

## Chapter 4

### Results

Four Orders, 5 Families, 12 Genera and 18 species were collected, classified and identified. The list is shown in table 4-1. The descriptions of each species are presented below.

Table 4-1 list of pulmonates species in mangrove of upper Gulf of Thailand.

Order	Family	Genus	Species
Archeopulmonata	Ellobiidae	<i>Auriculastra</i>	<i>A. elongata</i>
		<i>Cassidula</i>	<i>Ca. aurisfelis</i>
			<i>Ca. mustelina</i>
		<i>Cylindrotis</i>	<i>Cy. siamensis</i>
		<i>Ellobium</i>	<i>E. aurisjudae</i>
			<i>E. aurismidae</i>
		<i>Laemodonta</i>	<i>L. punctigera</i>
<i>L. siamensis</i>			
<i>Laemodonta</i> sp.			
<i>Melampus</i>	<i>M. siamensis</i>		
<i>Pythia</i>	<i>Py. plicata</i>		
	<i>Py. trigona</i>		
Basommatophora	Siphonariidae	<i>Siphonaria</i>	<i>Si. laciniosa</i>
	Amphibolidae	<i>Salinator</i>	<i>Salinator</i> sp.
Systellommatophora	Onchidiidae	<i>Onchidium</i>	<i>Onchidium</i> sp1.
			<i>Onchidium</i> sp2.
		<i>Platevindex</i>	<i>Platevindex</i> sp.
Stylommatophora	Succineidae	<i>Succinea</i>	<i>Succinea</i> sp.

*Auriculastra elongata* (Küster, 1844)

(Fig. 4-1, 4-2)

- 1844 *Auricula elongata* Küster, Conch. Cab. , 1, 16: 53, pl. 3 Fig. 6-8 (Sandwich Island).
- 1875 *Auricula elongata* Küster, Morelet, Sér. Conch. , 4: 93 (Maurice)
- 1898 *Auriculastra elongata* (Küster), Koblelt, Conch. Cab. , 1, 16: 96, pl. 15 Fig. 17-18 (von Mauritius bis zu den Sandwich Island)
- 1964 *Auriculastra elongata* (Küster), Habe, Shell of the western Pacific in color II pl. 44 Fig. 6 (Amami islands).
- 1974 *Auriculastra elongata* (Küster), Brandt, Arch. Moll. , 105: 423 (Trat).

Shell is 9.9 - 16.4 mm long and 4.3 - 6.2 mm wide, thick elongated oval, solid, pale yellow color and glossy. Spire height is 1.8 – 4.5 mm, conic with pointed apex (generally eroded) and slightly indented suture. Shell surface is smooth and polished with very fine, low radial ribs. There are about 6-8 whorls. The largest part of body whorl is about 0.76 of shell length. Aperture height is about 0.78 of body whorl length, elongated oval, white color inside, ear-shaped. Parietal wall has a strong parietal tooth and 2 small teeth. Columella simple, truncated at the base with a small tooth. Palatal wall is smooth (Fig. 4-1a). Animal has creamy white or cream color with subcylindrical tentacles, tapering. Foot and mantle skirt is creamy white.

The formula of radula is (28-36) + 1 + (28-36) with a small central tooth; wide base, triangular, emarginated, short crown, unicuspid and round shaped. Lateral teeth base is rhombic shaped, crown bicuspid; mesocone rounded and broader than endocone. Marginal teeth base is quadrangular and elongated with bicuspid crown; mesocone rounded and elongated. Sizes of outer lateral teeth are about a half of lateral teeth (Fig. 4-2).

Reproductive system contains conical, pale yellow with brown ovotestis and short hermaphroditic duct. Albumen gland is multilobed, white. Seminal vesicle is convoluted, long (Fig. 4-1e). Penial complex is moderately long; vas deferens is separated from penial sheath and entered penial structure at penis base. Penis is oval, blunt. Penial sheath is about 2 times of penial length. Penial retractor muscle is thin, about 2 times longer than penial sheath (Fig. 4-1d).

Nervous system composed of large lobed cerebral ganglia and unlobed parietal, pedal, pleural and visceral ganglia. Cerebral ganglia is the largest, which diameter is about 0.26 – 0.43 mm. Pedal ganglia is almost the same size as cerebral ganglia, and round shaped. Visceral ganglia are rounded, about half size of pedal ganglia. Pleural and parietal ganglia, except right parietal ganglion, are long and round shape but smaller than visceral ganglia. Statocysts present at posterior part of pedal ganglia. Left cerebropedal and cerebropleural commissures are about 2 times longer than the right. Right pleuroparietal commissure is 2 times longer than left commissure and vice versa in parietovisceral commissure (Fig. 4-1c).

Habitat notes: *A. elongata* frequently crawls on mud surface at high tide of the mangrove and nipa palm forests. Sometimes they hide themselves under log or substratum.

Distribution in upper Gulf of Thailand: Chonburi, Samutprakan, Samutsongkram and Phetchaburi Provinces

World distribution: Japan, Sandwich Island, Thailand, Maurice, Mauritius.

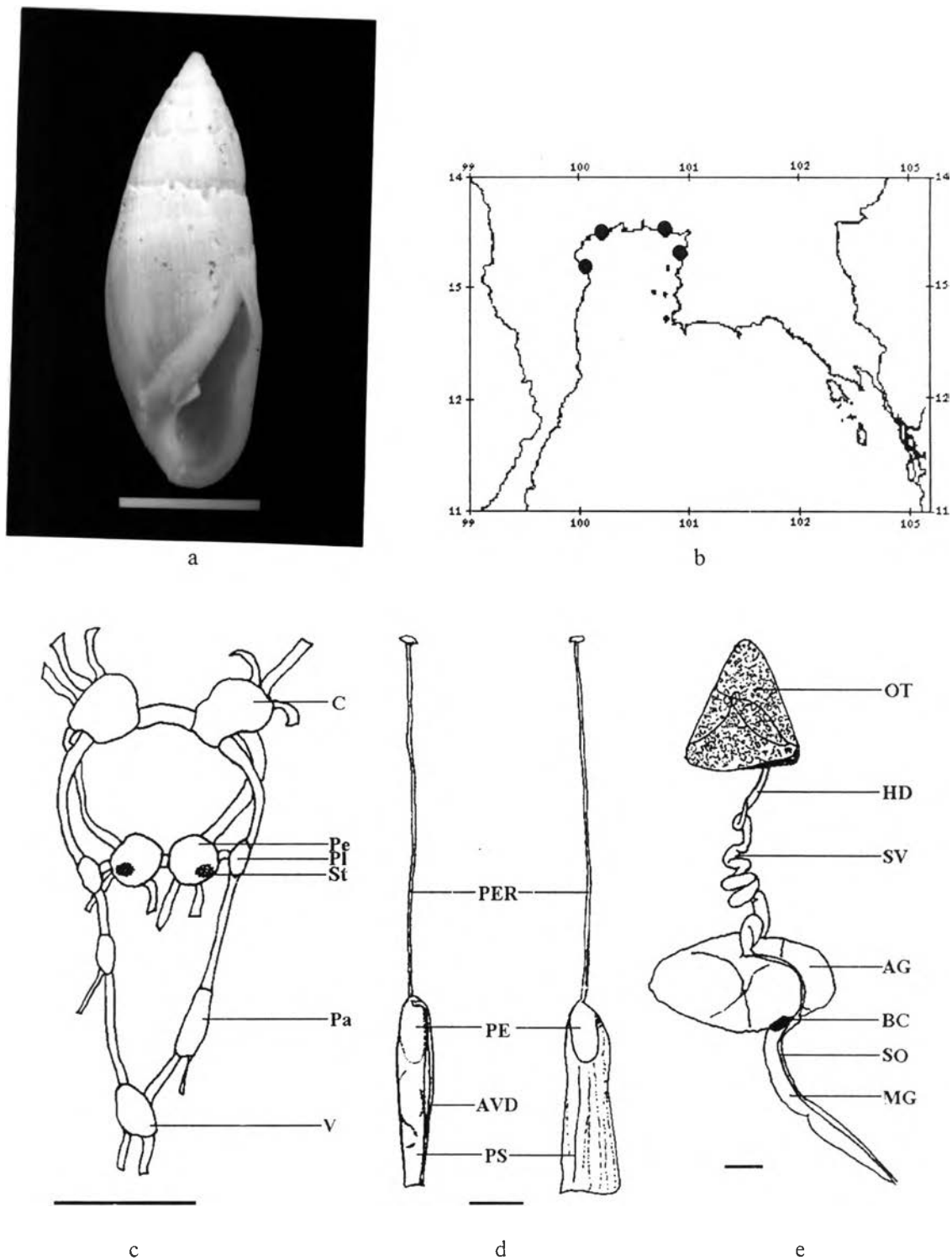


Fig. 4-1 *Auriculastra elongata* ; a) Shell, b) distribution in upper Gulf of Thailand, c) nerve ganglia, d) penial complex, and e) female reproductive organ. Scale bars = 1mm.



*Cassidula aurisfelis* (Bruguière, 1789)

(Fig. 4-3, 4-4)

- 1789 *Bulinus auris-felis* Bruguière, Encycl. Méth. , 1: 343. pl. 460 Fig. 5 (Mers des grandes Indes, Mers du Sud).
- 1798 *Ellobium inflammatum* Bolten, Mus. Bolten. : 106; ed. alt. :74 (no locality).
- 1819 *Auricula felis* Lamardk. Anim. s. vert. , 6 (1) : 2 (Sin. pers.).
- 1825 *Voluta coffeae* Wood, Index test. : 102, pl. 19 Fig. 15 [non *V. coffea* Linnaeus].
- 1837 *Cassidula chemnitzii* Bck, Index moll. : 105 (no locality).
- 1841 *Auricula fusca* Hombron & Jacquinot, voy. Pole Sud: pl. 9 fig 7-9 (text see Rousseaus 1854).
- 1875 *Cassidula auris felis* (Bruguière), Morelet, Sér. Conch. , 4: 373 (Cocinchine: Baria)
- 1885 *Sidula auris-felis* (Bruguière), Morgan, Bull. Soc. zool. France, 10: 394 (P. Tikous; Bukit Tamboun. Perak).
- 1950 *Cassidula felex* (Bruguière), Suvatti, Fauna Thailand , 105: 423 (Khan nu Paknam; Tachalom).
- 1974 *Cassidula aurisfelis* (Bruguière), Brandt, Arch. Moll. , 105: 423, pl. 16 Fig. 86 (Thailand).
- 1976 *Cassidula aurisfelis* (Bruguière), Tantanasiriwong, Phuket Mar. Biol. Center Res. Bull. 10: 22, Fig. 257.

Shell is 19.2-28.9 mm long and 9.4-18.9 mm wide, ovate, thick, solid and light brown to dark brown color. Spire height is 2.1-3.9 mm, conic, slightly indented suture. In young specimens, the shells cover with a cuticular periostracum, some with hairy character on growth line in juveniles and always lose in adults. There are about 5-7 whorls. The largest part of body whorl and aperture length is about 0.87 and 0.80 of the shell length, respectively. Aperture is narrow, ear-shaped. Narrow umbilicus present, surrounded by a carina. Parietal wall has 2 teeth, vertical and horizontal arrangement. Columellar tooth is twisted and bifurcated. Palatal wall has a vertical keel with 11-13 small calluses (Fig. 4-3a). Animal has yellowish white color on head and tentacles, with many black pigment present on the skin. Tentacles are cylindrical and tapering with eye at inside of tentacular base. Foot is thick, rounded anteriorly, acute posteriorly.

The formula of radula is  $(69-86)+1+(69-86)$  for a longer row. Every 4 rows left or right marginal teeth of the 2 short rows are reduced. Central tooth is small about a half of inner lateral teeth. Base of central tooth is subquadrangular shaped, elongated, emarginate with lateral projections; crown is unicuspid and triangular shaped. Lateral teeth have is subquadrangular shaped, elongate, crown is unicuspid, elongated, rounded end. Marginal teeth have elongated bicuspid crown; endocone is small, sharp; mesocone is about 3 times wider than endocone (Fig. 4-4).

Reproductive system contains conical, with pale brown spots on brownish ovotestis. Seminal vesicle is long, yellow with dark brown dot, convoluted in posterior part. Albumen gland is white, multilobed. Mucous gland is long, simple, white (Fig. 4-3e). Penial complex is long; anterior vas deferens is separated from penial sheath and entered penial structure at penis base; penis is elongated oval, distinct vertical muscular fold, pointed; penial sheath is about 2.5 times longer than penis; penial retractor muscle is about 3 times longer than penis (Fig. 4-3d).

Nervous system composed of round lobed cerebral ganglia, and round unlobed parietal, pedal, pleural, and visceral ganglia. Cerebral and pedal ganglia are almost similar in size, diameter at about 0.37 – 0.50 mm. Visceral ganglion is a half the size of cerebral ganglia. Pleural and parietal are about 1/3 of cerebral ganglia. Left parietal ganglia are smaller than the right. Left cerebropleural commissure is longer than the right while that of the left parietovisceral are shorter. Statocysts are located at anterior part of visceral ganglion (Fig. 4-3c).

Habitat notes: *Ca. aurisfelis* is often crawling on mud, and other substrata in mangrove and nipa palm forests. At high tide they usually move to higher place such as on plant stems and *Bruguiera* pneumatophore.

Distribution in upper Gulf of Thailand: Trat, Rayong, Chonburi, Chachoengsao, Samutprakan, Samutsongkram and Phetchaburi Provinces.

World distribution: Philippines, Indonesia, Vietnam, Malaysia, Thailand, Myanmar, Sri Lanka, India.

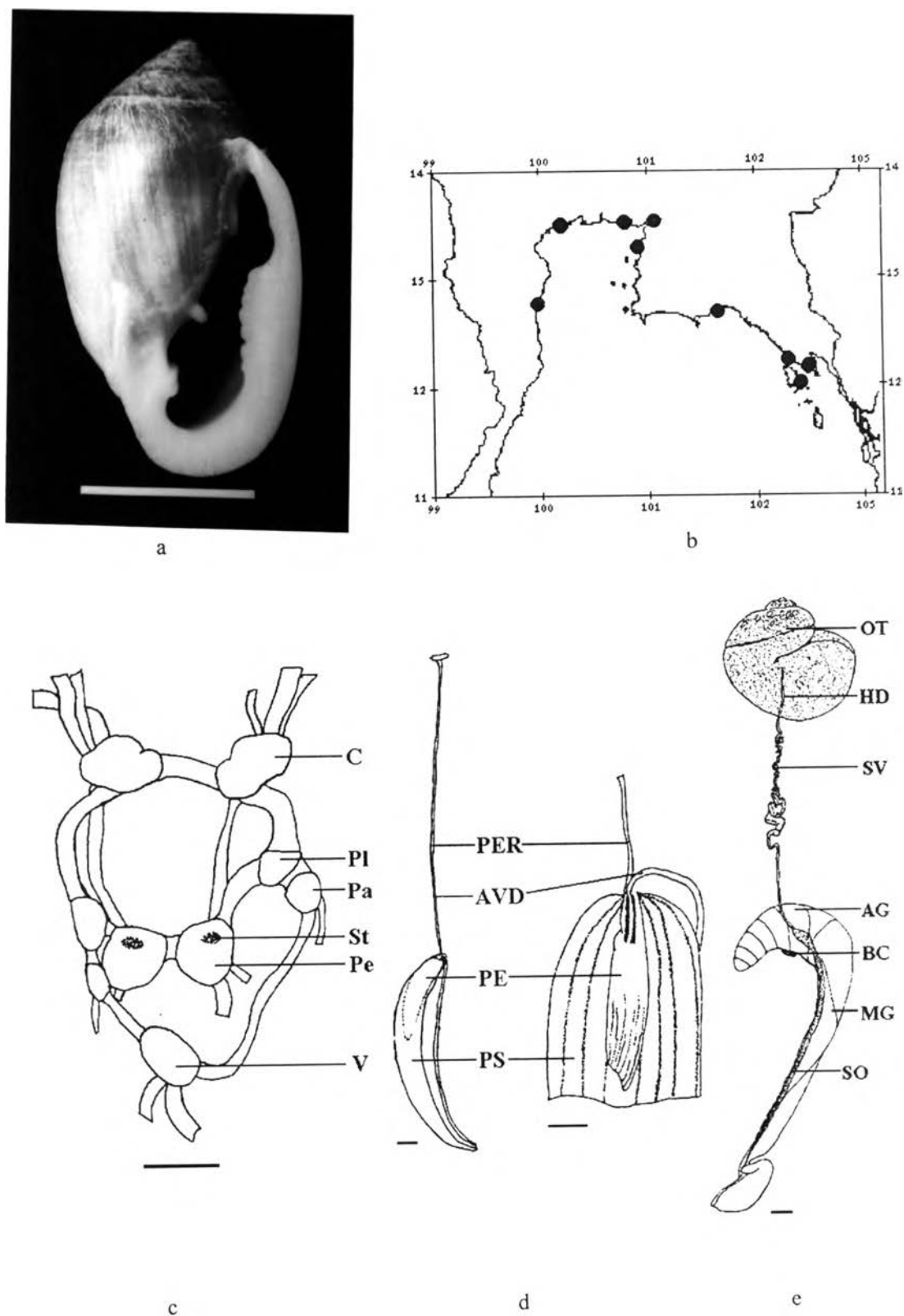
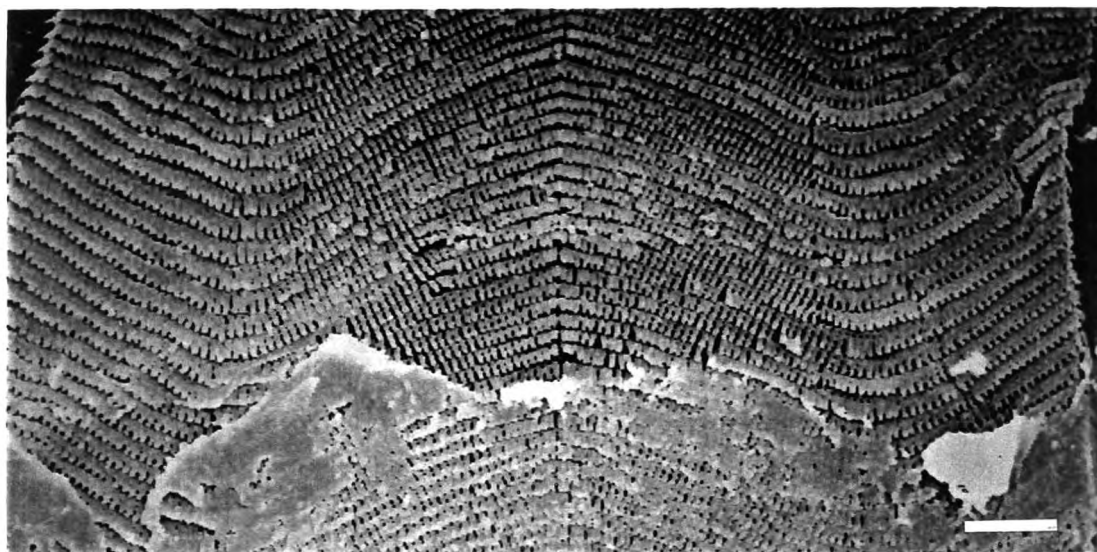
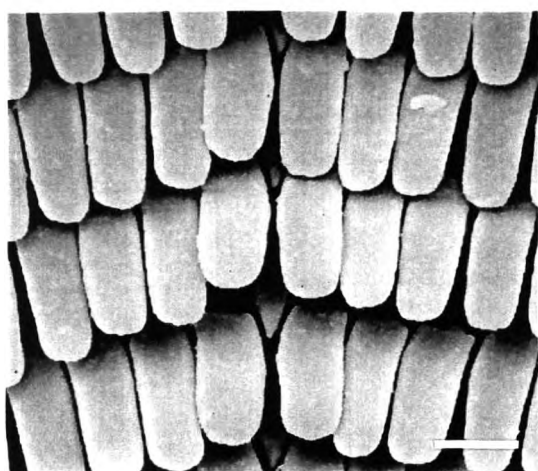


Fig. 4-3 *Cassidula aurisfelis*; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglia, d) penial complex, and e) female reproductive organ. Scale bar = 1 cm in (a) and 1mm in (c) to (e).

