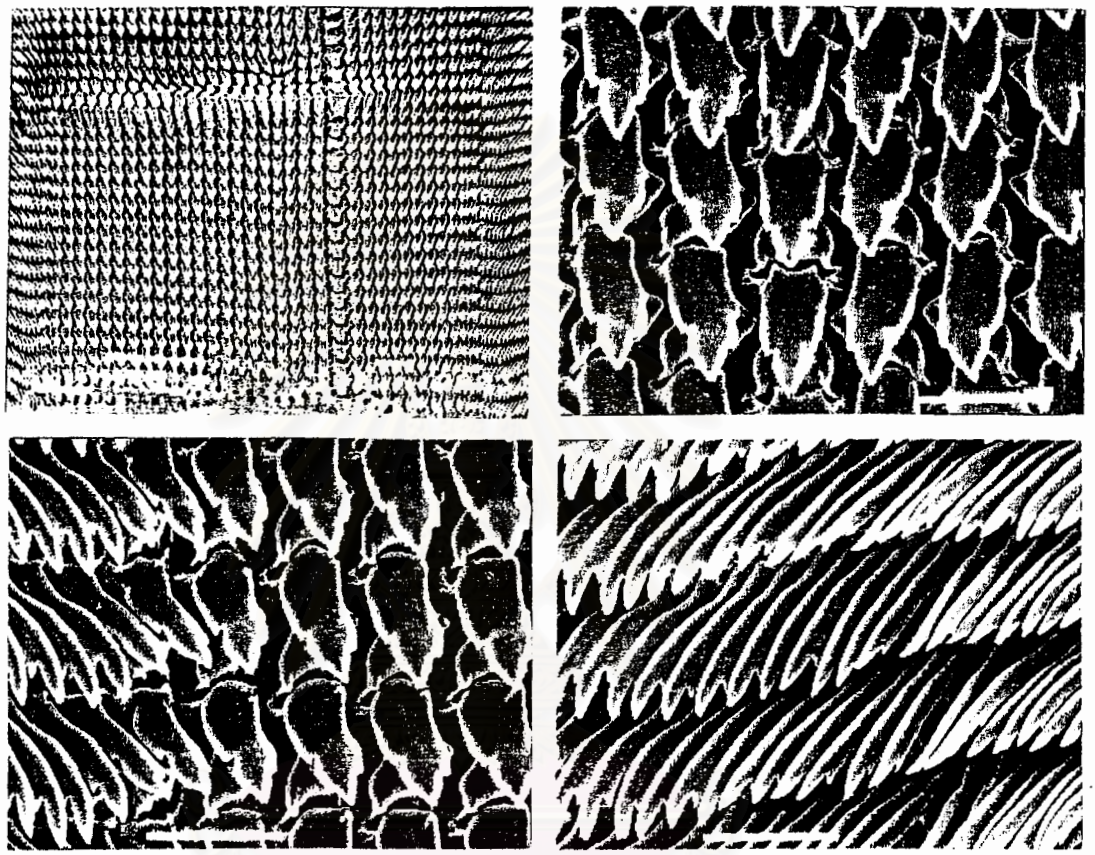
Radula teeth of *Macrochlamys* sp 699 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 10 μm)



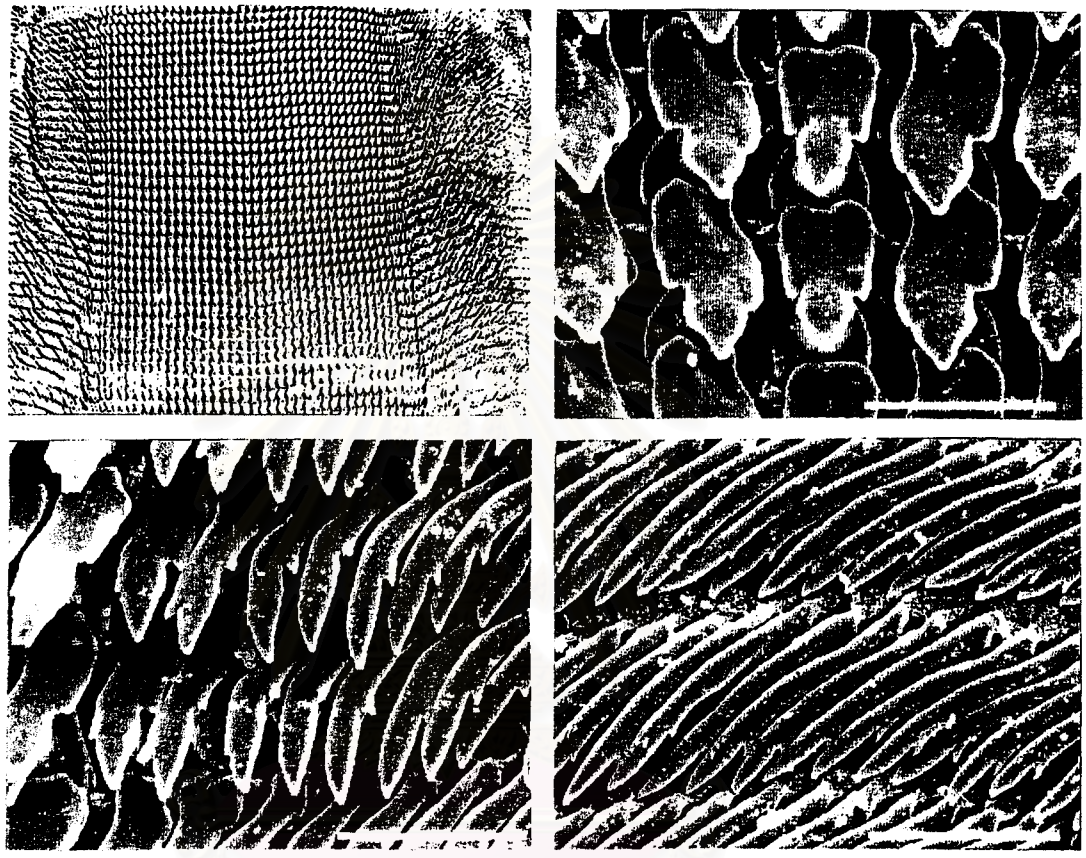
Radula teeth of *Macrochlamys* sp 703 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 10 μm)