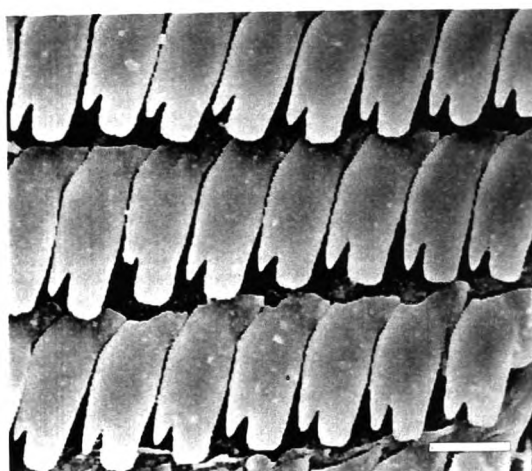




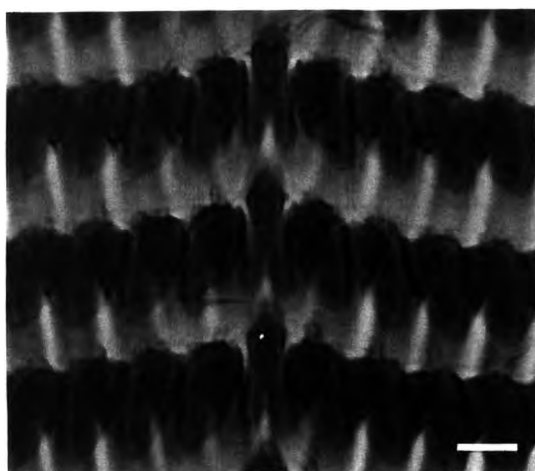
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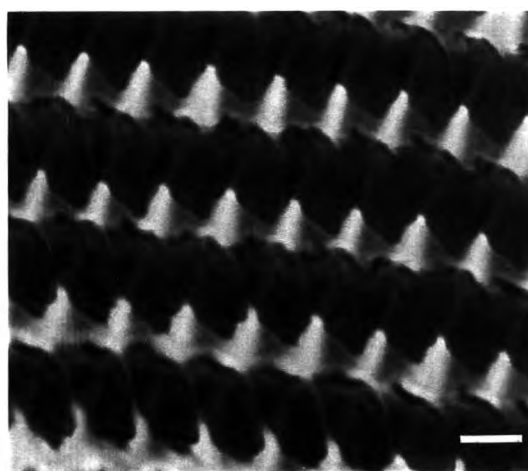
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Fig. 4-4 Radula of *Ca. aurisfelis*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 100  $\mu\text{m}$  in (a) and 10  $\mu\text{m}$  in (b) - (e).

*Cassidula mustelina* (Deshayes, 1830)

(Fig. 4-5, 4-6)

- 1830 *Auricula mustelina* Deshayes, Encycl. Méth. , Vers. , 2: 92 (New Zealand).
- 1834 *Cassidula mustelae* Beck, Index moll. : 105 (O. pf. N. Zealand).
- 1854 *Auricula rhodostoma* Rousseau in Hombron & Jacquinot, Voy. Pole sud: 33, pl. 9 Fig. 1-3 (New Guinea).
- 1885 *Sidula mustelina* (Deshayes), Morgan, Bull. Soc. zool. France, 10: 394 (Singapore, Penang, Wellesley).
- 1889 *Cassidula mustelina* (Deshayes), Morelet, J. de Conch. , 37 : 129 (Entre Kampot et Bangkok).
- 1897 *Cassidula mustelina* (Deshayes), Martens in Weber, Zool. Ergebon. Reise Niederl.-Ostind., 4: 144. pl. 8 Fig. 15 (Java, Borneo, Sumatra, Aru Isl. , New Guinea, Siam, Penang, Singapore, Cambodia, Formosa, mauritius).
- 1950 *Cassidula mustelina* (Deshayes), Suvatti, Fauna Thailand:88 (Tachin).
- 1962 *Cassidula mustelina* (Deshayes), Kira, Shell of the western Pacific in color pl. 69 Fig. 5 (Tropical Pacific).
- 1974 *Cassidula mustelina* (Deshayes), Brandt, Arch. Moll. , 105: 423 pl. 16 Fig. 88 (Thailand).
- 1976 *Cassidula mustelina* (Deshayes), Tantanasiwong, Phuket Mar. Biol. Center Res. Bull. 10: 22, Fig. 259.

Shell is 9.2 - 21.6 mm long, and 6.2 - 13.0 mm wide, ovate, thick, solid, brown to dark brown, and some shells with 3-4 whitish spiral bands. Spire height is 0.8 – 9.4 mm, cone shaped and slightly indented. In young specimens, the shells cover with a cuticular periostracum, some with hairy character on growth line in juveniles that always lose in adults. There are about 6 – 7 whorls. The largest part of body whorl and aperture length is about 0.86 and 0.72 of shell length, respectively. Umbilicus narrows, small, surrounded by a carina. Aperture is narrow, ear-shaped. Parietal wall has 2 teeth in vertical and horizontal arrangement. Columellar wall has a small simple tooth. Palatal wall has a vertical keel with 11-12 fine calluses (Fig. 4-5a). Animal has white of light yellow colored on the head, foot and tentacles, which many black pigment presented on the skin. Tentacles are subcylindrical and tapering with eyes at the inside of the tentacular base. Foot is thick, rounded anteriorly and acute posteriorly.

The formula of radula is (80-90)+1+(80-90) with a long and slender central tooth; long and slender, crown, unicuspid; base is subquadrangular, elongated. Lateral-teeth base is subquadrangular, elongate; crown unicuspid with elongated and rounded end. Marginal teeth are tricuspid and shorter than lateral teeth. Mesocone is broad, blunt and longer than other cusps; endocone is sharp, short; ectocone is small, blunt and shortest (Fig. 4-6).

Reproductive system contains conical, brown ovotestis and short hermaphroditic duct. Albumen gland is white and multilobed. Seminal vesicle is long, convoluted (Fig. 4-5e). Penial complex is long. Anterior vas deferens is separated from penial sheath and entered penial structure at the penis base. Penis is elongate with many fine horizontal muscular folds and blunt end. Penial retractor muscle is as long as penis length. Penial sheath is a little longer than the penis with fine, longitudinal groove in side (Fig. 4-5d).

Nervous system composed of round lobed cerebral ganglia and round unlobed parietal, pedal, pleural and visceral ganglia. Cerebral and pedal ganglia are almost similar in size. The diameter of cerebral ganglia is about 0.40 – 0.96 mm. Parietal, pleural and visceral ganglia are smaller than cerebral and pedal ganglia. Left cerebropleural commissure is longer than the right but left parietovisceral are shorter than the right. Statocysts are located at the anterior part of pedal ganglion (Fig. 4-5c).

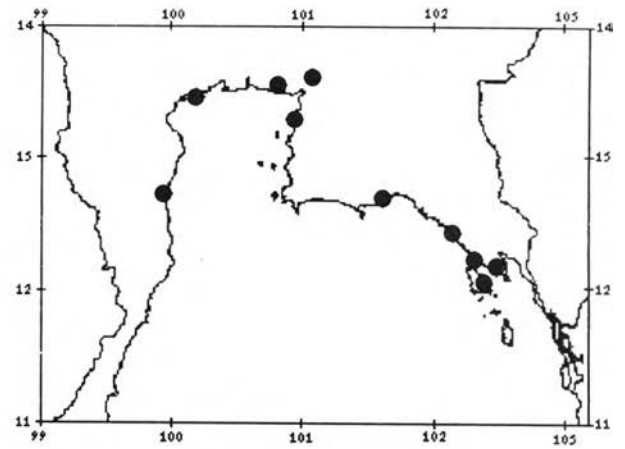
Habitat notes: *Ca. mustelina* is often found on mud, and other substrata in mangrove and nipa-palm forests. At high tide they usually move to higher places such as on plant stems and *Bruguiera* pneumatophores.

Distribution in upper Gulf of Thailand: Trat, Chantaburi, Rayong, Chonburi, Chachoengsao, Samutprakan, Bangkok, Samutsongkram and Phetchaburi Provinces.

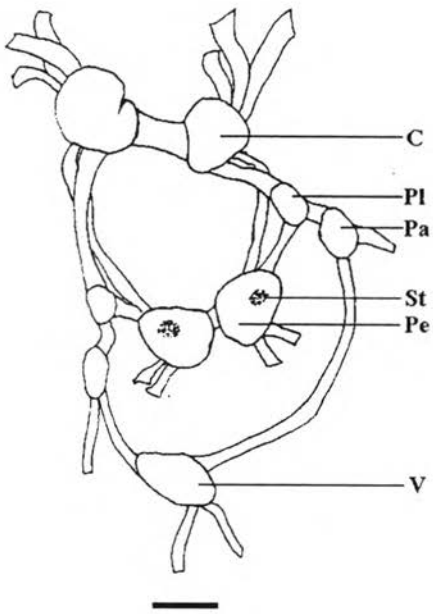
World distribution: Philippines, Indonesia, Taiwan, New Zealand, Australia, Cambodia, Malaysia, Singapore, Thailand, Mauritius.



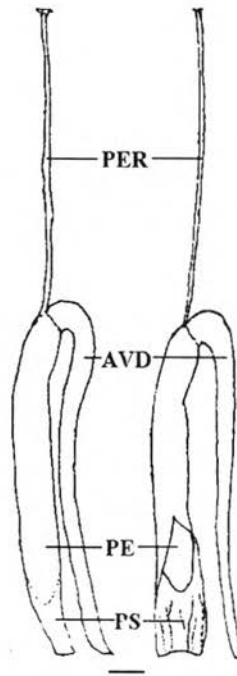
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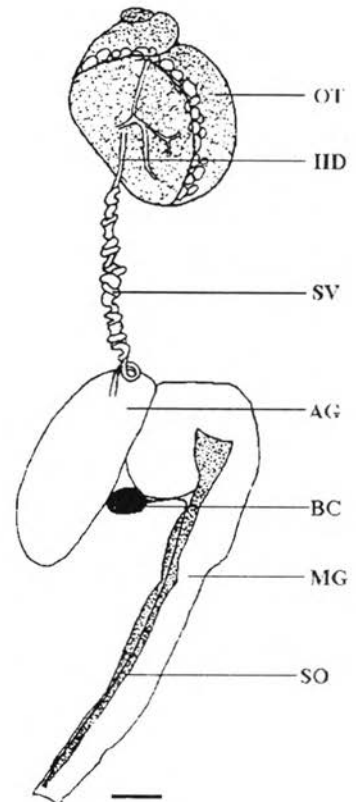
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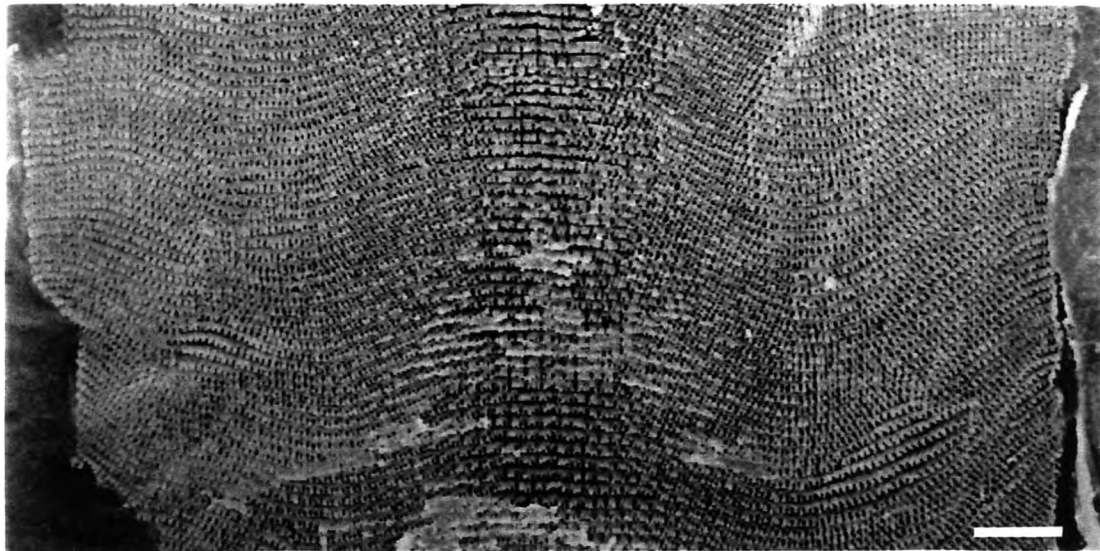


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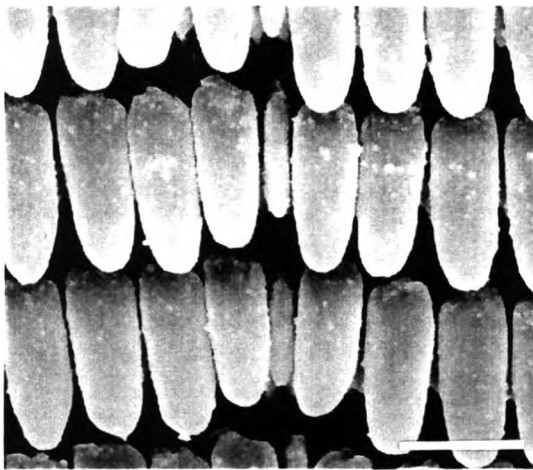


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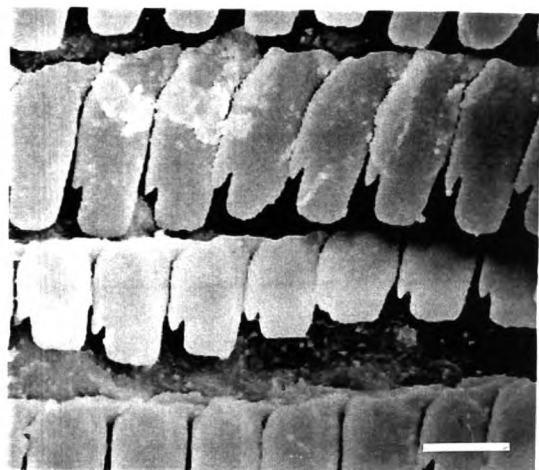
Fig. 4-5 *Cassidula mustelina* ; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglion, d) penial complex, and e) female reproductive organ. Scale bar = 1cm in (a) and 1 mm in (c)-(e).



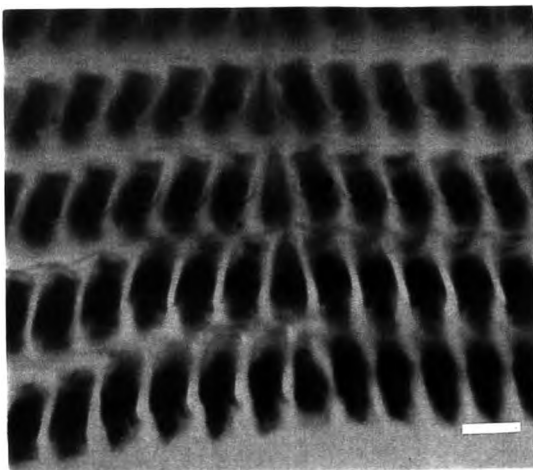
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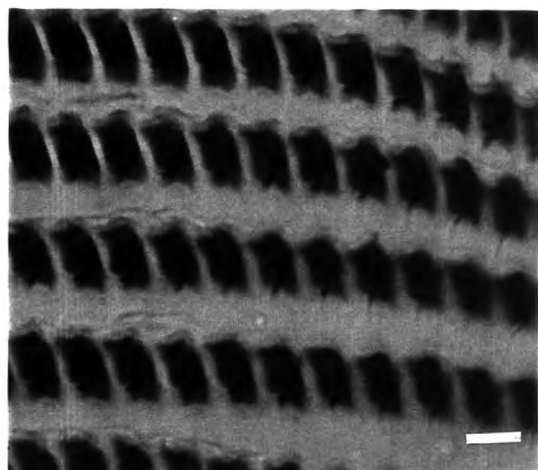
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Fig. 4-6 Radula of *Ca. mustelina*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 100  $\mu\text{m}$  in (a) and 10  $\mu\text{m}$  in (b) - (e).

*Cylindrotis siamensis* Brandth, 1974

(Fig. 4-7, 4-8)

1974 *Cylindrotis siamensis* Brandt. Arch. Moll. , 105: 423 pl. 16 Fig. 85 (Klung Harbour, Chantaburi Province).

Shell is 5.1 – 7.4 mm long and 2.5 – 3.6 mm wide, cylindrical, slender, thin, smooth, with corneous, transparent, glossy and yellowish-brown colored. Spire height is 0.1 – 1.0 mm, dome shaped and moderately indented suture. There are about 4 – 5 whorls that increase rapidly in size. The largest part of body whorl and aperture length is about 0.95 and 0.88 of shell length, respectively. Aperture is very high narrow and ear-shaped. Base of columella is simple, twisted and has a horizontal columellar tooth. Palatal wall has a parietal tooth (Fig. 4-7a). Animal has white color with black mantle skirt. Tentacles are short, thick, black and blunt end.

The formula of radula is 27+1+27 with a small, long, slender central tooth with wide base, triangular, emarginated, and long slender crown, unicuspid and pointed. Lateromarginal teeth are 2-3 times broader than central tooth. the crown is bicuspid with rhombic , large and round mesocone and short or slightly short endocone. Endocone of marginal teeth are larger and longer than lateral teeth (Fig. 4-8).

Reproductive system contains conical, pale yellow ovotestis and short hermaphroditic duct. Seminal vesicle is long and convoluted. Bursa duct run along anterior mucous gland and opposite the prostate gland and jointed with oviduct near the genital pore. Prostate gland is slightly dark yellow. Lobed albumen gland and mucous gland are yellow (Fig. 4-7e). Penial complex is small. Penial sheath is long, dilated in three fourth of distal portion. Penial retractor muscle is slender and about 1/3 of penial sheath. Anterior vas deferens is about 2 times longer than penial sheath, which separated from penial sheath and entered at penis base. Penis is about 1/3 of penial sheath, slender with pointed end (Fig. 4-7d).

Nervous system composes of lobed, rounded cerebral ganglia, unlobed triangular pedal ganglia and unlobed rounded parietal, pleural and visceral ganglia. Cerebral ganglia have short cerebral commissure, which measures about 2/3 of the ganglia. Cerebral ganglia is the largest with diameter about 0.31 mm. Cerebral and pedal ganglia are similar in size. Left cerebropedal

and cerebropleural commissure is longer than the right. Right pleuroparietal commissure is 2 times longer than the left. Left pleuroparietal commissure is about 3 times longer than the right. Statocysts are located at anterior part of pedal ganglia (Fig. 4-7c).

Habitat notes: *Cy. siamensis* inhabit under rotten log in mangrove forest.

Distribution in upper Gulf of Thailand: Chonburi and Samutsongkram Provinces.

World distribution: Thailand.

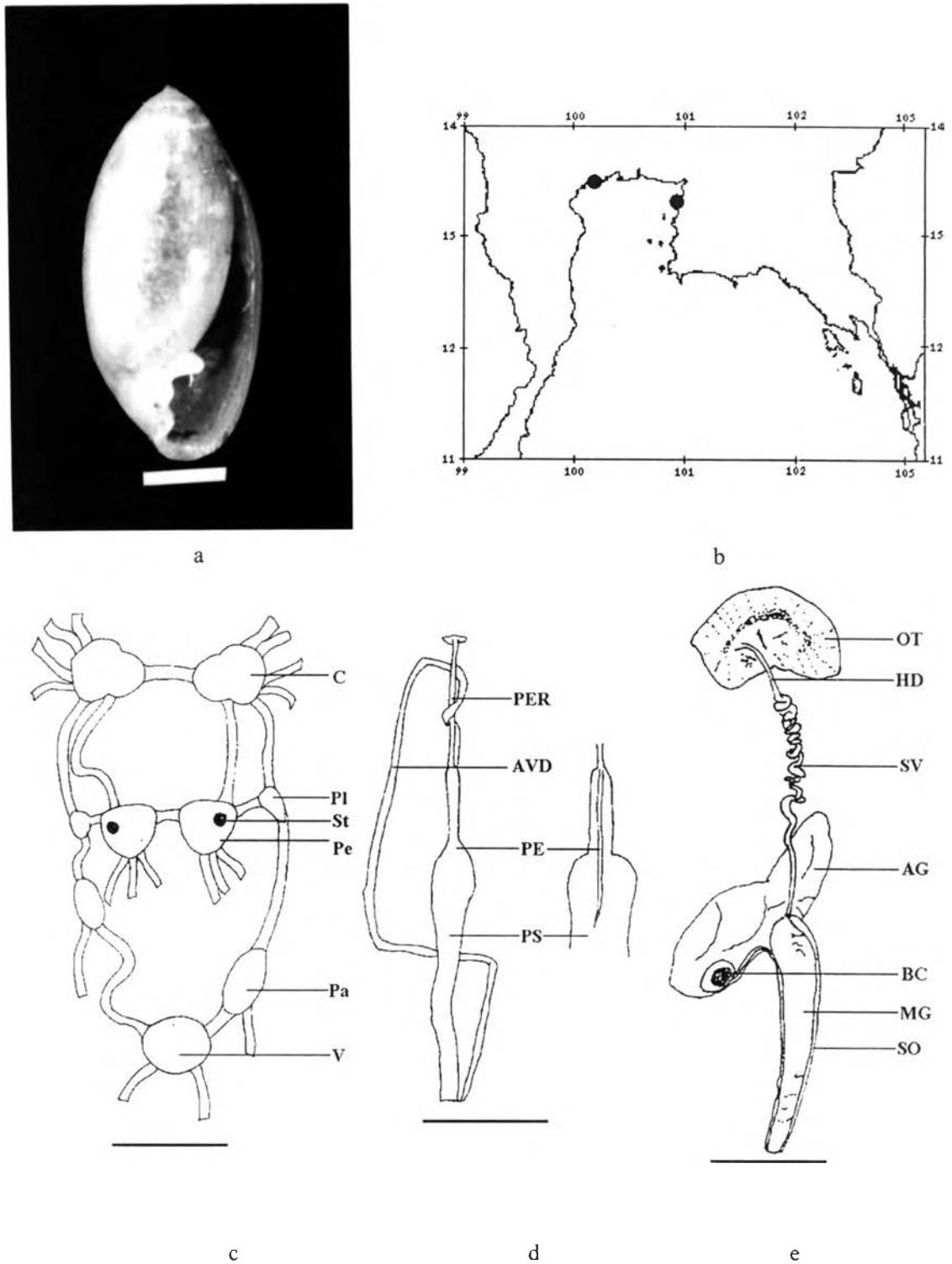


Fig. 4-7 *Cylindrotis siamensis*; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglia, d) penial complex, and e) female reproductive organ. Scale bars = 1 mm.



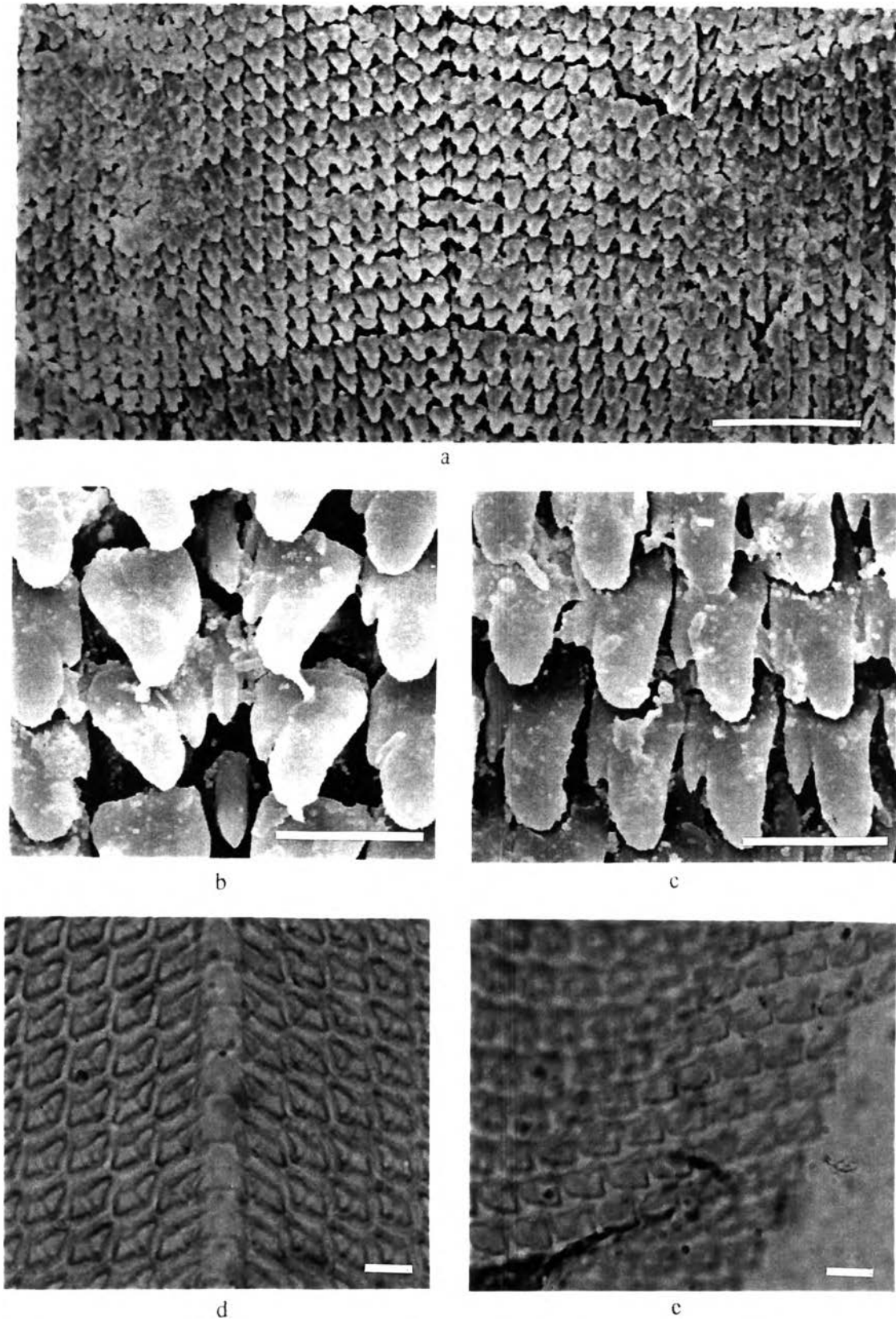


Fig. 4-8 Radula of *Cr. siamensis*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 50.  $\mu\text{m}$  in (a), and 10  $\mu\text{m}$  in (b) - (e).

*Ellobium aurisjudae* (Linnaeus, 1758)

(Fig. 4-9, 4-10)

- 1758 *Bulla auris judae* Linnaeus, Syst. Nat. , ed. 10: 728 (no locality).
- 1798 *Ellobium labrosum* and *E. subtile* Röding, Mus. Bolten. : 105 (no locality).
- 1817 *Auricula reticulata* Schumacher, Essai nouv. syst. : 229 (no locality).
- 1854 *Auricula dactylus* and *A. turrita* Pfeifer, Nov. conch. , 1: 15, pl. 5 fig. 15-16 (Borneo), pl. 4 fig. 8-9 (Philippines).
- 1889 *Auricula dactylus* (Linnaeus), Morelet, J. de Conch. , 37: 129 (Kampot, Kep. Cambodge).
- 1950 *Auricula auris-judae* (Linnaeus), Suvatti, Fauna Thailand:88 (Singora, Bandan, Koh Samui, Chantaburi estuary, Tachin).
- 1974 *Ellobium aurisjudae* (Linnaeus), Brandt, Arch. Moll. , 105: 423 pl. 16 fig. 94 (Thailand).
- 1998 *Ellobium aurisjudae* (Linnaeus), Vermeulen & Whitten, Fauna Malaysiana guide to land snails of Bali , 164, fig. 39 (Sarawak, Singapore).
- 1976 *Ellobium aurisjudae* (Linnaeus), Tantanasiwong, Phuket Mar. Biol. Center Res. Bull. 10: 22, fig. 256.

Shell is 19.7-57.3 mm long 6.6-23.2 mm wide, cylindrical, thick, solid and white, covered by brownish periostracum which pale brown in juvenile. Spire high 3.9-1.9 mm, cone-shaped, blunt, slightly indented suture, and generally eroded. There are about 5-6 whorls. The largest part of body whorl and aperture length is about 0.85 and 0.64 of shell length, respectively. Umbilical area is marked by shallow excavation. Some shells are very shallow. Aperture is ear-shaped. Columella wall has a simple columellar tooth. Parietal wall has a horizontal tooth and a vertical tooth. Palatal wall is smooth (Fig. 4-9 a). Animal has a creamy or pinky white. Foot is thick with white or black pigment spots on its skin. Tentacles are subcylindrical shaped, acute tip, swollen nears the tip, red color in some specimens. Mantle skirt is creamy white and fleshy. Eyes located at the base of tentacles and covered by thick skin.

The formula of radula is (30-37)+1+(30-37) with a small central tooth, which about 1/3 of first lateral tooth; narrow base, subquadrangular, long, emarginated and short crown, unicuspid, slender and rounded. Lateral teeth base is narrow, long, and rhombic, crown tricuspid; mesocone large, broad and rounded; endocone and ectocone are very weak and blunt. Marginal teeth are smaller than lateral teeth; crown unicuspid (Fig. 4-10).

Reproductive system contains flat, dark yellow ovotestis, which enclosed by large hepatopancreases and short hermaphroditic duct. Seminal vesicle is long and straight. Bursa duct connects to oviduct on anterior third. Albumen gland and mucous gland are bright yellow and lobed except anterior part of mucous gland (Fig. 4-9 e). Penial complex is very long; anterior vas deferens is very tiny, attach to the penial sheath; penis is long, narrow except at the base, which is swelling, chitinous and convoluted at the proximal part; penial sheath is slightly thick, as long as the penis; penial retractor muscle is short and thick (Fig. 4-9 d).

Nervous system composed of rounded cerebral and pedal ganglia, slightly elongate rounded pleural, parietal and visceral ganglia. Diameter of cerebral ganglia is about 0.05-0.60 mm. Pedal and visceral ganglia are almost the same size as cerebral ganglia. Left parietal ganglia are divided into anterior and posterior portion which connect by a short commissure. Left pleuroparietal commissures are very long and shorter than the right. Left parietovisceral commissure is longer than the right. Statocysts are located at anterior part of pedal ganglia (Fig. 4-9 c).

Habitat notes: *E. aurisjudae* usually live in and under rotten logs. Sometimes they appear crawling on the mud surface.

Distribution in upper Gulf of Thailand: Trat, Chantaburi, Chonburi, Samutprakan and Samutsongkram Provinces.

World distribution: Philippines, Indonesia, Australia, Thailand, Myanmar, India, Moluccas.

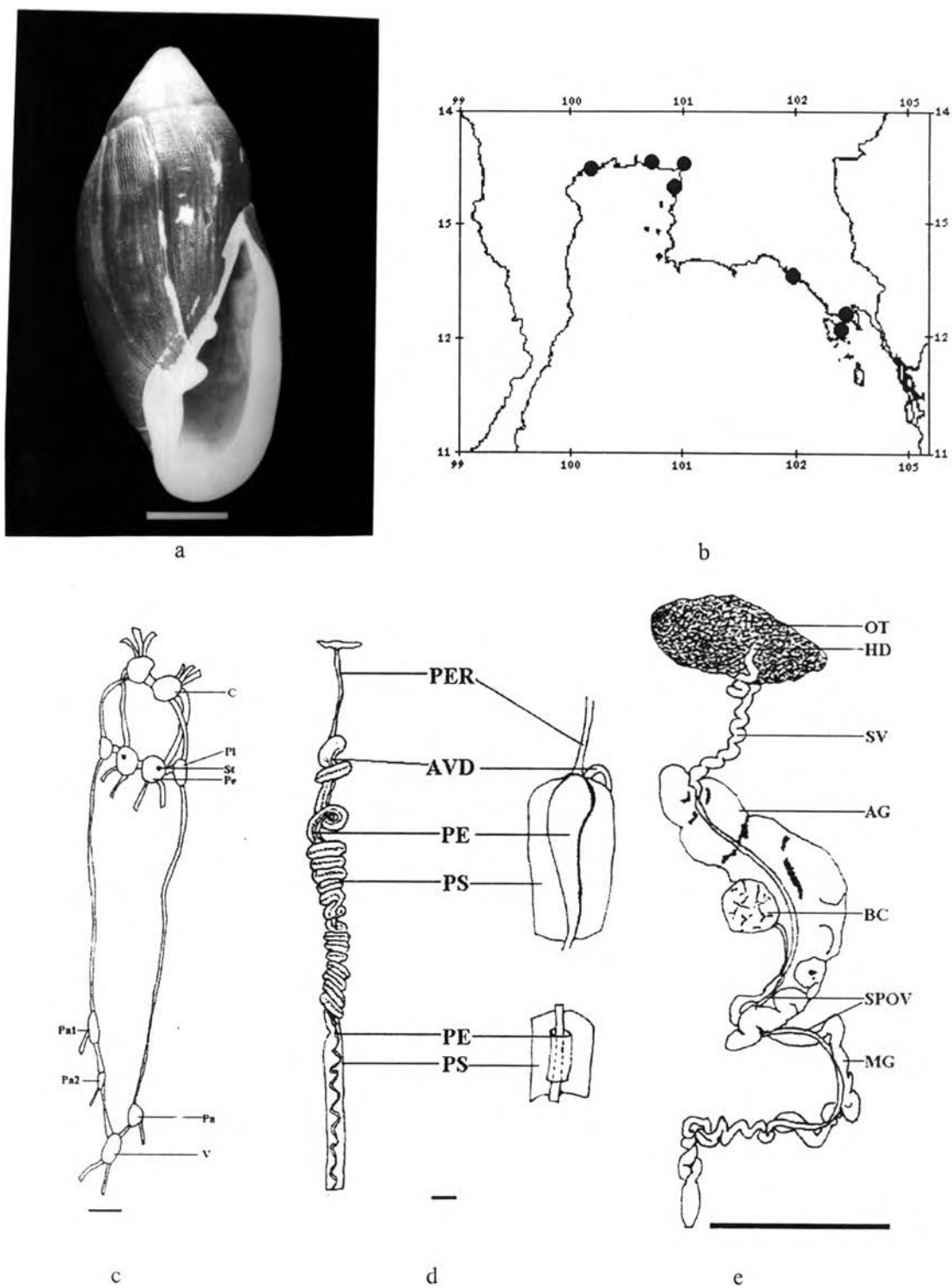
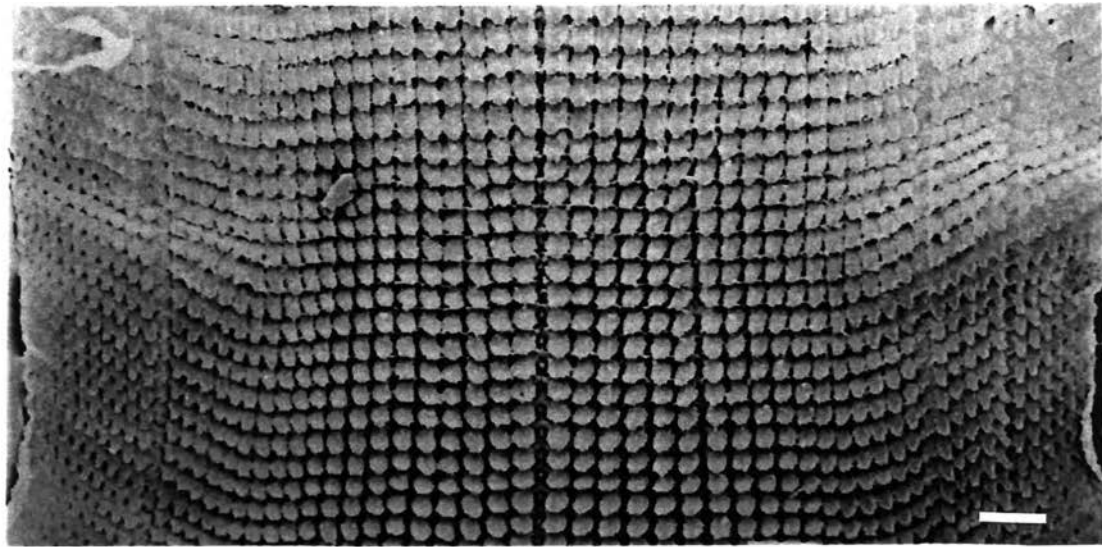
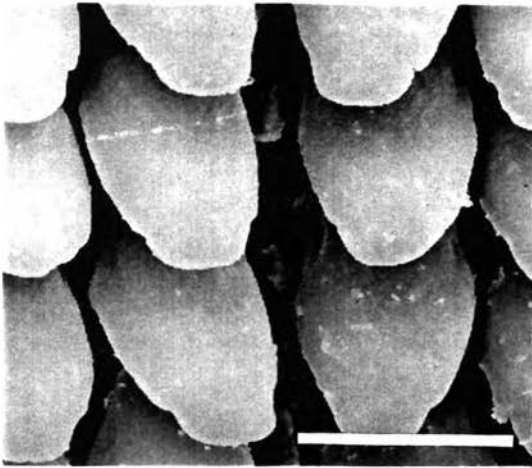


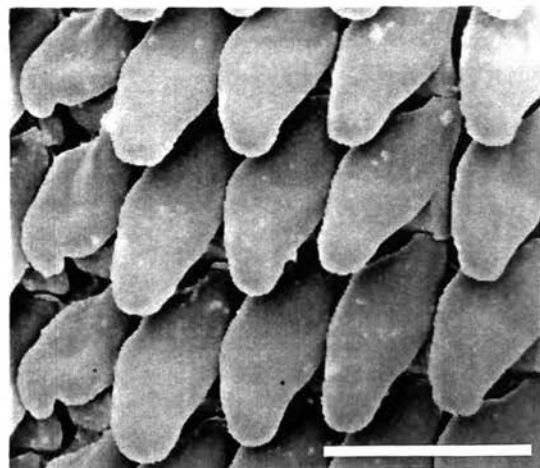
Fig. 4-9 *Ellobium aurisjudae*; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglia, d) penial complex, and e) female reproductive organ. scale bars = 1 cm.



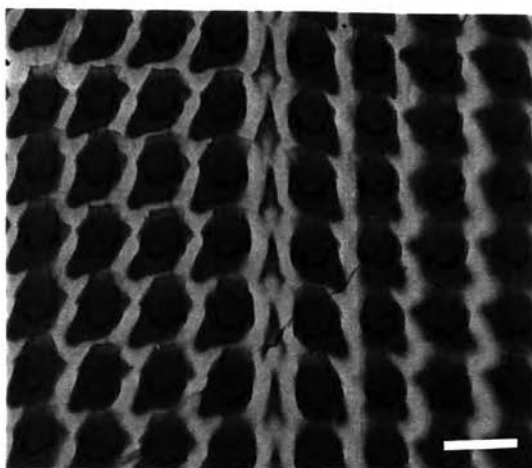
a



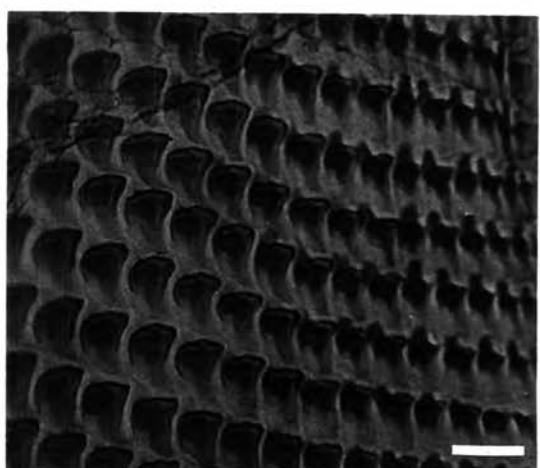
b



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Fig. 4- 10 Radula of *E. aurisjudae*; a) radula rows, b) and d) central and lateral teeth, c) and c) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph. scale bars are 100  $\mu\text{m}$  in (a), (d) and (e), and 50 $\mu\text{m}$  in (b) and (c).

*Ellobium aurismidae* (Linnaeus, 1758)

(Fig. 4-11, 4-12)

- 1758 *Bulla auris judae* Linnaeus, Syst. Nat. , ed. 10: 728 (no locality).
- 1798 *Ellobium midae* Röding, Mus. Bolten. : 105 (no locality).
- 1798 *Ellobium ceramense* and *E. tumidum* Röding, Mus. Bolten. : 105 (no locality).
- 1801 *Auricula midae* Lamarck, Syst. anim. s. vert. : 92 (no locality).
- 1889 *Auricula auris-midae* (Linnaeus), Morelet, J. de Conch. , 37: 129 (de Hatien à Kampot, Cambodia).
- 1904 *Auricula auris-midae* (Linnaeus), Fisher & Dautzenberg. Miss. Pavie, 3: 413 (Canbodge, Tonkin, Bangkok, Kompong-Som).
- 1950 *Auricula auris-midae* (Linnaeus), Suvatti, Fauna Thailand:88 (Bandon Bight).
- 1974 *Ellobium aurismidae* (Linnaeus), Brandt, Arch. Moll. , 105: 423 pl. 16 fig. 93 (Thailand).
- 1966 *Ellobium (Ellobium) aurismidae* (Linnaeus), Solem, Spolia zool. Mus. haun. , 24:40 (Kao Soi Dao, Makham District; Chantaburi Prov.).
- 1976 *Ellobium aurismidae* (Linnaeus), Tantanasiwong, Phuket Mar. Biol. Center Res. Bull. 10: 22.
- 1998 *Ellobium aurismidae*(Linnaeus), Vermeulen & Whitten, Fauna Malaysiana guide to land snails of Bali , 164, fig. 40 (Sumatra, Bali).