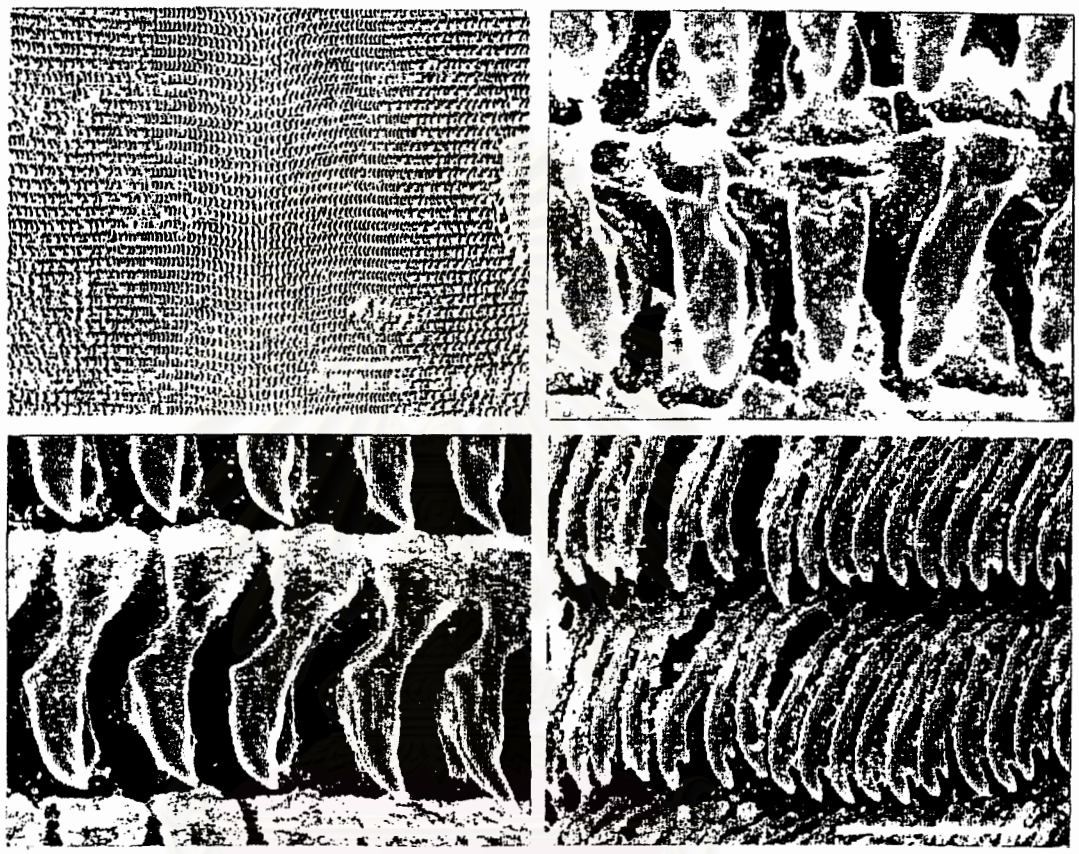
Radula teeth of *Macrochlamys* sp 711 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 50 μm)



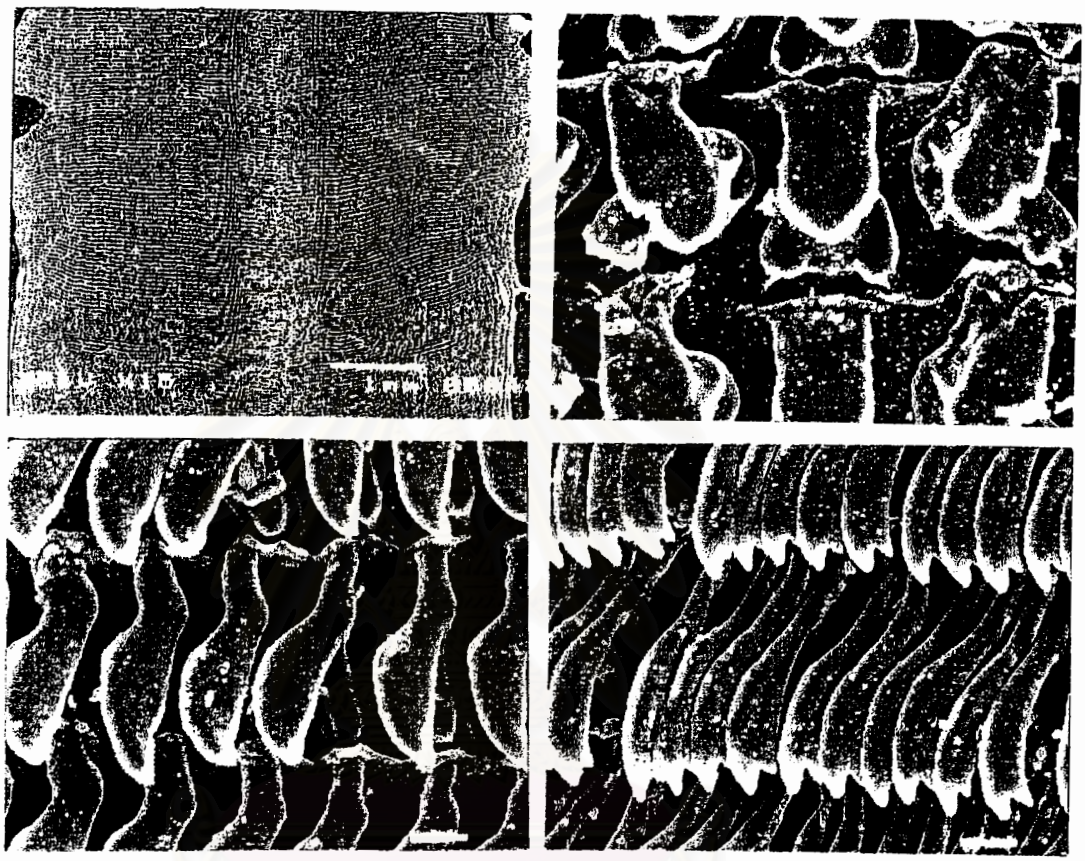
Radula teeth of *Cryptozona siamensis* 1 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 50 µm)