Shell is 61.0-95.1 mm long and 33.4-50.3 mm wide, oval, very thick, solid, white and covered with brownish periostracum. Spire height is 6.5-19.9 mm, cone-shaped, blunt, slightly indented suture and generally eroded. There are about 6-7 whorls. The largest part of body whorl and aperture length is about 0.85 and 0.73 of shell length, respectively. Umbilicus is deep and narrow. Columella wall has a simple columellar tooth. Parietal wall has a vertical tooth and a horizontal tooth. Palatal wall is smooth (Fig. 4-11 a). Animal has creamy white or flesh-colored, with strips of white or black or both. Tentacles are subcylindrical, acute at the tip, swollen nears the tip, brown-red and tapering. Mantle skirt is white and fleshy. Eyes are located at tentacular base and covered by thick skin.

The formula of Radula is (42-51)+1+(42-51) with a small central tooth; narrow base, triangular and emarginated, short crown with unicuspid and triangular. Lateral teeth base is rhombic shaped and large, crown tricuspid; mesocone is large and rounded, endocone and

ectococone are very short and rounded. Marginal teeth base is subquadrangular, long. the crown has 2-4 small, rounded cusps (Fig. 4-12).

Reproductive system contains flat, brown to orange ovotestis, which enclosed by large hepatopancreases and short hermaphroditic duct. Bursa duct connects to oviduct towards the center of oviduct. Albumen gland and mucous gland are bright yellow, lobed exception of the anterior mucous gland (Fig. 4-11e). Penial complex is very long and thick. The penial sheath is about 2 times longer than the penis with thick and dilates at the proximal part. Anterior vas deferens is very small and attached to penial sheath. Penial retractor muscle is as long as penial length. The penis is slender and pointed (Fig. 4-11d).

Nervous system composed of rounded cerebral and pedal ganglia, slightly elongate and rounded pleural, parietal and visceral ganglia. Diameter of cerebral ganglia is about 0.09-0.75 mm. Pedal and visceral ganglia are almost the same size of cerebral ganglia. Left parietal ganglia are divided into anterior and posterior portion, which connected by a short commissure. Pleuroparietal commissures are very long, the left one is shorter than the right one. Left parietovisceral commissure is longer than the right. Statocysts are located at anterior part of pedal ganglia (Fig. 4-11c).

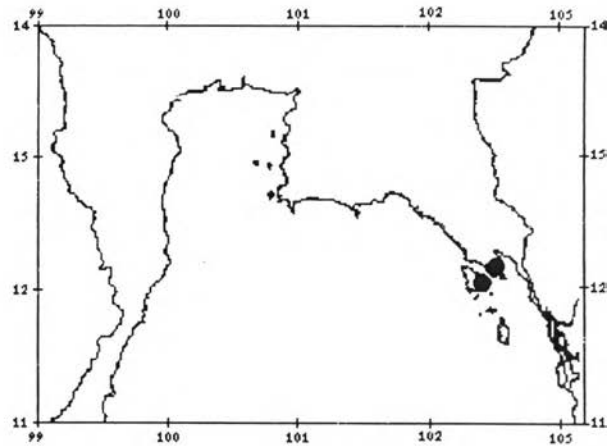
Habitat note: *E. aurismidae* usually lives in and under rotten log in terrestrial zone of mangrove.

Distribution in upper Gulf of Thailand: Trat Province.

World distribution: Vietnam, Indonesia, Cambodia, Australia, Thailand, Malaysia, Singapore.



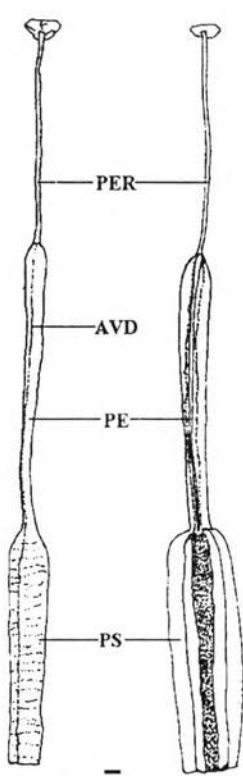
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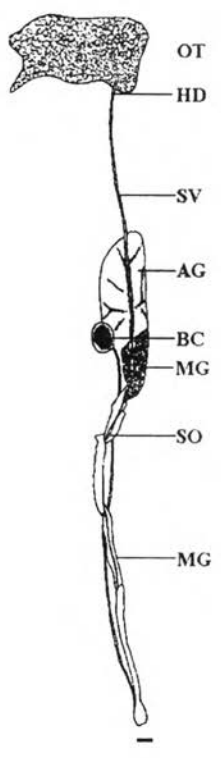
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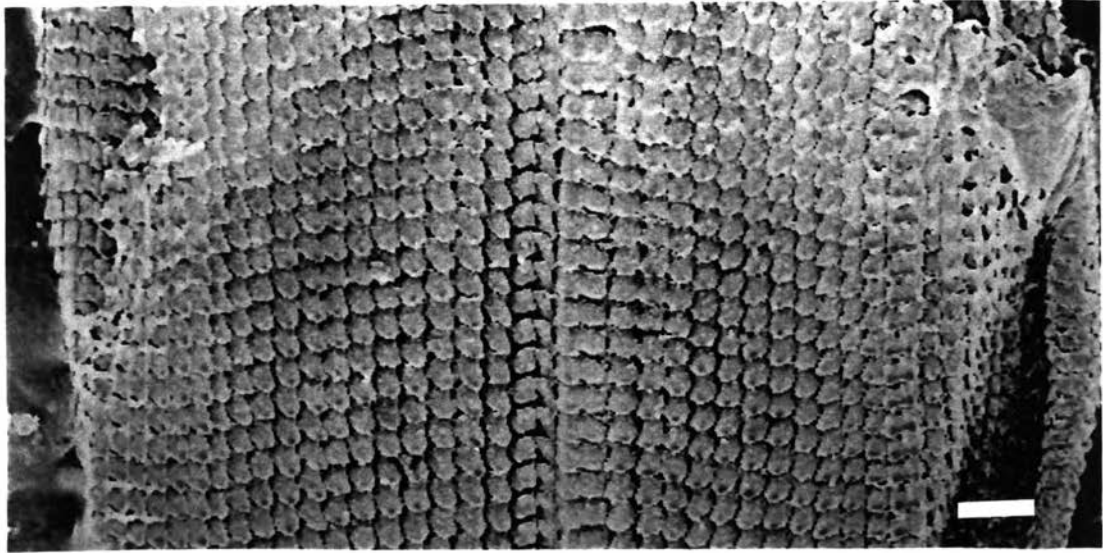
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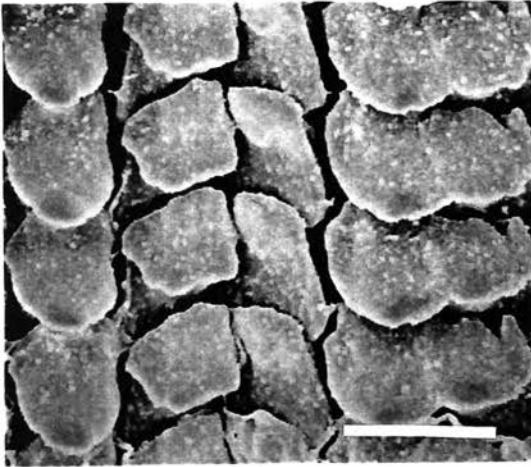
e

Fig. 4-11 *Ellobium aurismidae*; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglion, d) penial complex, and e) female reproductive organ, scale bars = 1 cm.

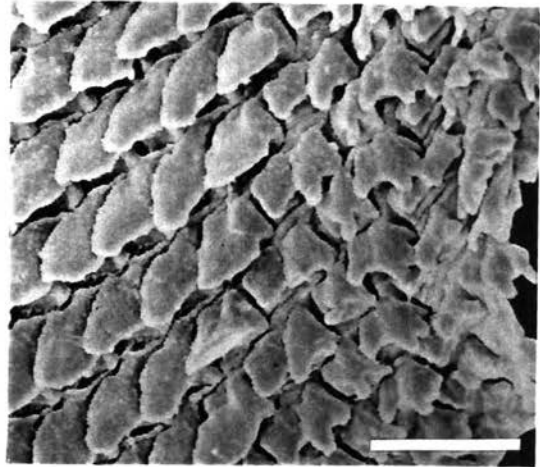




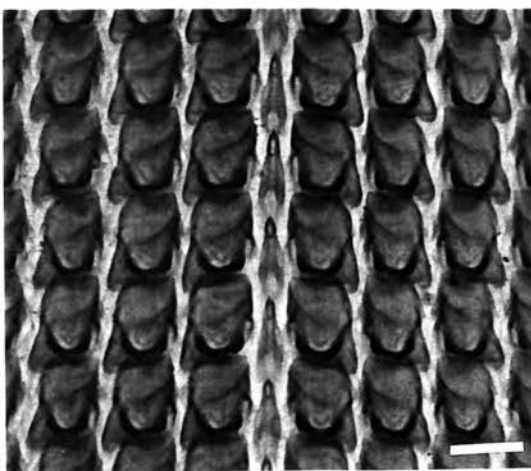
a



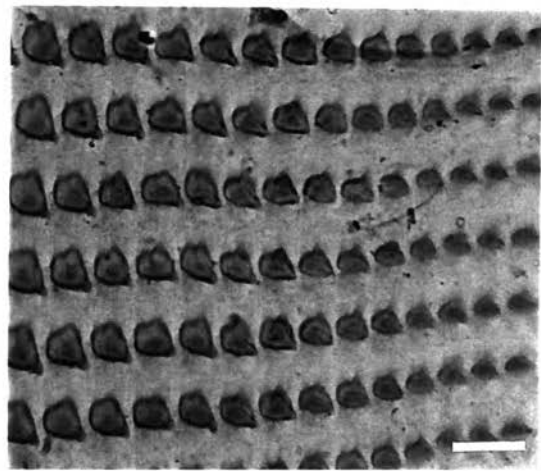
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Fig. 4-12 Radula of *E. aurismidae*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph. d) and e) are LM photograph, scale bars are 500  $\mu\text{m}$  in (d) and (e), 100  $\mu\text{m}$  in (a), and 50  $\mu\text{m}$  in (b) and (c).

*Laemodonta punctigera* (H. & A. Adams, 1853)

(Fig. 4-13, 4-14)

- 1853 *Plecotrema punctigerum* H. & A. Adams, Proc. zool. Soc. London, 21: 120 (Borneo)
- 1853 *Plecotrema imperforatum* H. & A. Adams, H. & A. Adams, Proc. zool. Soc. London, 21: 120 (Negros, Philippines).
- 1864 *Plecotrema punctigera* H. & A. Adams, Crosse & Fisher, J. de Conch. , 12: 330 (Embouchure de Vaico, Cochinchine).
- 1875 *Plecotrema punctigera* H. & A. Adams, Morelet, Sér. Conch. , 4: 273 (Siam; Cochinchine).
- 1956 *Plecotrema punctigera* H. & A. Adams, Hubendick, Proc. malac. Soc. London, 32: 120 (Bandr, N of Bombay; Vizagapatam; Irvady delta; Coasts of the South China sea from Singapore to Swatow; Philippines).
- 1959 *Laemodonta punctigera* (H. & A. Adams), van Benthem Jutting, Beaufortia, 7: 107 (Tandjong Tiram, Sumatra).
- 1974 *Laemodonta punctigera* (H. & A. Adams), Brandt, Arch. Moll. , 105: 423 pl. 15 fig. 79 (Thailand).

Shell is about 5.7 - 8.7 mm long and 3.6 - 6.1 mm wide, oval, solid, pale brown with 3-4 brown bands on body whorl. Spire height is about 0.5 – 1.8 mm, dome-shaped, slight indented suture. Umbilicus is deep and vertical. There are about 8 - 10 whorls. The largest part of body whorl and aperture length is about 0.86 and 0.67 of the shell length, respectively. Aperture is narrowly ovate-lunate. Parietal wall has 2 teeth, vertical and horizontal arrangement and bifurcated. Columellar tooth is simple. Palatal wall has 2 horizontal teeth (Fig. 4-13 a). Animal has creamy white head and foot with black pigments on their skin. Tentacles are cylindrical and tapering. Eyes located inside of the tentacular base.

The formula of radula is (16-18) + (9-12) + 1 + (9-12) + (16-18) with a small central tooth. The tooth has a wide base, triangular and emarginated, small crown, unicuspid narrow and round. Lateral teeth are about 3 times larger than the central teeth. Lateral teeth base is rhombic shaped with tricuspid crown; mesocone is largest and rounded; ectocone and endocone are short and pointed. Marginal teeth are about 2 – 3 times larger than lateral teeth; large crown, tricuspid, large mesocone and rounded; ectocone and endocone are short and pointed. The radula sheath

composed of a short row, with central and lateral teeth and a complete row of central, lateral and marginal teeth in alternating along the sheath (Fig. 4-14).

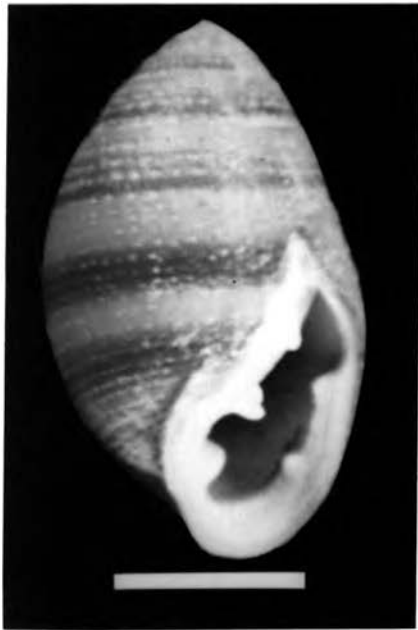
Reproductive system contains conical, cream colored ovotestis and short hermaphroditic duct. Seminal vesicle is convoluted and long. Albumen gland is short, lobed and transparent. Mucous gland are very long, unlobed and transparent. Bursa duct joined to oviduct near the female genital pore (Fig. 4-13 e). Penial complex is cylindrical, small; penial sheath is about 3-4 times longer than penis; penial retractor muscle is about 1/3 of penial sheath; penis is short, round, cylindrical; anterior vas deferens attached to the penial sheath at the distal part and entered to penial structure at the base (Fig. 4-13 d).

Nervous system composes of large round lobed cerebral ganglia and round unlobed parietal, pedal, pleural and visceral ganglia. Cerebral and pedal ganglia is almost similar in size, which diameter is about 0.2 – 0.3 mm. Pleural ganglia are smallest and slightly elongated. Parietal ganglia are about 2 times larger than pleural ganglia. Right cerebropedal and cerebropleural are as long as the left. Left pleuroparietal commissure shorter than the right and vice versa in parietovisceral. Statocyst located at the anterior part of the pedal ganglia (Fig. 4-13c).

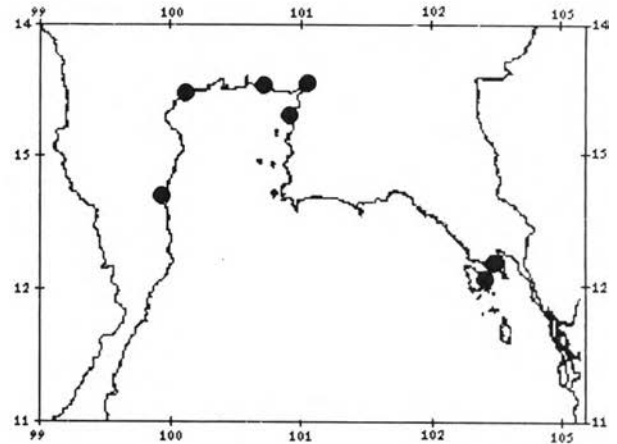
Habitat notes: *L. punctigera* frequently found on mud surface in mangrove and nipa palm forest.

Distribution in upper gulf of Thailand: Trat, Chonburi, Chachoengsao, Samutprakan, Samutsongkram and Phetchaburi Provinces.

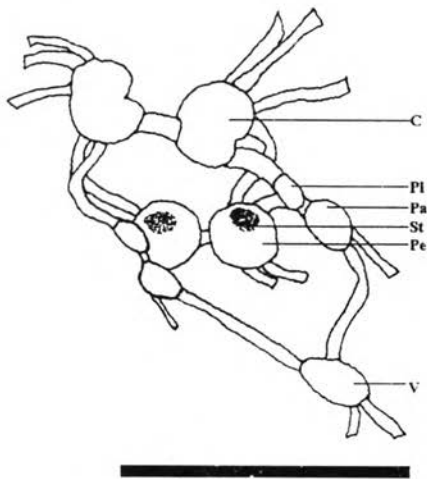
World distribution: Vietnam, Philippines, Indonesia, Cambodia, Malaysia, Thailand, Singapore, Myanmar and India.



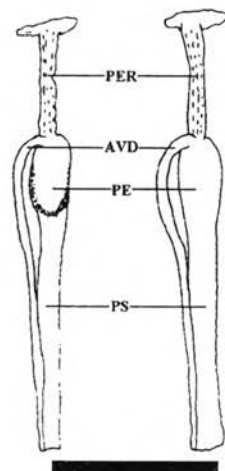
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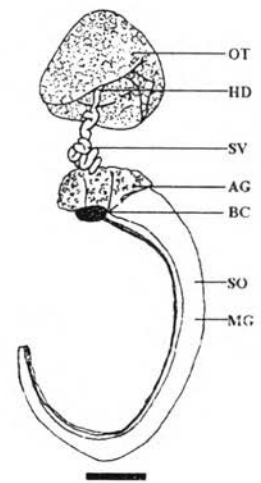
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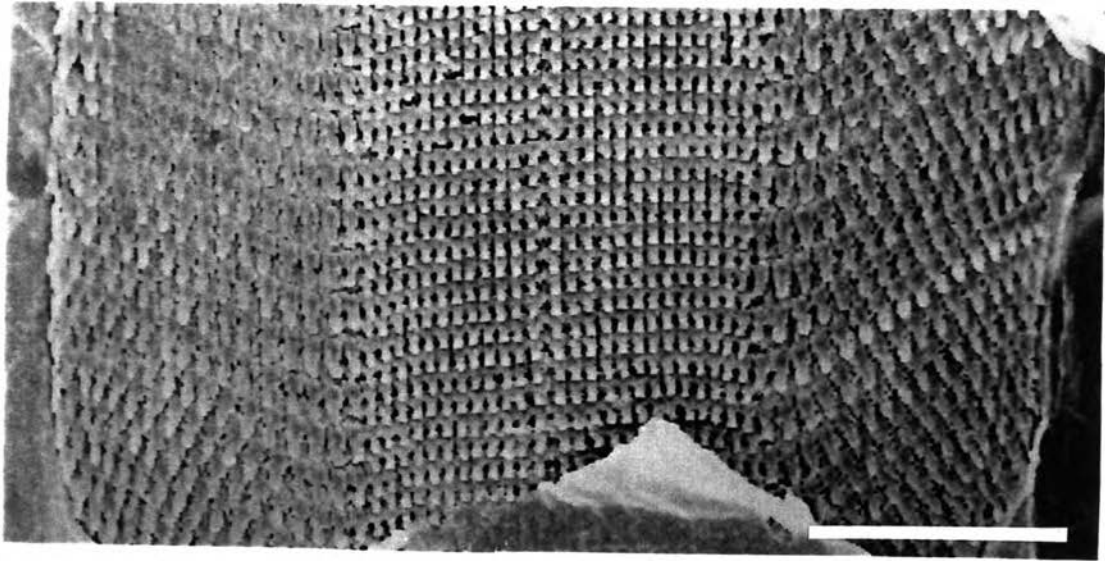


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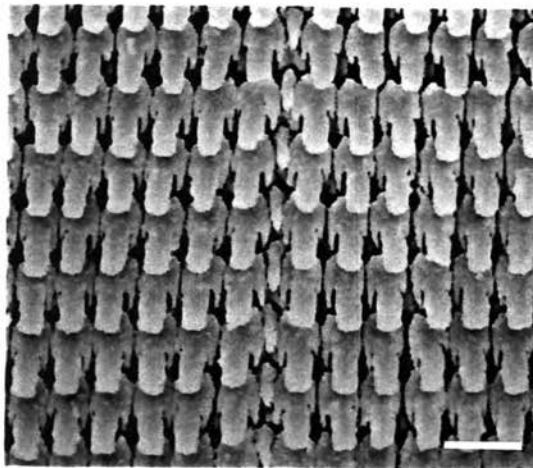


e

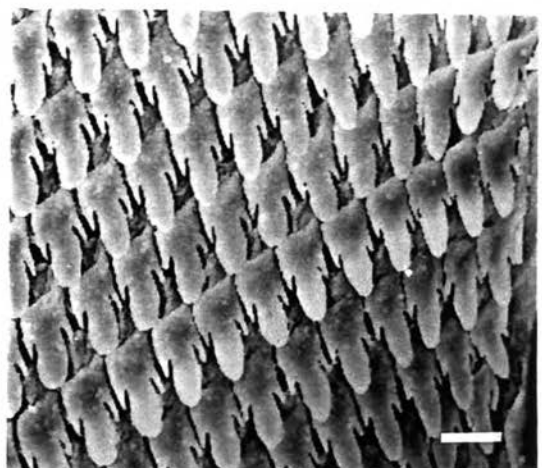
Fig. 4-13 *Laemodonta punctigera*; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglia, d) penial complex, and e) female reproductive organ, scale bar = 5mm in (a) and 1 mm in (c) to (e).



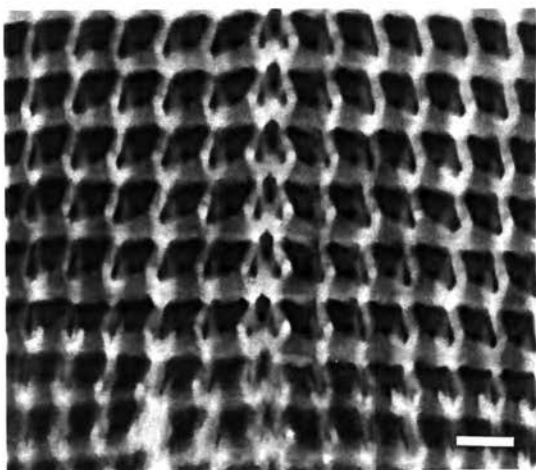
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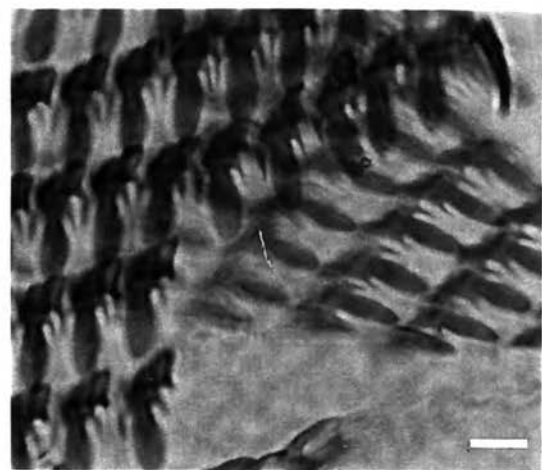
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Fig. 4-14 Radula of *L. punctigera*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 100  $\mu\text{m}$  in (a), and 10  $\mu\text{m}$  in (b) - (e).

*Laemodonta siamensis* (Morelet, 1875)

(Fig. 4 – 15, 4-16)

- 1875 *Plecotrema siamensis*, Morelet, Sér. Conch. , 4: 273, pl. 13 fig. 6 (Siam).
- 1891 *Plecotrema siamensis* Morelet, Fischer, Bull. Soc. Hist. Nat, Autun, 4:40 (Siam).
- 1895 *Plecotrema siamensis* Morelet, Sykes, Proc. malac. Soc. London, 1: 245 (Siam).
- 1956 *Plecotrema siamensis* Morelet, Hubendick, Proc. malac. Soc. London, 32: 121, pl. 23 fig. 6 (Borneo, Celebes, Philippines, Korea).
- 1959 *Laemodonta siamensis* (Morelet), van Benthem Jutting, Beaufortia, 7 (83) : 108 (Sibloga, Tapanuli, sumatra).
- 1974 *Laemodonta siamensis* (Morelet), Brandt, Arch. Moll. , 105: 423 pl. 15 fig. 81 (Chantaburi, Rayong, Chonburi, Trad).
- 1998 *Laemodonta siamensis* (Morelet), Vermeulen & Whitten, Fauna Malaysiana guide to land snails of Bali , 164, fig. 59 (Sumbawa).

Shell is 6.1 - 9.3 mm long and 3.3 – 5.4 mm wide, oval, solid, brown, unicolored. Spire height is about 0.5 – 1.6 mm, dome-shaped, slightly indented suture. There are about 6 – 8 whorls. The largest part of body whorl and aperture length is about 0.86 and 0.66 of shell length, respectively. Umbilicus is shallow, narrow and vertical. Aperture is narrow, ear-shaped. Parietal wall has 2 teeth, vertical and horizontal arrangement. Columellar tooth is simple. Palatal wall has 1 - 2 teeth. Animal has creamy white body with black cylindrical and tapering tentacles. Eyes locate at the inside of tentacular base (Fig. 4- 15 a).

The formula of radula with (44-46) + 1 + (44-46), with a small central tooth, which is about a half of first lateral tooth. The tooth has a wide base, triangular, emarginated, short crown, unicuspid and pointed. Lateromarginal teeth have bicuspid crown; mesocone is large and rounded; endocone is short, pointed with rectangular and long base (Fig. 4-16).

Reproductive system contains yellowish brown, conoidal ovotestis and long hermaphroditic duct. Seminal vesicle is long and convoluted. Albumen gland and mucous gland are transparent (Fig. 4- 15 e). Penial complex is small and long. Penial retractor muscle and anterior vas deferens are as long as penial sheath length. Anterior vas deferens run along the

penial sheath and entered to penial structure at the penis base. Penis is rounded and short about 1/8 of penial sheath (Fig. 4-15d).

Nervous system composed of large round lobed cerebral ganglia, round unlobed parietal, pedal, plural and visceral ganglia. Cerebral ganglia is the largest, which diameter is about 0.24 - 0.36 mm. Visceral and pedal ganglia are almost similar in size, which is about  $\frac{3}{4}$  of cerebral ganglia. Parietal are about  $\frac{1}{2}$  -  $\frac{1}{3}$  of pedal ganglia and about 2 times larger than pleural ganglia. Right and left cerebropedal and cerebropleurial are similar in length. Statocyst located at anterior part of pedal ganglia (Fig. 4-16).

Habitat notes: *L. siamensis* usually found on mud surface in mangrove and nipa palm forest.

Distribution in upper Gulf of Thailand: Chonburi, Chachoengsao, Samutprakan, Bangkok, Samutsongkram and Phetchaburi Provinces.

World distribution: Korea, Philippines, Indonesia, Malaysia, Thailand and Singapore.

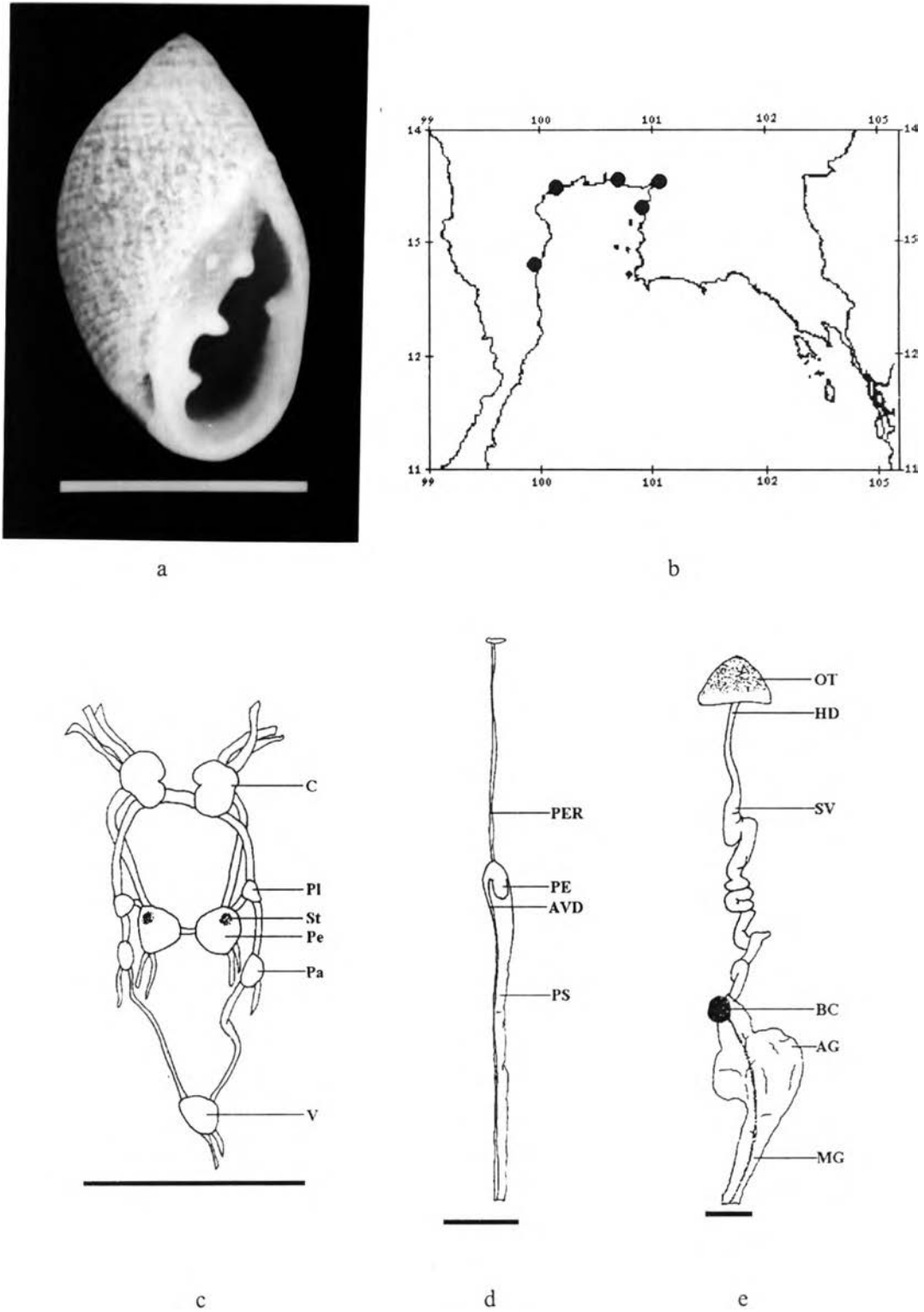


Fig. 4-15 *Laemodonta siamensis*; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglion. d) penial complex, and e) female reproductive organ, scale bar = 5mm in (a) and 1 mm in (c) to (e).



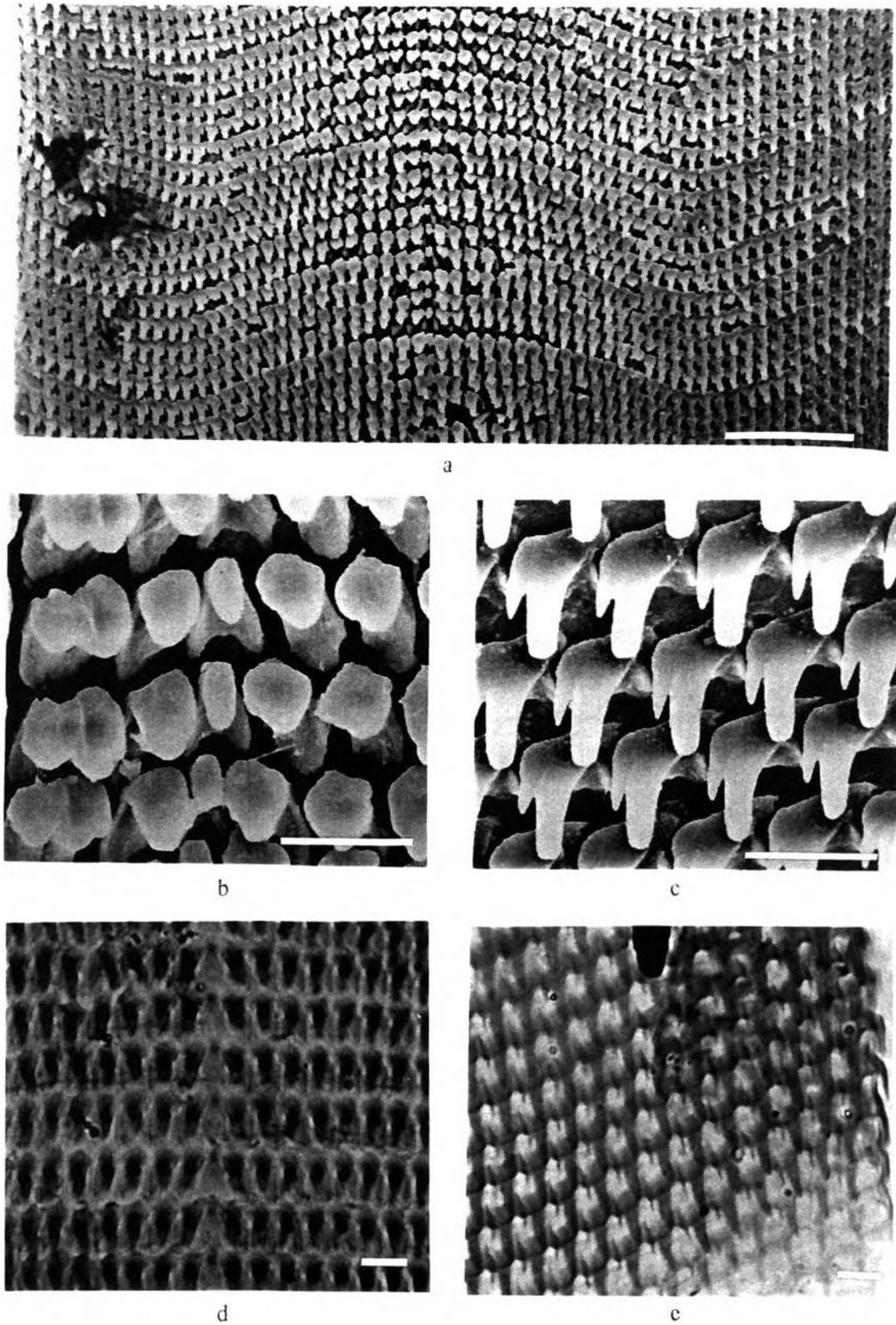


Fig. 4-16 Radula of *L. siamensis*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 50  $\mu\text{m}$  in (a), and 10  $\mu\text{m}$  in (b) - (e).

*Laemodonta* sp.

(Fig. 4-17, 4-18)

Shell is 9.3 - 12.2 mm long and to 6.0-7.5 mm wide, oval, solid and brown. Spire height is about 0.6 – 1.4 mm, cone shaped with generally eroded and slightly indented suture. Shell surface is generally smooth but some shells have hairy periostracum. There are about 6 – 9 whorls. The largest part of body whorl and aperture length is about 0.91 and 0.73 of shell length, respectively. Aperture is narrowly ovate-lunate. Parietal wall has 2 teeth with vertical and horizontal arrangement. Columellar tooth is simple. Palatal wall has a long vertical tooth. Umbilicus is narrow and shallow (Fig. 4-17 a). Animal has creamy white head and foot. Head and tentacles have black pigmented. Mantle skirt is thin and white. Tentacles are cylindrical, tapering with eye located inside of the tentacular base.

The formula of radula is (66-71)+1+(66-71) with small narrow central tooth. The tooth has a wide base, triangular, emarginated, short crown, unicuspid, narrow and rounded shaped. Lateral teeth are about 2-3 times wider than central tooth. Lateral teeth base is quadrangular and long; crown unicuspid triangular shaped and rounded. Marginal teeth base is rhombic shaped; crown bicuspid; mesocone is long and rounded; endocone is short and pointed (Fig. 4-18).

Reproductive system contains light brown and conical ovotestis and short hermaphroditic duct. Seminal vesicle is long and convoluted. Albumen gland is lobed, yellow and transparent. Mucous gland is simple, yellow and transparent. Prostate gland is dark yellow. Oviduct enlarges near genital opening (Fig. 4-17 e). Penial complex is short; anterior vas deferens separate from penial sheath, thick, enter to penial structure at the base of penis and about 1.5 times longer than the penial sheath. Penis is about 2/3 of penial sheath, oval, thick and short. Penial sheath is thin, constricted at distal end which thick and vertical grooves. Penial retractor muscle is as long as penial sheath and relatively thick (Fig. 4-17 d).

Nervous system composed of round lobed cerebral ganglia, round unlobed parietal, pleural, pedal, and visceral ganglia. Cerebral ganglia is the largest, which diameter is 0.39 - 0.45 mm. Pedal and visceral ganglia are almost similar in size. Visceral ganglion is about 2/3 of cerebral ganglia. Parietal ganglia are rounded and about 2 – 3 times longer than pleural ganglia.

Left cerebropedal, cerebropleural and parietopedal commissures are as long as the right. Left pleuroparietal commissure is longer than the right. Statocysts located at the anterior part of pedal ganglia (Fig. 4-17c).

Habitat notes: *Laemoodonta* sp. is often found on mud surface in mangrove.

Distribution in upper Gulf of Thailand: Chonburi, Samutsongkram and Phetchaburi Provinces.

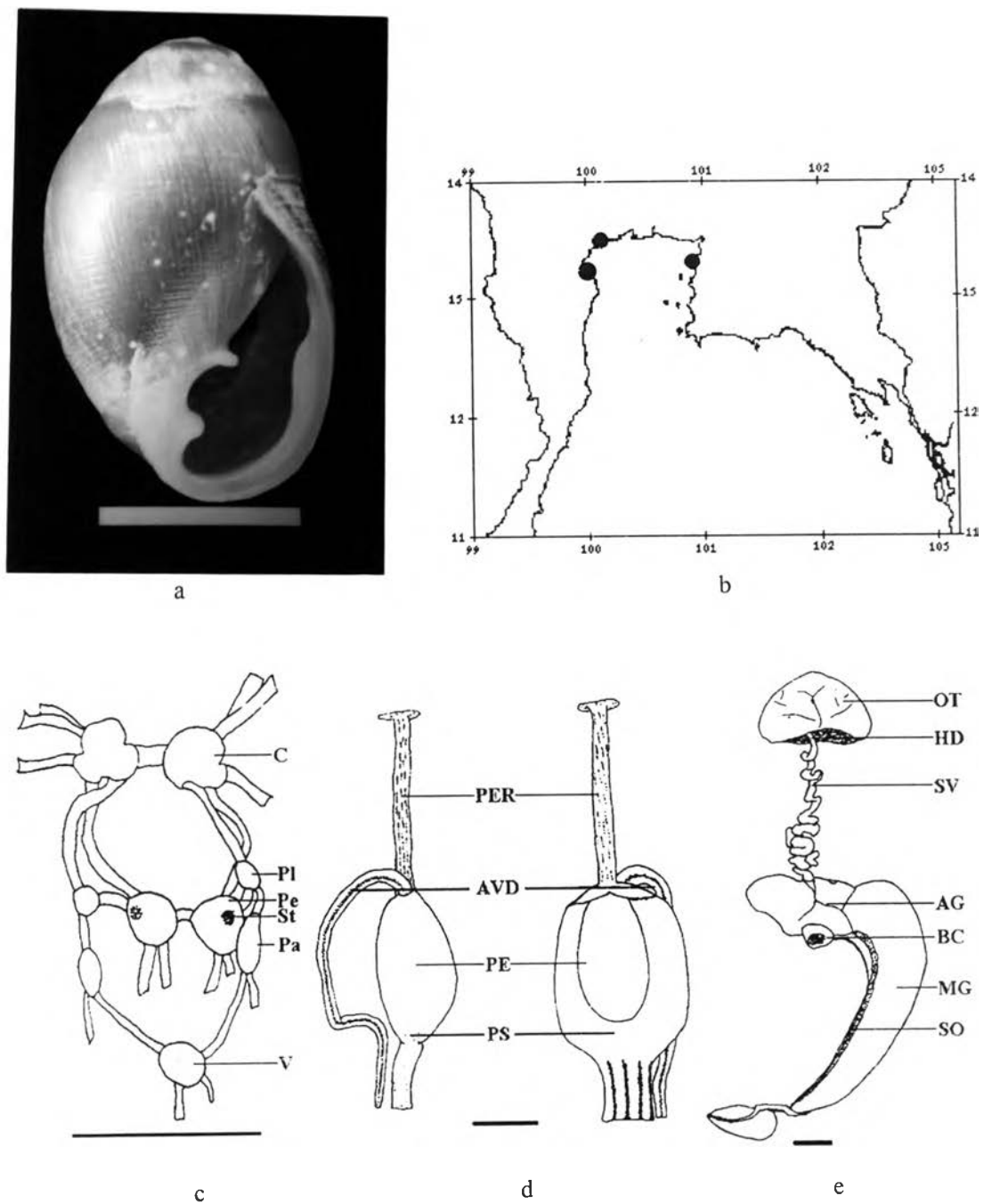
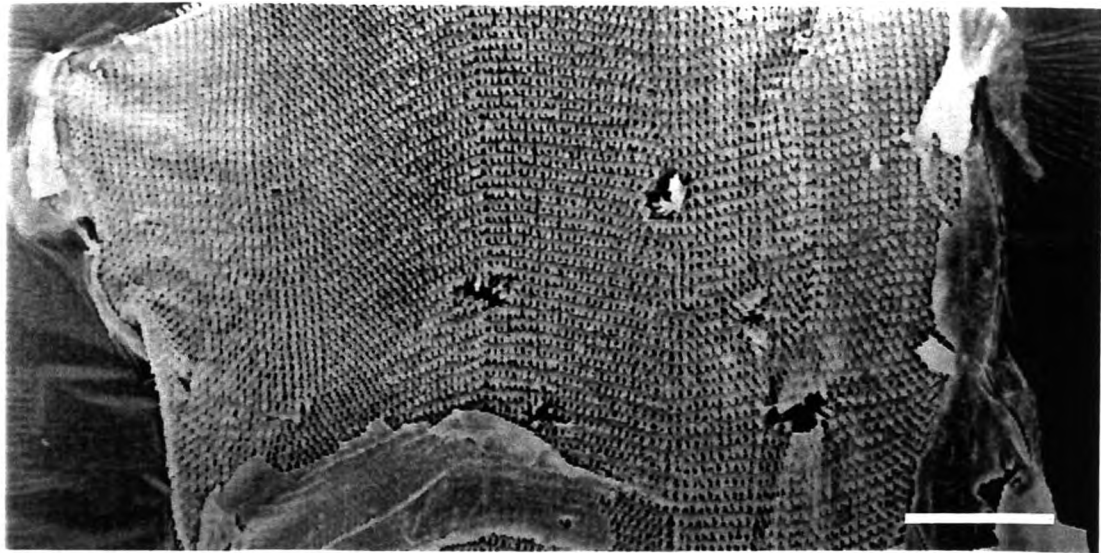
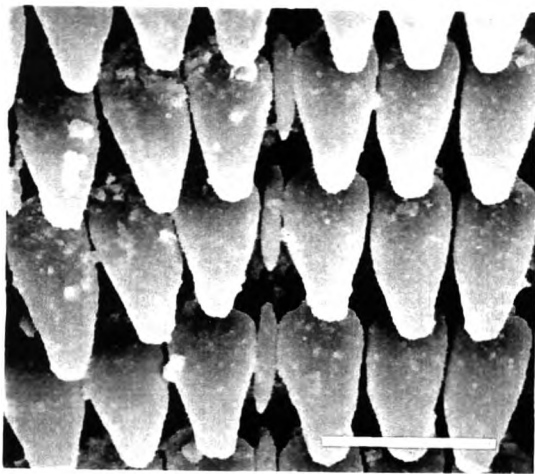