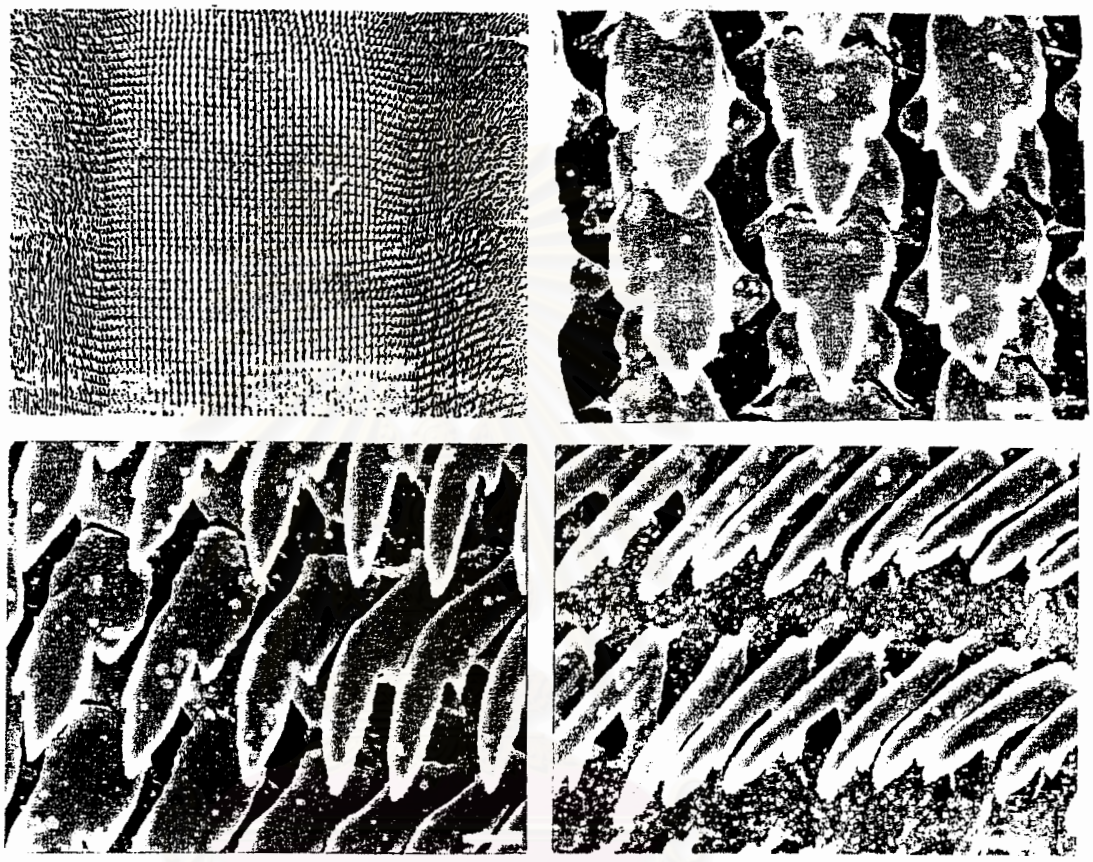
Radula teeth of *Cryptozona siamensis* 2 : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 50 µm)



Radula teeth of *Hemiplecta distincta* : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 50 μm)



Radula teeth of *Hemiplecta neptunus* : a) radula rows b) central and lateral teeth
c) lateral teeth and marginal teeth d) marginal teeth (Bar = 10 μm)



Radula teeth of *Hemiplecta siamensis* : a) radula rows b) central and lateral teeth c) lateral teeth and marginal teeth d) marginal teeth (Bar = 10 μm)

APPENDIX VI

REGRESSION ANALYSIS

Descriptive Statistics

	Mean	Std. Deviation	N
ECL	.7552	.4328	169
EL	.5433	.2103	169

Correlations

		ECL	EL
Pearson Correlation	ECL	1.000	.016
	EL	.016	1.000
Sig. (1-tailed)	ECL	.	.421
	EL	.421	.
N	ECL	169	169
	EL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.016[a]	.000	-.006	.4341	.492

a. Predictors: (Constant), EL

b. Dependent Variable: ECL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.604E-03	1	7.604E-03	.040	.841[a]
	Residual	31.463	167	.188		
	Total	31.471	168			

a. Predictors: (Constant), EL

b. Dependent Variable: ECL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.738	.093		7.958	.000	.555	.921
	EL	3.199E-02	.159	.016	.201	.841	-.282	.346

a. Dependent Variable: ECL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	ECL
163	15.00	3.872	2.44

a. Dependent Variable: ECL

Regression ECL and PAL

Descriptive Statistics

	Mean	Std. Deviation	N
ECL	.7552	.4328	169
PAL	.2491	.1140	169

Correlations

		ECL	PAL
Pearson Correlation	ECL	1.000	.489
	PAL	.489	1.000
Sig. (1-tailed)	ECL	.	.000
	PAL	.000	.
N	ECL	169	169
	PAL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.489[a]	.240	.235	.3786	.799

a. Predictors: (Constant), PAL

b. Dependent Variable: ECL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.539	1	7.539	52.610	.000[a]
	Residual	23.932	167	.143		
	Total	31.471	168			

a. Predictors: (Constant), PAL

b. Dependent Variable: ECL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.292	.070		4.170	.000	.154	.431
	PAL	1.858	.256	.489	7.253	.000	1.352	2.363

a. Dependent Variable: ECL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	ECL
163	15.00	3.956	2.44