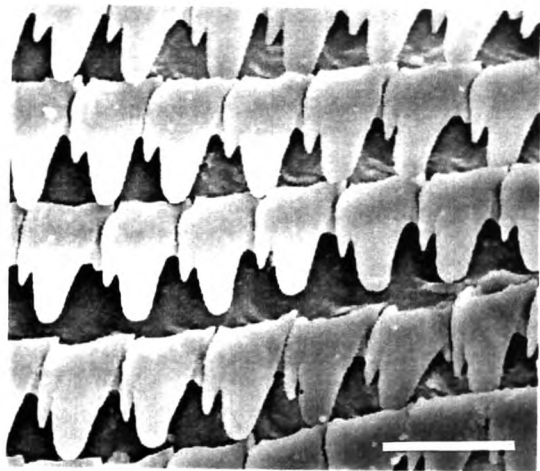
Fig. 4-17 *Laemodonta* sp. ; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglion, d) penial complex, and e) female reproductive organ, scale bar = 5 mm in (a) and 1 mm in (c)-(e).



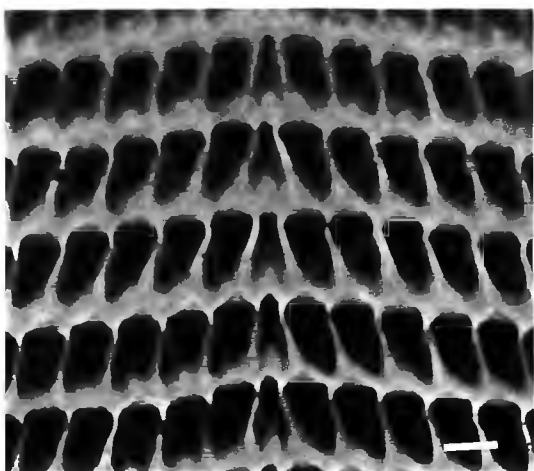
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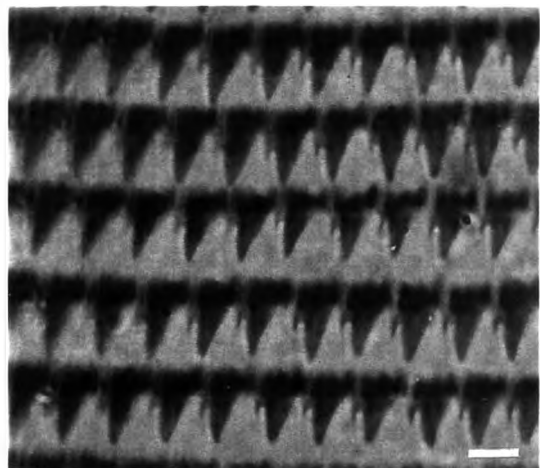
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Fig. 4-18 Radula of *Laemodonta* sp. : a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth. a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 100  $\mu\text{m}$  in (a) and 10  $\mu\text{m}$  in (b) - (e).

*Melampus siamensis* Martens, 1865

(Fig. 4 – 19, 4-20)

- 1865 *Melampus siamensis* Martens, Martens, Mber. Akad. Wiss. Berlin, 1865: 54 9 (Petchaburi, Siam).
- 1874 *Melampus siamensis* Martens, Jickeli, Act. nov. Leop. , 37: 176, pl. 7 fig 2 (Schech Said, Dahlak Ins.).
- 1875 *Melampus siamensis* Martens, Morelet, Sér. Conch. , 4: 271 (Siam).
- 1898 *Melampus siamensis* Martens, Kobelt, Conch. Cab. , 1 (16, 2) : 197, pl. 22 fig. 18, pl. 23 fig. 25-26 (Am vorderen Indischen Ozean, von Hinterindien bis zum Rothen Meer).
- 1974 *Melampus siamensis* Martens, Brandt, Arch. Moll. , 105: 423 pl. 16 fig. 92 (Coast of Indian and western Pacific Ocean).
- 1998 *Melampus siamensis* Martens, Vermeulen & Whitten, Fauna Malaysiana guide to land snails of Bali , 164, fig. 57 (Bali, Thailand).

Shell is 7.0 - 13.1 mm long and 4.6 – 7.6 mm wide, solid, oval, brown, some shells have 2-4 spiral light bands on body whorl. Spire height is about 0.3 – 0.4 mm, cone-shaped and slightly indented suture. There are about 8-10 whorls. The largest part of body whorl and aperture length is about 0.92 and 0.84 of shell length, respectively. Umbilical area is very shallow vertical excavation. Aperture is narrowly ovate-lunate. Columellar tooth is simple and twisted. Parietal wall has 2 vertical teeth. Palatal wall has 4-7 horizontal teeth, which varies in size (Fig. 4–19a). Animal has gray color with black head and foot edge. Tentacles are cylindrical, blunt ended and black color at the tip. Eyes are located inside of tentacular base. Foot has a transverse groove at the anterior part.

The formula of radula is (41-46)+1+(41-46) with large central tooth; the tooth has a wide base, triangular, emarginated, small crown, is about half of the first lateral teeth which are tricuspid; outer cusps are short and stout; median cusp is round and longer than the outer cusps. Lateral teeth have round unicuspid crown and long rectangular base. Marginal teeth have short base and multicuspid crown; mesocone is the largest and the longest, round; endocone long narrow and pointed, which has 1-2 cusps; ectocone short and pointed, which have 6-8 cusps (Fig. 4-20).

Reproductive system contains light brown conical ovotestis and short convoluted hermaphroditic duct. Seminal vesicle is long and convoluted. Albumen gland is lobed. Bursa copulatrix is long, with pointed end. Insertion of bursa duct is position on the posterior of oviduct (Fig. 4 – 19e). Penial complex is long and narrow; penial sheath is very long and constricted near penial retractor muscle: penial retractor muscle is as long as penial sheath; anterior vas deferens is about 2/3 of penial sheath, separated from penial sheath and entered to penial structure near penial retractor muscle; penis is lacking (Fig. 4 – 19d).

Nervous system composes of large and rounded cerebral and pedal ganglia and small, rounded parietal, pleural and visceral ganglia. Cerebral ganglia is the largest, which diameter is about 0.28 – 0.40 mm. Pedal ganglia is almost the same size as cerebral ganglia that about 2 times larger than parietal and visceral ganglia and about 4 times larger than pleural ganglia. Left cerebropedal and cerebropleural commissures are longer than the right. Left and right parietovisceral and pleuroparietal commissures are similar in length. Pedal commissures are very short. Statocysts located at the anterior part of pedal ganglia (Fig. 4 – 19c).

Habitat notes: *M. siamensis* usually crawling on mud surface in mangrove. Sometimes hide themselves under variant substrata.

Distribution in upper gulf of Thailand: Trat, Chonburi, Chachoengsao, Samutprakan, Bangkok, Samutsongkram and Phetchaburi Provinces.

World distribution: Thailand, Malaysia, coast of India Ocean, and Western Pacific Ocean.

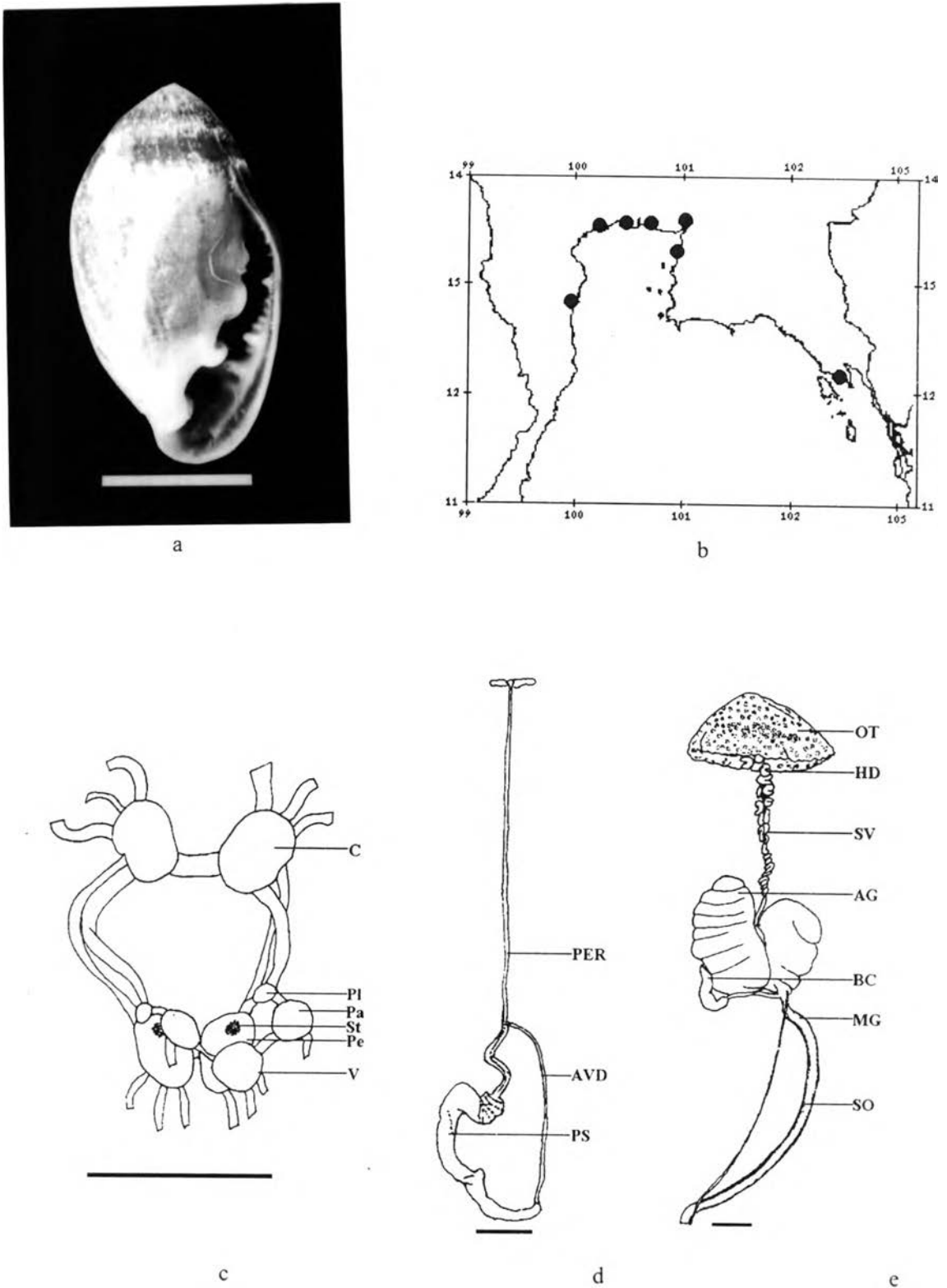


Fig. 4-19 *Melampus siamensis*; a) Shell, b) distribution in upper Gulf of Thailand, c) nerve ganglion, d) penial complex, and e) female reproductive organ; scale bar = 5 mm in (a) and 1 mm in (c)-(e).



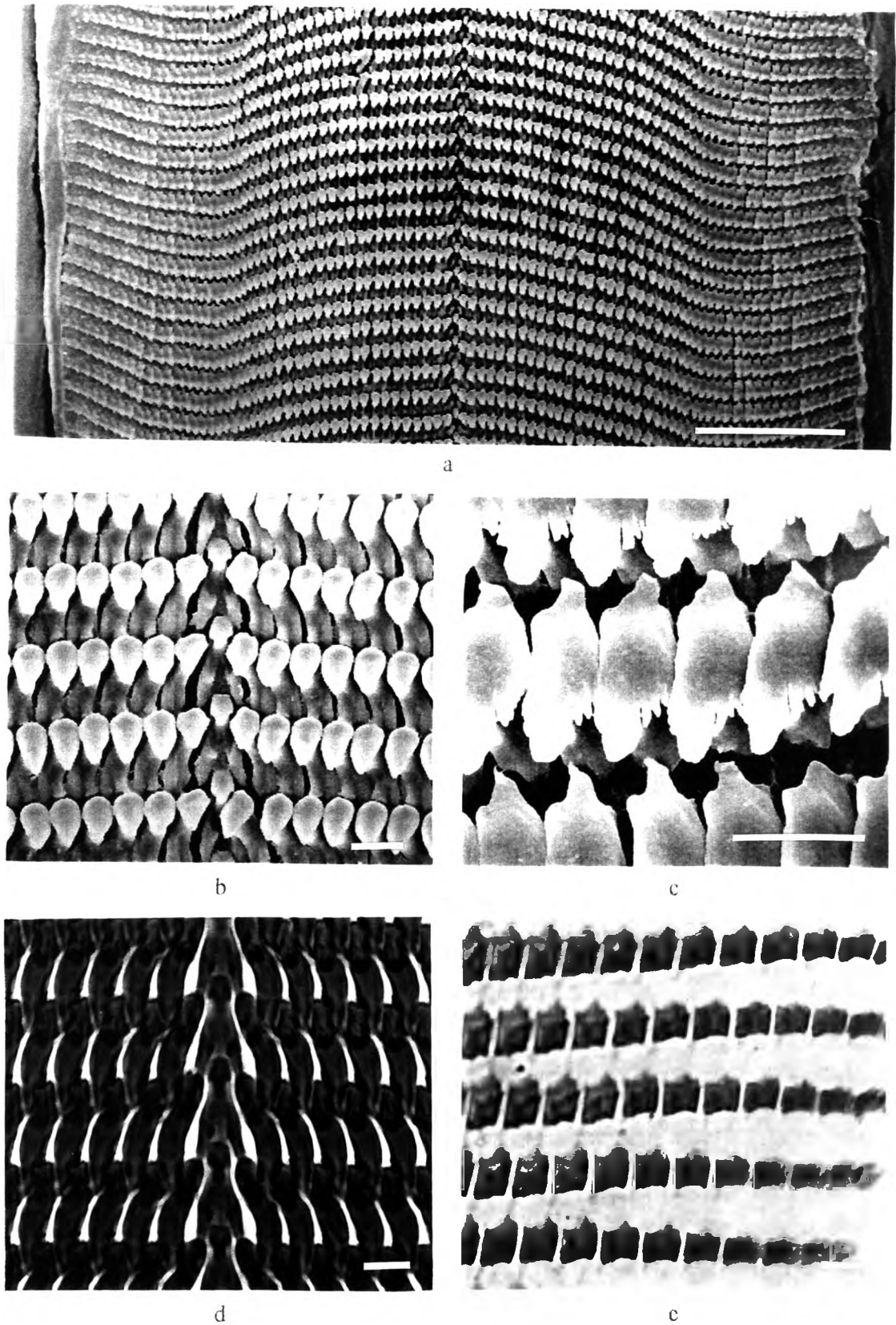


Fig. 4-20 Radula of *M. siamensis*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 100  $\mu\text{m}$  in (a), and 10  $\mu\text{m}$  in (b) - (e).

*Pythia plicata* (Gray, 1825)

(Fig. 4-21, 4-22)

- 1825 *Scarabus plicatus* Gray, Ann. Phil. , 25: 415 (Bengal).  
 1836 *Scarabus triangularis* Benson, J. asiat. Soc. , 5: 354 (Bengal).  
 1844 *Scarabus plicatus* Gray, Küster, Coonch. Cab. , 1 (16): 9, pl. 1 dig 3-4 (Bengal).  
 1854 *Pythia inflata* Pfeifer, Novit, Conch. , 1:7, pl. 3 fig. 3-4 (Borneo).  
 1875 *Scarabus plicatus* (Gray), Morelet, Sér. Conch. , 4: 270 (Petburi, Thailand).  
 1950 *Pythia plicata* (Gray), Suvatti, Fauna Thailand:88 (Pakpun).  
 1974 *Pythia plicata* (Gray), Brandt, Arch. Moll. , 105: 423 pl. 15 fig. 82 (Coast of Indian and western Pacific Ocean ).

Shell is 7.8 – 21.4 mm long and 5.6 – 15.2 mm wide, thin except aperture, pale yellow to brown, some shells are purple, usually with spiral bands on the whorls. Spire height is about 0.4 – 4.5 mm, conic shaped, slightly indented suture. There are about 8 – 10 whorls. The largest part of body whorl and aperture length is about 0.83 and 0.70 of shell length, respectively. Umbilicus is triangular, imperforated and horizontal. Aperture is broadly lunate. Columellar tooth is simple. Parietal wall has 3 teeth with vertical and horizontal arrangement. Palatal wall has 6-8 teeth, horizontal and vertical (Fig. 4-21a). Animal has gray color with black head and white mantle skirt. Tentacles are cylindrical and tapering with black tips. Eyes located inside of tentacular bases and covered by thin black skin.

The formula of radula is (56-63) + 1 + (56-63) with small central tooth; small crown, unicuspid, triangular; wide base, triangular with deeply concave at the base. Lateral teeth base is elongated rectangular; crown unicuspid, hexagonal or rounded. Marginal teeth are smaller than lateral teeth; crown bicuspid; mesocone long and rounded; endocone short and slightly pointed with quadrangular base. Transitional teeth is about 20<sup>th</sup> – 23<sup>rd</sup> of radular row (Fig. 4-22)

Reproductive system contains orange to yellow, conical ovotestis and a short hermaphroditic duct. Seminal vesicle is long and convoluted. Albumen gland is lobed. Posterior mucous gland is lobed but anterior mucous gland is simple. Bursa duct joined to oviduct near female genital opening (Fig. 4-21e). Penial complex is moderately short; anterior vas deferens adheres to penial sheath and enters to penial structure at the base; penis is cylindrical, short and

blunt end; penial retractor muscle is as long as penial sheath. Penial sheath is about 3 times longer than penis, without longitudinal groove (Fig. 4-21d).