a. Dependent Variable: ECL

Regression ECL and PEL

Descriptive Statistics

	Mean	Std. Deviation	N
ECL	.7552	.4328	169
PEL	1.1963	.6784	169

Correlations

		ECL	PEL
Pearson Correlation	ECL	1.000	-.272
	PEL	-.272	1.000
Sig. (1-tailed)	ECL	.	.000
	PEL	.000	.
N	ECL	169	169
	PEL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.272[a]	.074	.068	.4178	.593

a. Predictors: (Constant), PEL

b. Dependent Variable: ECL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.326	1	2.326	13.328	.000[a]
	Residual	29.145	167	.175		
	Total	31.471	168			

a. Predictors: (Constant), PEL

b. Dependent Variable: ECL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.963	.065		14.745	.000	.834	1.092
	PEL	-.173	.048	-.272	-3.651	.000	-.267	-.080

a. Dependent Variable: ECL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	ECL
163	15.00	3.972	2.44

a. Dependent Variable: ECL

Regression ECL and SL

Descriptive Statistics

	Mean	Std. Deviation	N
ECL	.7552	.4328	169
SL	1.8954	1.0525	169

Correlations

		ECL	SL
Pearson Correlation	ECL	1.000	.826
	SL	.826	1.000
Sig. (1-tailed)	ECL	.	.000
	SL	.000	.
N	ECL	169	169
	SL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.826[a]	.683	.681	.2446	1.293

a. Predictors: (Constant), SL

b. Dependent Variable: ECL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.482	1	21.482	359.135	.000[a]
	Residual	9.989	167	5.981E-02		
	Total	31.471	168			

a. Predictors: (Constant), SL

b. Dependent Variable: ECL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.111	.039		2.864	.005	.035	.188
	SL	.340	.018	.826	18.951	.000	.304	.375

a. Dependent Variable: ECL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	ECL
163	15.00	4.965	2.44

a. Dependent Variable: ECL

Regression ECL and VDL

Descriptive Statistics

	Mean	Std. Deviation	N
ECL	.7552	.4328	169
VDL	1.6074	.8671	169

Correlations

		ECL	VDL
Pearson Correlation	ECL	1.000	-.111
	VDL	-.111	1.000
Sig. (1-tailed)	ECL	.	.076
	VDL	.076	.
N	ECL	169	169
	VDL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.111[a]	.012	.006	.4314	.542

a. Predictors: (Constant), VDL

b. Dependent Variable: ECL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.387	1	.387	2.078	.151[a]
	Residual	31.084	167	.186		
	Total	31.471	168			

a. Predictors: (Constant), VDL

b. Dependent Variable: ECL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.844	.070		12.049	.000	.706	.982
	VDL	-5.53E-02	.038	-.111	-1.442	.151	-.131	.020

a. Dependent Variable: ECL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	ECL
163	15.00	3.949	2.44

a. Dependent Variable: ECL

Regression EL and PAL

Descriptive Statistics

	Mean	Std. Deviation	N
EL	.5433	.2103	169
PAL	.2491	.1140	169

Correlations

		EL	PAL
Pearson Correlation	EL	1.000	.156
	PAL	.156	1.000
Sig. (1-tailed)	EL	.	.022
	PAL	.022	.
N	EL	169	169
	PAL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.156[a]	.024	.018	.2084	.966

a. Predictors: (Constant), PAL

b. Dependent Variable: EL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.180	1	.180	4.154	.043[a]
	Residual	7.252	167	4.343E-02		
	Total	7.433	168			

a. Predictors: (Constant), PAL

b. Dependent Variable: EL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.472	.039		12.217	.000	.395	.548
	PAL	.287	.141	.156	2.038	.043	.009	.566

a. Dependent Variable: EL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	EL
56	6.00	3.213	1.19
83	7.00	3.535	1.26

a. Dependent Variable: EL

Regression EL and PEL

Descriptive Statistics

	Mean	Std. Deviation	N
EL	.5433	.2103	169
PEL	1.1963	.6784	169

Correlations

		EL	PEL
Pearson Correlation	EL	1.000	.506
	PEL	.506	1.000
Sig. (1-tailed)	EL	.	.000
	PEL	.000	.
N	EL	169	169
	PEL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.506[a]	.256	.251	.1820	1.189

a. Predictors: (Constant), PEL

b. Dependent Variable: EL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.900	1	1.900	57.353	.000[a]
	Residual	5.533	167	3.313E-02		
	Total	7.433	168			

a. Predictors: (Constant), PEL

b. Dependent Variable: EL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.356	.028		12.505	.000	.300	.412
	PEL	.157	.021	.506	7.573	.000	.116	.198

a. Dependent Variable: EL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	EL
80	7.00	3.016	1.11
83	7.00	3.599	1.26

a. Dependent Variable: EL

Regression EL and SL

Descriptive Statistics

	Mean	Std. Deviation	N
EL	.5433	.2103	169
SL	1.8954	1.0525	169

Correlations

		EL	SL
Pearson Correlation	EL	1.000	-.038
	SL	-.038	1.000
Sig. (1-tailed)	EL	.	.310
	SL	.310	.
N	EL	169	169
	SL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.038[a]	.001	-.005	.2108	.995

a. Predictors: (Constant), SL

b. Dependent Variable: EL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.092E-02	1	1.092E-02	.246	.621[a]
	Residual	7.422	167	4.444E-02		
	Total	7.433	168			

a. Predictors: (Constant), SL

b. Dependent Variable: EL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.558	.033		16.660	.000	.492	.624
	SL	-7.66E-03	.015	-.038	-.496	.621	-.038	.023

a. Dependent Variable: EL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	EL
56	6.00	3.028	1.19
83	7.00	3.409	1.26

a. Dependent Variable: EL

Regression EL and VDL

Descriptive Statistics

	Mean	Std. Deviation	N
EL	.5433	.2103	169
VDL	1.6074	.8671	169

Correlations

		EL	VDL
Pearson Correlation	EL	1.000	.411
	VDL	.411	1.000
Sig. (1-tailed)	EL	.	.000
	VDL	.000	.
N	EL	169	169
	VDL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.411[a]	.169	.164	.1923	1.015

a. Predictors: (Constant), VDL

b. Dependent Variable: EL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.255	1	1.255	33.923	.000[a]
	Residual	6.178	167	3.699E-02		
	Total	7.433	168			

a. Predictors: (Constant), VDL

b. Dependent Variable: EL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.383	.031		12.264	.000	.321	.445
	VDL	9.967E-02	.017	.411	5.824	.000	.066	.133

a. Dependent Variable: EL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	EL
80	7.00	3.039	1.11
83	7.00	3.565	1.26

a. Dependent Variable: EL

Regression PAL and PEL

Descriptive Statistics

	Mean	Std. Deviation	N
PAL	.2491	.1140	169
PEL	1.1963	.6784	169

Correlations

		PAL	PEL
Pearson Correlation	PAL	1.000	.261
	PEL	.261	1.000
Sig. (1-tailed)	PAL	.	.000
	PEL	.000	.
N	PAL	169	169
	PEL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.261[a]	.068	.063	.1104	1.011

a. Predictors: (Constant), PEL

b. Dependent Variable: PAL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.149	1	.149	12.254	.001[a]
	Residual	2.035	167	1.219E-02		
	Total	2.185	168			

a. Predictors: (Constant), PEL

b. Dependent Variable: PAL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.197	.017		11.392	.000	.162	.231
	PEL	4.395E-02	.013	.261	3.501	.001	.019	.069

a. Dependent Variable: PAL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	PAL
12	3.00	3.659	.64
17	3.00	3.553	.66

a. Dependent Variable: PAL

Regression PAL and SL

Descriptive Statistics

	Mean	Std. Deviation	N
PAL	.2491	.1140	169
SL	1.8954	1.0525	169

Correlations

		PAL	SL
Pearson Correlation	PAL	1.000	.509
	SL	.509	1.000
Sig. (1-tailed)	PAL	.	.000
	SL	.000	.
N	PAL	169	169
	SL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.509[a]	.259	.254	9.847E-02	1.256

a. Predictors: (Constant), SL

b. Dependent Variable: PAL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.565	1	.565	58.280	.000[a]
	Residual	1.619	167	9.697E-03		
	Total	2.185	168			

a. Predictors: (Constant), SL

b. Dependent Variable: PAL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.145	.016		9.250	.000	.114	.176
	SL	5.511E-02	.007	.509	7.634	.000	.041	.069

a. Dependent Variable: PAL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	PAL
12	3.00	3.060	.64
22	4.00	3.481	.51

a. Dependent Variable: PAL

Regression PAL and VDL

Descriptive Statistics

	Mean	Std. Deviation	N
PAL	.2491	.1140	169
VDL	1.6074	.8671	169

Correlations

		PAL	VDL
Pearson Correlation	PAL	1.000	.208
	VDL	.208	1.000
Sig. (1-tailed)	PAL	.	.003
	VDL	.003	.
N	PAL	169	169
	VDL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.208[a]	.043	.038	.1119	.956

a. Predictors: (Constant), VDL

b. Dependent Variable: PAL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.450E-02	1	9.450E-02	7.551	.007[a]
	Residual	2.090	167	1.252E-02		
	Total	2.185	168			

a. Predictors: (Constant), VDL

b. Dependent Variable: PAL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.205	.018		11.292	.000	.169	.241
	VDL	2.735E-02	.010	.208	2.748	.007	.008	.047

a. Dependent Variable: PAL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	PAL
12	3.00	3.545	.64
17	3.00	3.636	.66

a. Dependent Variable: PAL

Regression PEL and SL

Descriptive Statistics

	Mean	Std. Deviation	N
PEL	1.1963	.6784	169
SL	1.8954	1.0525	169

Correlations

		PEL	SL
Pearson Correlation	PEL	1.000	-.275
	SL	-.275	1.000
Sig. (1-tailed)	PEL	.	.000
	SL	.000	.
N	PEL	169	169
	SL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.275[a]	.075	.070	.6543	.441

a. Predictors: (Constant), SL

b. Dependent Variable: PEL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.834	1	5.834	13.628	.000[a]
	Residual	71.490	167	.428		
	Total	77.324	168			

a. Predictors: (Constant), SL

b. Dependent Variable: PEL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.532	.104		14.742	.000	1.327	1.737
	SL	-.177	.048	-.275	-3.692	.000	-.272	-.082

a. Dependent Variable: PEL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	PEL
27	4.00	3.021	3.34
28	4.00	3.750	3.86
29	4.00	3.799	3.86

a. Dependent Variable: PEL

Regression PEL and VDL

Descriptive Statistics

	Mean	Std. Deviation	N
PEL	1.1963	.6784	169
VDL	1.6074	.8671	169

Correlations

		PEL	VDL
Pearson Correlation	PEL	1.000	.742
	VDL	.742	1.000
Sig. (1-tailed)	PEL	.	.000
	VDL	.000	.
N	PEL	169	169
	VDL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.742[a]	.550	.547	.4565	.610

a. Predictors: (Constant), VDL

b. Dependent Variable: PEL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	42.529	1	42.529	204.120	.000[a]
	Residual	34.795	167	.208		
	Total	77.324	168			

a. Predictors: (Constant), VDL

b. Dependent Variable: PEL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.264	.074		3.556	.000	.117	.410
	VDL	.580	.041	.742	14.287	.000	.500	.660

a. Dependent Variable: PEL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	PEL
22	4.00	3.027	2.91
28	4.00	3.201	3.86
41	6.00	-3.120	.94

a. Dependent Variable: PEL

Regression SL and VDL

Descriptive Statistics

	Mean	Std. Deviation	N
SL	1.8954	1.0525	169
VDL	1.6074	.8671	169

Correlations

		SL	VDL
Pearson Correlation	SL	1.000	-.162
	VDL	-.162	1.000
Sig. (1-tailed)	SL	.	.018
	VDL	.018	.
N	SL	169	169
	VDL	169	169

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.162[a]	.026	.020	1.0417	.562

a. Predictors: (Constant), VDL

b. Dependent Variable: SL

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.884	1	4.884	4.501	.035[a]
	Residual	181.207	167	1.085		
	Total	186.091	168			

a. Predictors: (Constant), VDL

b. Dependent Variable: SL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2.211	.169		13.073	.000	1.877	2.545
	VDL	-.197	.093	-.162	-2.122	.035	-.380	-.014

a. Dependent Variable: SL

Casewise Diagnostics[a]

Case Number	SPECIES	Std. Residual	SL
18	3.00	3.192	5.23

a. Dependent Variable: SL

APPENDIX VII

DUNCAN'S MULTIPLE RANGE TEST

Means of genital organ length ratio for groups in homogeneous subsets in each species.