Nervous system composes of large, round lobed cerebral ganglia, round unlobed pedal, pleural and parietal ganglia and small lobed visceral ganglion. Cerebral ganglia is the largest about 0.30 - 0.54 mm. Pedal ganglia is almost the same size as cerebral ganglia. Visceral ganglia is about 1/3 of pedal ganglia and is about 2 times larger than parietal and pleural ganglia. Left cerebropedal and cerebropleurial are longer than the right. Right visceroparietal commissure is longer than the left. Statocysts located on the anterior part of pedal ganglia (Fig. 4-21c).

Habitat notes: *Py. plicata* frequently hide themselves under leaves of rotten log in nipa palm forest. They crawl to higher place during the time of raining.

Distribution in upper Gulf of Thailand: Chachoengsao, Samutprakan and Phetchaburi Provinces.

World distribution: Indonesia, Malaysia, Thailand and Singapore.

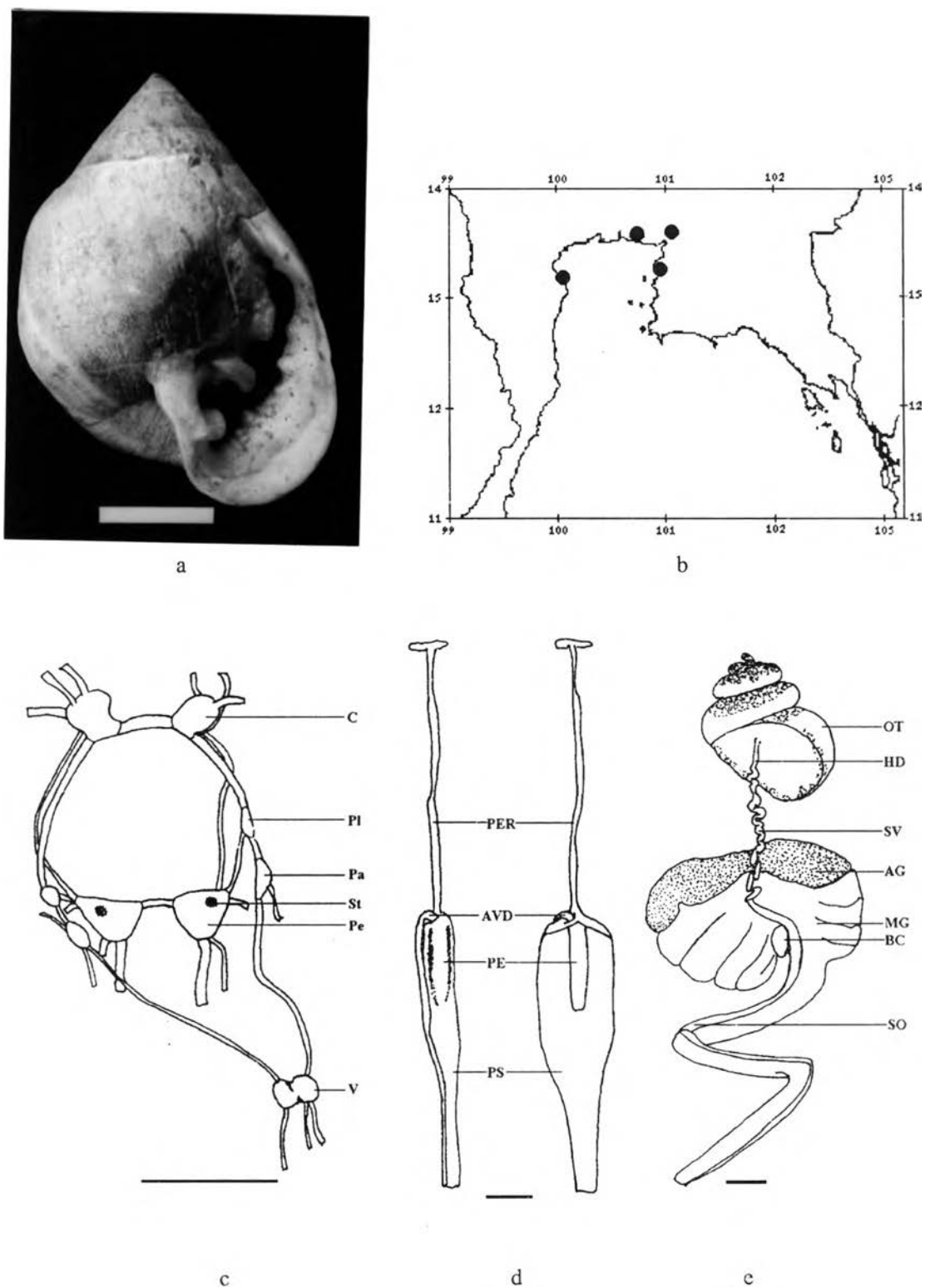
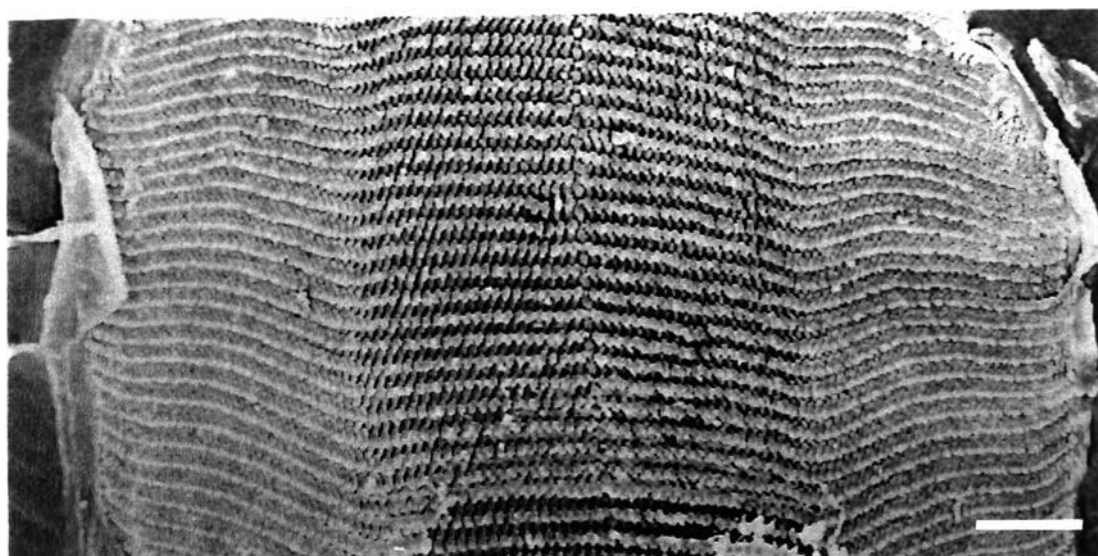
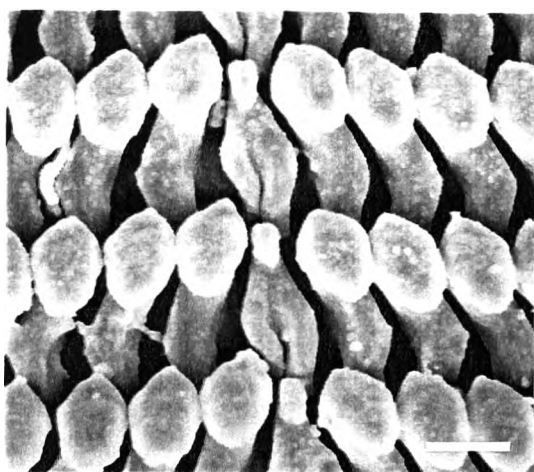


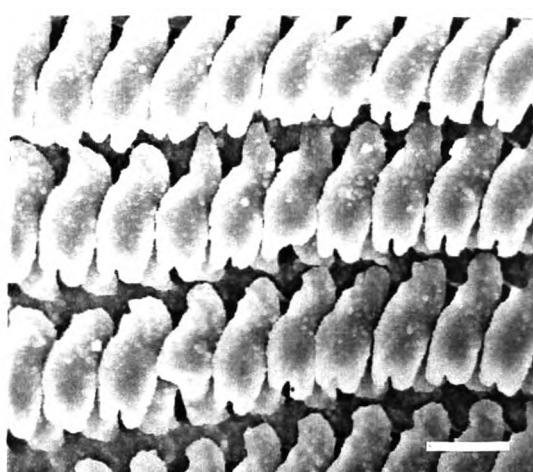
Fig. 4-21 *Pythia plicata*; a) shell, b) live snail, c) distribution in upper Gulf of Thailand, d) nerve ganglion, e) penial complex, and f) female reproductive organ, scale bar = 5 mm in (a) and (d)-(e) are 1 mm.



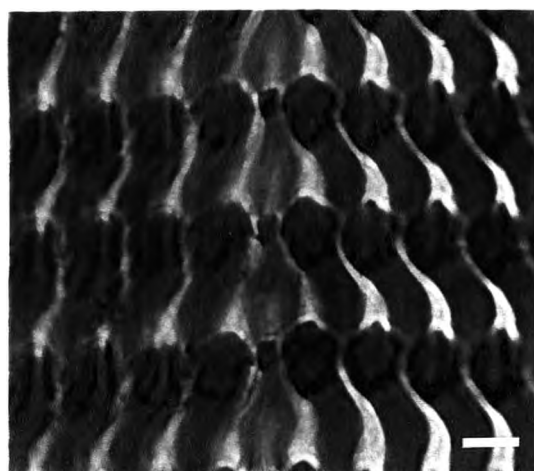
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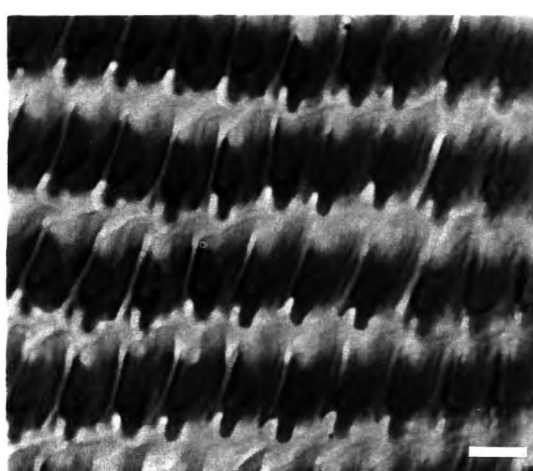
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c

Fig. 4-22 Radula of *Pr. plicata*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth. a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 100  $\mu\text{m}$  in (a), and 10  $\mu\text{m}$  in (b) - (e).

*Pythia trigona* (Troschel, 1838)

(Fig. 4 – 21, 4-22)

- 1837 *Polydonta carinata* Beck, Ind. Moll. : 101 [nom. Nod.] (Singapore).
- 1838 *Scarabus trigonus* Troschel, Arch. Naturg. , 1: 207, pl. 4 fig. 5 (Pululoz bei Bintang).
- 1881 *Scarabus trigonus* Troschel, Rochebrune, Bull. Soc. philom. Paris, 7: 33 (Indo-chine: Saigon).
- 1887 *Pythia trigona* (Troschel), Martens, J. linn. Soc. 21: 166 (Tapo, King Island; Sullivan Island, Pegu).
- 1889 *Scarabus trigonus* (Troschel), Morelet, J. de Conch. , 37: 129 (Prek Tuk Laak, Cambodia).
- 1974 *Pythia trigona* (Troschel), Brandt, Arch. Moll. , 105: 423 pl. 15 fig. 83 (Coast of Indian Ocean and western Pacific and South China sea).

Shell is 12.0 – 18.3 mm long and 0.33 – 0.48 mm wide, triangular, thin, pale brown with numerous dark brown spots, inflated body whorls (dorsoventral compress). Spire height is about 1.54 – 4.4 mm, cone shaped, slightly indented suture. There are about 8 –10 whorls. The largest part of body whorl and aperture length is about 0.82 and 0.65 of shell length, respectively. Aperture is narrow and ear shaped. Umbilicus has a long horizontal canal. Columellar tooth is simple. Parietal wall has 3 teeth, vertical and horizontal arrangement. Palatal wall has 5-7 teeth (Fig. 4 – 21a). Animal has black or dark brown color. Tentacles are tapering; the bases are lighter than tips, eyes located inside of tentacular base. Foot is black with pale edge.

The formula of radula is (50-56) + 1 + (50-56) with a small central tooth which is about 1/3 of first lateral tooth; crown unicuspid, oval-elongate and rounded; base is triangular with emarginated and deeply concave. Lateral teeth base is oval elongate; unicuspid crown, triangular, and slightly pointed. Marginal teeth base is subquadrangular with long bicuspid crown, long; mesocone and endocone are short and blunt (Fig. 4-22).

Reproductive system contains conical, yellowish brown with brown spots ovotestis, which cover posterior portion of stomach and short hermaphroditic duct. Seminal vesicle is long and convoluted. Albumen gland is spiral (Fig. 4 – 21e). Pallial gland is presented. Penial complex is moderately short; anterior vas deferens adhere to penial sheath and enter to penial structure at the base; penis is about 3/4 of penial sheath, cylindrical, slender with blunt end; penial

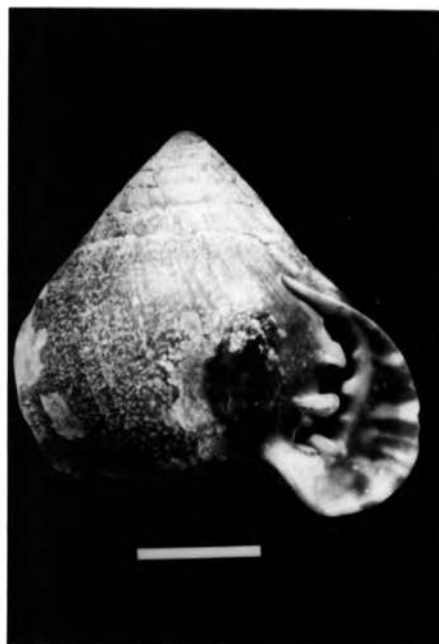
retractor muscle is as long as penial sheath; penial sheath with longitudinal groove inside (Fig. 4 – 21d).

Nervous system composes of large, slightly round lobed cerebral ganglia and round unlobed parietal, pedal, pleural and visceral ganglia. Cerebral ganglia is the largest, which diameter is about 0.33 – 0.48 mm. Pedal ganglia is almost the same size as cerebral ganglia. Visceral ganglia is about half size of pedal ganglia and about 2 times larger than pleural and right parietal ganglia. Right parietal ganglion is about 2-3 times larger than the left. Left cerebropleural and pleuroparietal commissures are longer than the right. The right visceroparietal commissure is longer than the left. Statocysts located on anterior part of pedal ganglia (Fig. 4 – 21c).

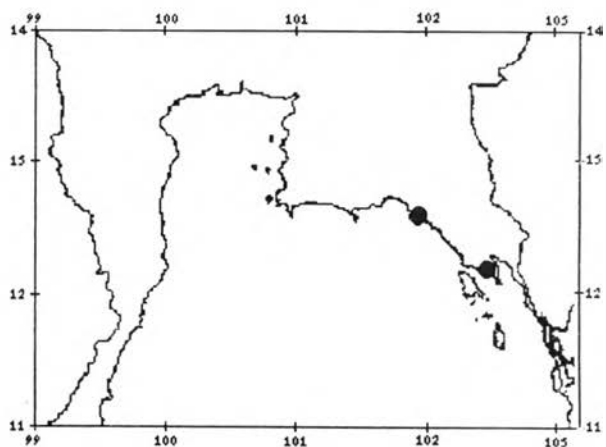
Habitat notes: *Py. trigona* frequently hide themselves under leaf litter and under rotten log.

Distribution in upper Gulf of Thailand: Trat and Chantaburi Provinces.

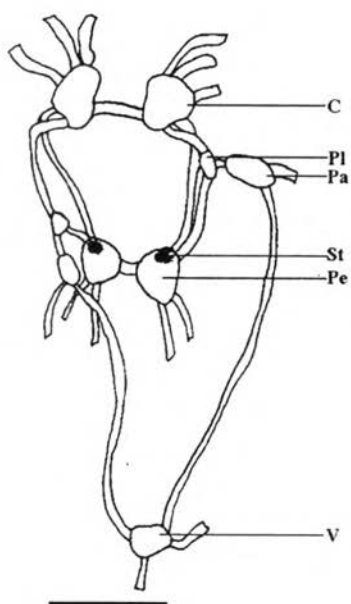
World distribution: Philippines, Indonesia, Vietnam, Cambodia, Malaysia, Thailand, Singapore, Myanmar, Sri Lanka and India.



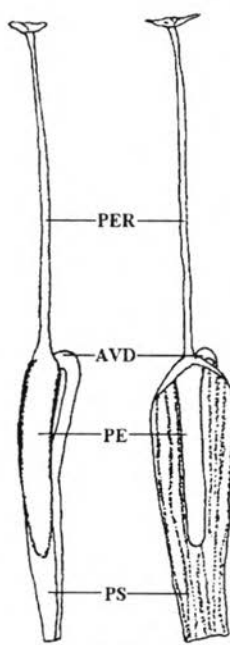
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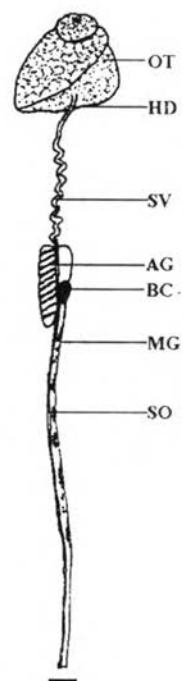
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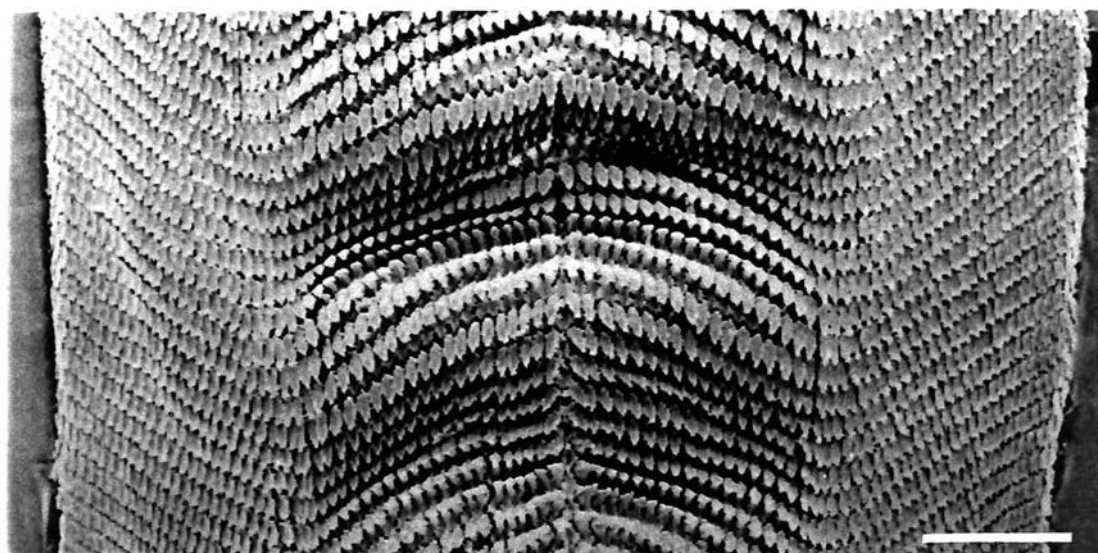
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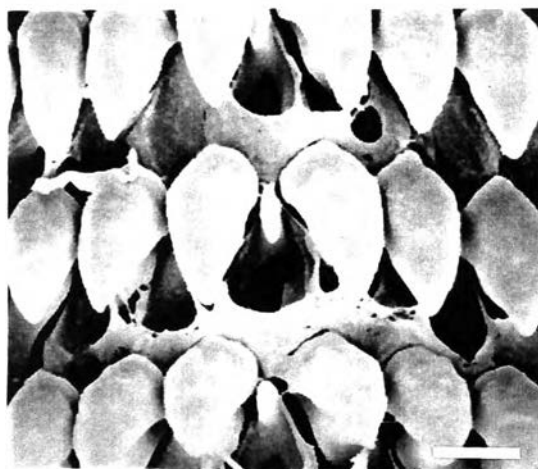
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Fig. 4-23 *Pythia trigona*; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglion, d) penial complex, and e) female reproductive organ, scale bar = 5 mm in (a) and (c)-(e) are 1 mm.