ECL_PAL

Duncan[a,b]

species	N	Subset for alpha = .05				
		1	2	3	4	5
Hemiplecta distincta	10	1.09080				
Hemiplecta neptunus	20	1.65445	1.65445			
Syama diadema	10	1.83790	1.83790			
Macrochlamys sp (557) KSD	5		2.33660	2.33660		
Macrochlamys sp [699]	10			3.07480	3.07480	
Cryptozona siamensis (1)	10			3.12510	3.12510	
Macrochlamys sp (711)	10			3.18400	3.18400	
Macrochlamys sp [703]	10			3.31700	3.31700	
Macrochlamys sp [622]	10				3.48300	
Cryptozona siamensis[709]	9				3.72622	
Macrochlamys asamurai	25				3.93240	
Macrochlamys sp (690/688)	15				4.01520	
Cryptozona siamensis (2)	10				4.06490	
Macrochlamys sp (621/719)	20					5.06115
Macrochlamys sp (685)	5					5.52160
Sig.		.155	.194	.077	.093	.351

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

PL_PAL

Duncan[a,b]

species	N	Subset for alpha = .05				
		1	2	3	4	5
Macrochlamys sp [699]	10	2.56150				
Macrochlamys sp [622]	10	2.78770				
Cryptozona siamensis (1)	10	2.85890				
Macrochlamys sp (711)	10	2.89860				
Macrochlamys sp (621/719)	20	3.13785				
Macrochlamys sp (685)	5	3.27660				
Cryptozona siamensis[709]	9	3.36578				
Macrochlamys sp (557) KSD	5	3.69300	3.69300			
Cryptozona siamensis (2)	10	4.66680	4.66680	4.66680		
Syama diadema	10		5.75690	5.75690	5.75690	
Macrochlamys sp [703]	10		5.91960	5.91960	5.91960	
Macrochlamys asamurai	25			6.39440	6.39440	
Macrochlamys sp (690/688)	15				7.83253	
Hemiplecta distincta	10				8.03230	
Hemiplecta neptunus	20					11.56915
Sig.		.097	.055	.141	.055	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

SL_PAL

Duncan[a,b]

species	N	Subset for alpha = .05				
		1	2	3	4	5
Hemiplecta distincta	10	1.63970				
Hemiplecta neptunus	20		4.16765			
Syama diadema	10		5.95520	5.95520		
Macrochlamys sp [699]	10		6.05560	6.05560		
Macrochlamys sp (557) KSD	5			7.53520	7.53520	
Cryptozona siamensis (1)	10			8.29400	8.29400	
Macrochlamys asamurai	25				8.89232	8.89232
Macrochlamys sp (685)	5				9.52260	9.52260
Macrochlamys sp (711)	10				9.81073	9.81073
Macrochlamys sp [703]	10				9.90630	9.90630
Cryptozona siamensis (2)	10				9.98270	9.98270
Macrochlamys sp (621/719)	20				10.01070	10.01070
Macrochlamys sp [622]	10				10.03260	10.03260
Cryptozona siamensis[709]	9					11.20656
Macrochlamys sp (690/688)	15					11.64113
Sig.		1.000	.143	.078	.084	.055

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

EL_PAL

Duncan[a,b]

species	N	Subset for alpha = .05					
		1	2	3	4	5	6
Cryptozona siamensis (1)	10	.96850					
Cryptozona siamensis (2)	10	1.24920					
Macrochlamys sp [622]	10	1.42340					
Cryptozona siamensis[709]	9	1.43367					
Macrochlamys sp (711)	10	1.51310	1.51310				
Macrochlamys sp (557) KSD	5	1.61320	1.61320	1.61320			
Macrochlamys sp [699]	10	1.65360	1.65360	1.65360			
Macrochlamys sp (621/719)	20	1.75560	1.75560	1.75560			
Hemiplecta distincta	10	1.96700	1.96700	1.96700			
Macrochlamys sp (685)	5	2.01260	2.01260	2.01260			
Syama diadema	10		2.66790	2.66790	2.66790		
Macrochlamys sp [703]	10			2.76310	2.76310	2.76310	
Hemiplecta neptunus	20				3.64240	3.64240	
Macrochlamys sp (690/688)	15					3.81733	
Macrochlamys asamurai	25						4.95212
Sig.		.098	.056	.057	.078	.056	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

VDL_PAL

Duncan[a,b]

species	N	Subset for alpha = .05			
		1	2	3	4
Cryptozona siamensis (1)	10	2.90620			
Syama diadema	10	3.93610	3.93610		
Macrochlamys sp (557) KSD	5	3.94140	3.94140		
Macrochlamys sp [699]	10	4.40500	4.40500		
Cryptozona siamensis[709]	9	4.40922	4.40922		
Cryptozona siamensis (2)	10	4.81670	4.81670		
Macrochlamys sp [622]	10	4.89030	4.89030		
Macrochlamys sp (685)	5	5.06220	5.06220		
Macrochlamys sp [703]	10	6.01180	6.01180		
Macrochlamys sp (621/719)	20	6.15250	6.15250		
Macrochlamys sp (711)	10		6.67690		
Hemiplecta distincta	10		7.47250		
Macrochlamys asamurai	25		7.48768		
Macrochlamys sp (690/688)	15			10.92473	
Hemiplecta neptunus	20				19.49595
Sig.		.090	.066	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

PL_VDL

Duncan[a,b]

species	N	Subset for alpha = .05						
		1	2	3	4	5	6	7
Macrochlamys sp (711)	10	.48130						
Macrochlamys sp (621/719)	20	.55845						
Macrochlamys sp [622]	10	.58190	.58190					
Macrochlamys sp [699]	10	.58690	.58690					
Hemiplecta neptunus	20	.59560	.59560					
Macrochlamys sp (685)	5	.65740	.65740	.65740				
Cryptozona siamensis[709]	9		.77267	.77267	.77267			
Macrochlamys sp (690/688)	15			.80553	.80553			
Macrochlamys asamurai	25				.86140	.86140		
Macrochlamys sp (557) KSD	5				.90700	.90700	.90700	
Cryptozona siamensis (2)	10				.97000	.97000	.97000	
Macrochlamys sp [703]	10					1.03020	1.03020	
Cryptozona siamensis (1)	10					1.05560	1.05560	
Hemiplecta distincta	10						1.08940	
Syama diadema	10							1.43590
Sig.		.094	.063	.127	.054	.058	.076	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

PAL_VDL

Duncan[a,b]

species	N	Subset for alpha = .05					
		1	2	3	4	5	6
Hemiplecta neptunus	20	5.52E-02					
Macrochlamys sp (690/688)	15	.12147	.12147				
Hemiplecta distincta	10		.14670	.14670			
Macrochlamys sp [703]	10		.17440	.17440	.17440		
Macrochlamys sp (711)	10		.17570	.17570	.17570		
Macrochlamys asamurai	25		.18332	.18332	.18332		
Macrochlamys sp (621/719)	20		.18450	.18450	.18450		
Macrochlamys sp (685)	5		.19960	.19960	.19960	.19960	
Macrochlamys sp [622]	10		.20910	.20910	.20910	.20910	
Cryptozona siamensis (2)	10			.21650	.21650	.21650	
Macrochlamys sp [699]	10				.23590	.23590	
Cryptozona siamensis[709]	9				.26300	.26300	
Syama diadema	10					.27610	
Macrochlamys sp (557) KSD	5					.27680	
Cryptozona siamensis (1)	10						.37050
Sig.		.086	.052	.127	.052	.086	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

EL_VDL

Duncan[a,b]

species	N	Subset for alpha = .05								
		1	2	3	4	5	6	7	8	9
Hemiplecta neptunus	20	.18685								
Macrochlamys sp (711)	10	.24370	.24370							
Cryptozona siamensis (2)	10	.25900	.25900	.25900						
Hemiplecta distincta	10	.28280	.28280	.28280	.28280					
Macrochlamys sp [622]	10		.29513	.29513	.29513	.29513				
Macrochlamys sp (621/719)	20		.31575	.31575	.31575	.31575	.31575			
Cryptozona siamensis[709]	9		.33389	.33389	.33389	.33389	.33389	.33389		
Cryptozona siamensis (1)	10			.35100	.35100	.35100	.35100	.35100		
Macrochlamys sp [699]	10				.38040	.38040	.38040	.38040	.38040	
Macrochlamys sp (690/688)	15					.38793	.38793	.38793	.38793	
Macrochlamys sp (685)	5						.40200	.40200	.40200	
Macrochlamys sp (557) KSD	5							.42040	.42040	
Macrochlamys sp [703]	10								.45780	
Macrochlamys asamurai	25									.66852
Syama diadema	10									.68010
Sig.		.056	.087	.080	.062	.078	.102	.101	.137	.801

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

SL_VDL

Duncan[a,b]

species	N	Subset for alpha = .05						
		1	2	3	4	5	6	7
Hemiplecta neptunus	20	.21495						
Hemiplecta distincta	10	.23020						
Macrochlamys asamurai	25		1.22588					
Macrochlamys sp (690/688)	15		1.24547					
Macrochlamys sp [699]	10		1.36480	1.36480				
Syama diadema	10		1.57760	1.57760	1.57760			
Macrochlamys sp (711)	10			1.68440	1.68440	1.68440		
Macrochlamys sp [703]	10			1.71040	1.71040	1.71040		
Macrochlamys sp (621/719)	20				1.80835	1.80835		
Macrochlamys sp (685)	5				1.89320	1.89320		
Macrochlamys sp (557) KSD	5				1.93460	1.93460		
Cryptozona siamensis (2)	10					2.04950		
Macrochlamys sp [622]	10					2.05720		
Cryptozona siamensis[709]	9						2.56956	
Cryptozona siamensis (1)	10							2.97300
Sig.		.935	.087	.093	.097	.088	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

PL_ECL

Duncan[a,b]

species	N	Subset for alpha = .05					
		1	2	3	4	5	6
Macrochlamys sp (685)	5	.59680					
Macrochlamys sp (621/719)	20	.66240					
Macrochlamys sp [622]	10	.81810	.81810				
Macrochlamys sp [699]	10	.87160	.87160				
Cryptozona siamensis[709]	9	.91878	.91878				
Macrochlamys sp (711)	10	.92420	.92420				
Cryptozona siamensis (1)	10	.96620	.96620				
Cryptozona siamensis (2)	10	1.19430	1.19430	1.19430			
Macrochlamys sp (557) KSD	5		1.57740	1.57740	1.57740		
Macrochlamys asamurai	25			1.71248	1.71248		
Macrochlamys sp [703]	10			1.92690	1.92690		
Macrochlamys sp (690/688)	15				2.02993		
Syama diadema	10					3.13330	
Hemiplecta neptunus	20						7.37235
Hemiplecta distincta	10						7.56330
Sig.		.151	.060	.054	.243	1.000	.585

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

PAL_ECL

Duncan[a,b]

species	N	Subset for alpha = .05					
		1	2	3	4	5	6
Macrochlamys sp (685)	5	.18180					
Macrochlamys sp (621/719)	20	.21840	.21840				
Cryptozona siamensis (2)	10	.26930	.26930				
Macrochlamys sp (690/688)	15	.29220	.29220				
Macrochlamys asamurai	25	.29336	.29336				
Macrochlamys sp [622]	10	.29360	.29360				
Cryptozona siamensis[709]	9	.30367	.30367				
Macrochlamys sp (711)	10	.32710	.32710				
Macrochlamys sp [703]	10	.34050	.34050	.34050			
Cryptozona siamensis (1)	10	.34620	.34620	.34620			
Macrochlamys sp [699]	10		.35920	.35920			
Macrochlamys sp (557) KSD	5			.49400	.49400		
Syama diadema	10				.60140	.60140	
Hemiplecta neptunus	20					.70745	
Hemiplecta distincta	10						.98693
Sig.		.059	.111	.054	.142	.147	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

SL_ECL

Duncan[a,b]

species	N	Subset for alpha = .05						
		1	2	3	4	5	6	7
Hemiplecta distincta	10	1.58050						
Macrochlamys sp (685)	5	1.73400	1.73400					
Macrochlamys sp [699]	10	2.08850	2.08850	2.08850				
Macrochlamys sp (621/719)	20	2.15015	2.15015	2.15015	2.15015			
Macrochlamys asamurai	25		2.32456	2.32456	2.32456	2.32456		
Cryptozona siamensis (2)	10			2.52770	2.52770	2.52770	2.52770	
Hemiplecta neptunus	20			2.67300	2.67300	2.67300	2.67300	
Cryptozona siamensis (1)	10				2.75510	2.75510	2.75510	2.75510
Macrochlamys sp [622]	10					2.86780	2.86780	2.86780
Macrochlamys sp (690/688)	15						3.00553	3.00553
Cryptozona siamensis[709]	9						3.01589	3.01589
Macrochlamys sp [703]	10						3.12350	3.12350
Macrochlamys sp (711)	10						3.15740	3.15740
Macrochlamys sp (557) KSD	5							3.33600
Syama diadema	10							3.37400
Sig.		.071	.060	.070	.060	.094	.062	.067

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

PL_EL

Duncan[a,b]

species	N	Subset for alpha = .05					
		1	2	3	4	5	6
Macrochlamys asamurai	25	1.31660					
Macrochlamys sp [699]	10	1.57240					
Macrochlamys sp (685)	5	1.64080					
Macrochlamys sp (621/719)	20	1.83085	1.83085				
Macrochlamys sp (711)	10	2.00570	2.00570	2.00570			
Macrochlamys sp [622]	10	2.02250	2.02250	2.02250			
Macrochlamys sp (690/688)	15	2.15933	2.15933	2.15933			
Syama diadema	10	2.21840	2.21840	2.21840			
Cryptozona siamensis[709]	9	2.33800	2.33800	2.33800			
Macrochlamys sp [703]	10	2.37160	2.37160	2.37160			
Macrochlamys sp (557) KSD	5		2.83580	2.83580	2.83580		
Cryptozona siamensis (1)	10			3.03204	3.03204	3.03204	
Hemiplecta neptunus	20				3.70495	3.70495	3.70495
Cryptozona siamensis (2)	10					3.86820	3.86820
Hemiplecta distincta	10						4.37830
Sig.		.064	.073	.067	.085	.098	.185

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

PAL_EL

Duncan[a,b]

species	N	Subset for alpha = .05								
		1	2	3	4	5	6	7	8	9
Macrochlamys asamurai	25	.23096								
Macrochlamys sp (690/688)	15	.32033	.32033							
Hemiplecta neptunus	20	.36735	.36735	.36735						
Macrochlamys sp [703]	10	.41970	.41970	.41970	.41970					
Syama diadema	10		.43550	.43550	.43550					
Macrochlamys sp (685)	5		.50280	.50280	.50280	.50280				
Hemiplecta distincta	10			.53230	.53230	.53230	.53230			
Macrochlamys sp (621/719)	20				.59585	.59585	.59585	.59585		
Macrochlamys sp [699]	10					.63430	.63430	.63430		
Macrochlamys sp (557) KSD	5					.67020	.67020	.67020	.67020	
Macrochlamys sp [622]	10						.72180	.72180	.72180	
Macrochlamys sp (711)	10						.72420	.72420	.72420	
Cryptozona siamensis[709]	9							.77722	.77722	
Cryptozona siamensis (2)	10								.85800	
Cryptozona siamensis (1)	10									1.06200
Sig.		.051	.067	.099	.077	.094	.058	.074	.059	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

VDL_EL

Duncan[a,b]

species	N	Subset for alpha = .05			
		1	2	3	4
Macrochlamys asamurai	25	1.55552			
Syama diadema	10	1.59800			
Macrochlamys sp [703]	10	2.41760	2.41760		
Macrochlamys sp (557) KSD	5	2.50200	2.50200		
Macrochlamys sp (685)	5	2.55020	2.55020		
Macrochlamys sp [699]	10	2.73430	2.73430		
Macrochlamys sp (690/688)	15	2.88520	2.88520	2.88520	
Cryptozona siamensis (1)	10	3.02370	3.02370	3.02370	
Cryptozona siamensis[709]	9	3.05478	3.05478	3.05478	
Macrochlamys sp [622]	10		3.50750	3.50750	
Macrochlamys sp (621/719)	20		3.53440	3.53440	
Cryptozona siamensis (2)	10		3.89190	3.89190	
Hemiplecta distincta	10		3.92450	3.92450	
Macrochlamys sp (711)	10			4.37560	
Hemiplecta neptunus	20				6.22670
Sig.		.067	.071	.066	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 9.883

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Biography

Miss. Anchira Maneevong was born on the 3rd April 1977 in Bangkok. She graduated her bachelor's degree of science in Biology in 1995 from the department of Biology, Faculty of Science, Khonkean University. She continued study for Master's degree of Science Zoology at the Chulalongkorn University in 1999.