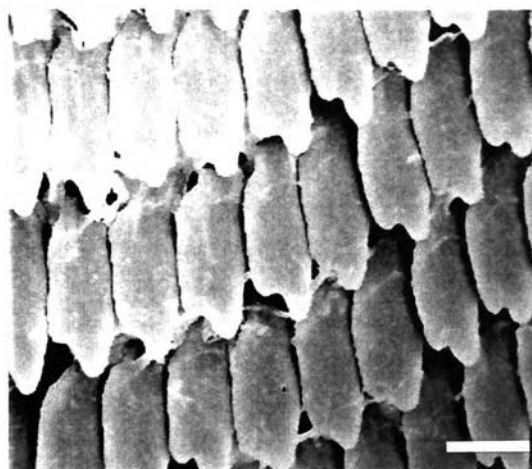




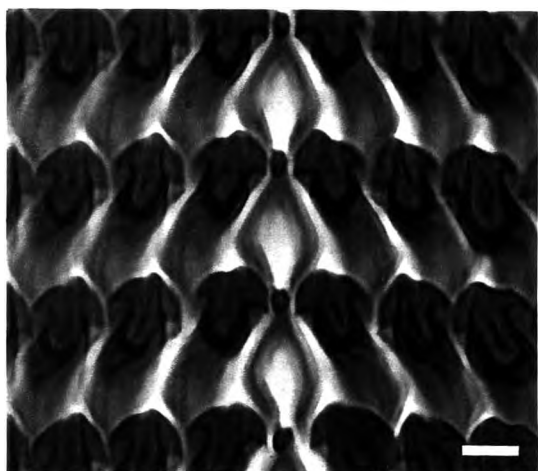
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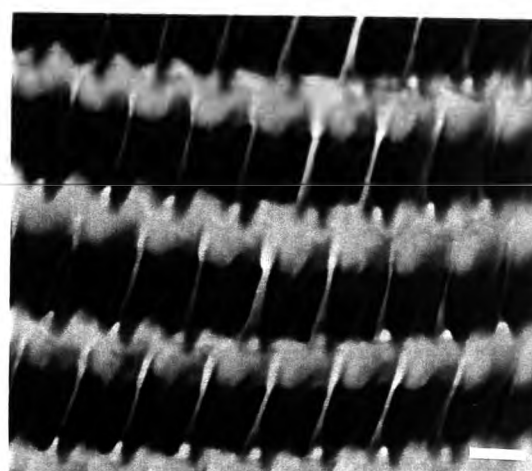
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Fig. 4- 24 Radula of *Py. trigona*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 100  $\mu\text{m}$  in (a) and 10  $\mu\text{m}$  in (b) - (e).

*Siphonaria laciniosa* (Linne', 1758)

(Fig. 4 – 25, 4-26)

- 1946 *Siphonaria laciniosa* (Linne', 1758), Hubendick, Kungl. Sv. Vet. Akademiens Handlingar, 23: 5, pl. 3 fig. 16-19. (Sunda Islands)
- 1962 *Siphonaria laciniosa* (Linne', 1758), Kira, Shells of the western Pacific in color, pl. 69 fig. 11. (tropical Pacific area up to Honshu)
- 1964 *Siphonaria laciniosa*, - Habe, Shells of the western Pacific in color vol. II, pl. 44 fig. 16. (Honshû to Amami and Ryukyu islands)

Shell is 3.9 – 14.4 mm long, 2.6 – 10.4 mm wide and 1.4 – 5.8 mm high, cap-shaped, reddish brown to brown. Exterior with 15-20 white or pale colored primary ribs reaching the apex and 2-3 thin secondary ribs occur between them. Interior bears a brownish spatula alternately margined by white and brown radial bars. Siphonal groove is usually distinct and interrupts the horseshoe-shaped pedal muscle scar of the right side. Apex pointed, central, generally eroded. Siphonal ribs slightly prominent (Fig. 4-25 a). Animal is creamy white to gray color with large foot. Tentacles are absent.

The formula of radula is  $(17 - 32) + 1 + (17 - 32)$  with small central tooth; narrow base, elongate, emarginated; short crown unicuspid and pointed. Lateromarginal teeth base rhombic; crown tricuspid, pointed; mesocone pointed; ectocone and endocone have varies in size but smaller than mesocone. First lateral teeth are about 3 times larger than central tooth (Fig. 4-26).

Reproductive system composed of yellow, conical ovotestis and short, thick hermaphroditic duct. Albumen gland and mucous gland large, white, anterior to ovotestis and envelop the seminal vesicle (Fig. 4-25f). Epiphallus gland large, lobed, white cream colored. Flagellum is white, long and thin. Penis is lacking. Bursa copulatrix is rounded and enters the genital atrium through a long thin, white bursa duct (Fig. 4-25e). Spermatophore is yellowish brown and translucent (Fig 4-25d).

Nervous system with rounded cerebral, pedal, pleuroparietal and visceral ganglia. Cerebral ganglia is the largest, which diameter is about 0.2 - 0.35 mm. Cerebral, pedal, right pleuroparietal and visceral ganglia are similar in size. Left pleuroparietal ganglion is about 3

times smaller than cerebral ganglia. Cerebral commissure is about 4 – 5 times longer than cerebral width. Left cerebropleural commissure is about 2 times longer than the right. Left parietovisceral commissure is about 4 times longer than the right. Statocysts located at anterior part of pedal ganglia (Fig. 4-25c).

Habitat notes: *Si. laciniosa* usually found on rock surface in seaward zone.

Distribution: Chonburi Province.

World distribution: Japan, Philippines, China, Indonesia, Australia, Malaysia, Thailand, Mauritius

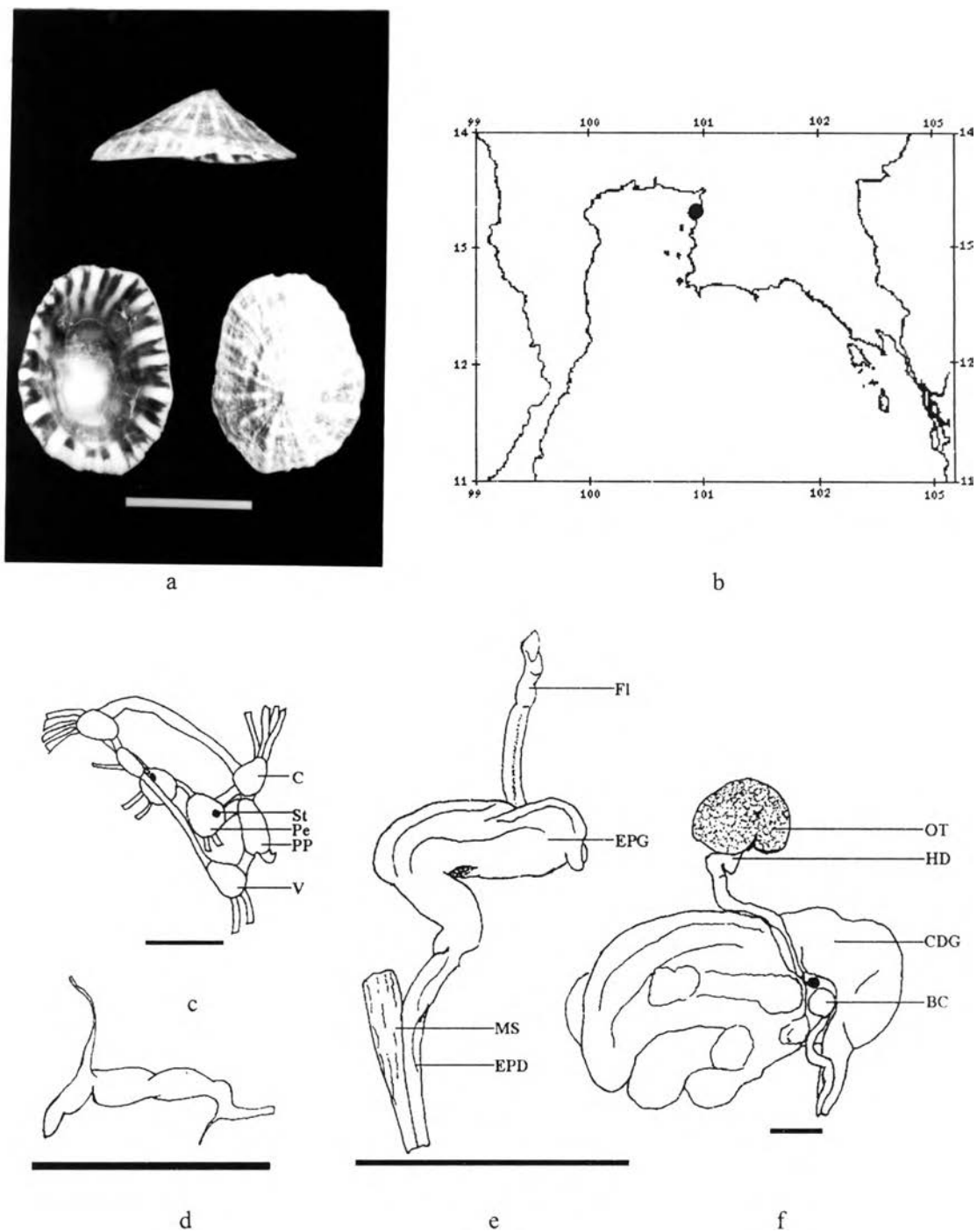
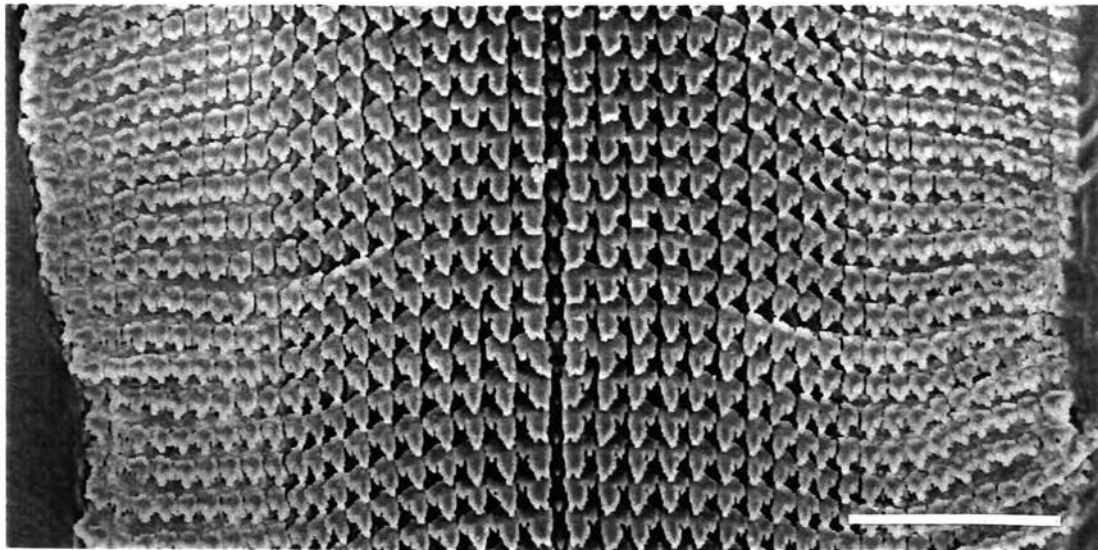
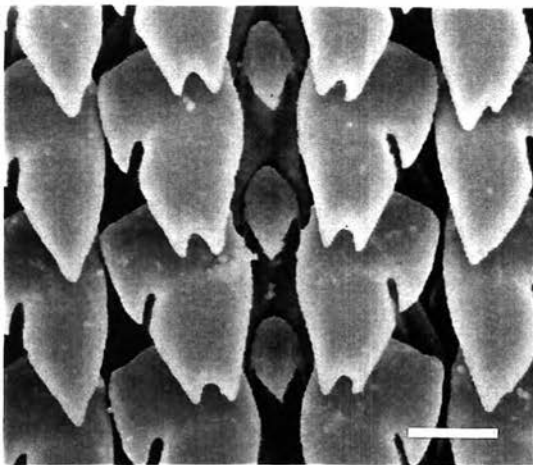


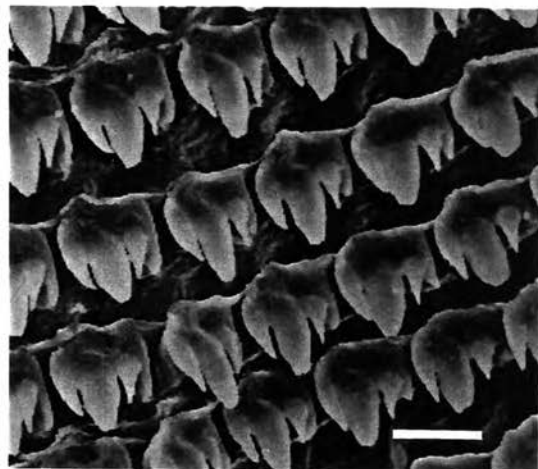
Fig. 4-25 *Siphonaria laciniosa*; a) shells, b) distribution in upper Gulf of Thailand, c) nerve ganglia, d) spermatophore, e) penial complex, and f) female reproductive organ, scale bar = 1 cm in (a) and are 1 mm in (c) – (f).



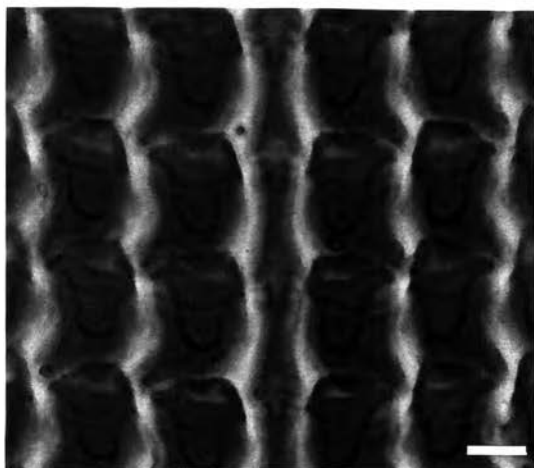
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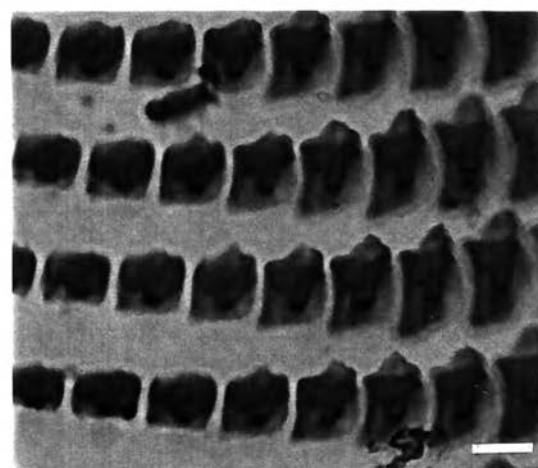
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Fig. 4-26 Radula of *Si. laciniosa*; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 100  $\mu\text{m}$  in (a) and 10  $\mu\text{m}$  in (b) - (e).

*Salinator* sp.

(Fig. 4-27, 4-28)

Shell is 8.3 - 11.8 mm long and 6.3 - 11.3 mm wide, thin, fragile, light brown or reddish brown, some shells have 1-2 spiral bands on subglobose body whorl, whorl rapidly increase in size. Spire height is 0.05 – 1.36 mm, cone shaped, strongly indented suture. Umbilicus deep, rounded, vertical. There are about 4-5 whorls. The largest part of body whorls is about 0.92 of the shell length. Aperture is roundly lunate lacking aperture tooth and is about 0.72 of shell length. Operculum is thin, brown color, transparent and paucispiral (Fig. 4-27a). Animal is gray to black with thick white foot and large black head. Tentacles are very short and blunt. Eyes located inside of the tentacles and covered by thin skin. Mantle skirt is fleshy and gray colored.

The formula of radula is (24-37) + 1 + 1 + 1 + (24-37) with wide central teeth; crown has 9 – 15 rounded cusps, central cusp is the biggest. Lateral tooth is wide, tricuspid crown; mesocone, endocone and ectocone are elongated, rounded and equally in size. Marginal teeth are narrow, crown unicuspid, elongated, round tip, base quadrangular and elongated (Fig. 4-28).

Reproductive system with light yellow ovotestis covered by black mantle, spiral, cone shaped and short hermaphroditic duct. Albumen gland and mucous gland is white, transparent and not distinctly separate (Fig. 4-27e). Penial complex is short. Penis is lobed and spiny. Penial retractor muscle is as long as penial sheath. Penial sheath is a little longer than the penis. Spermoviduct is very long and convoluted (Fig. 4-27d).

Nervous system composed of round unlobed cerebropleural, parietal, pedal and visceral ganglia. Cerebropleural and pedal ganglia are similar in size. Cerebropleural ganglia is triangular and rounded with long commissure, about 1.5 times of ganglia diameter. The diameter of cerebropleural is about 0.2-0.4 mm. Right pleuroparietal commissure is about 2-3 times longer than the left. Left parietovisceral commissure is a little longer than the right. Statocysts located at the posterior of pedal ganglia (Fig. 4-27c).

Habitat notes: *Salinator* sp. is often found on mud flat at low tide of mangroves.

Distribution in upper Gulf of Thailand: Chonburi and Phetchaburi Provinces.

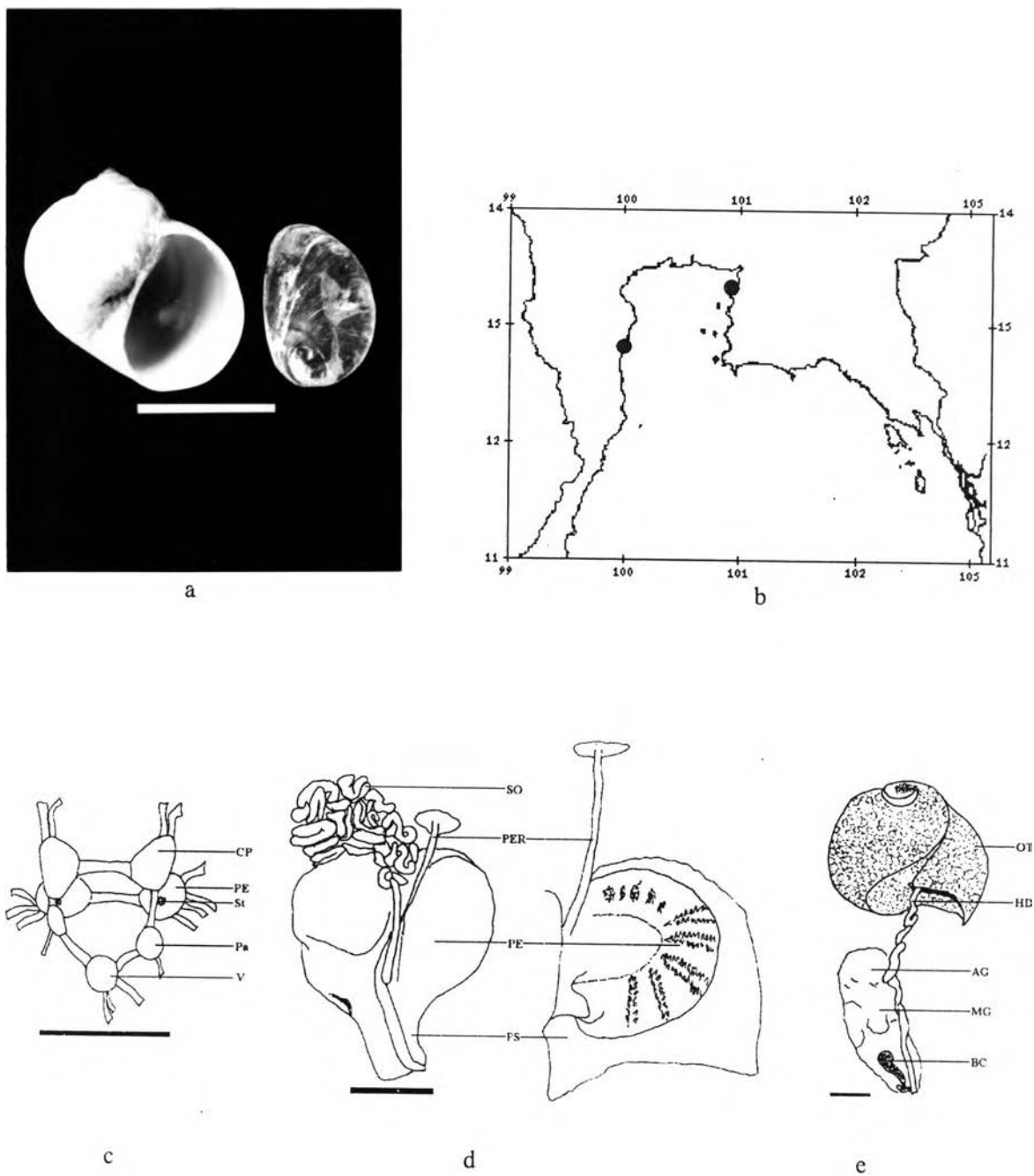
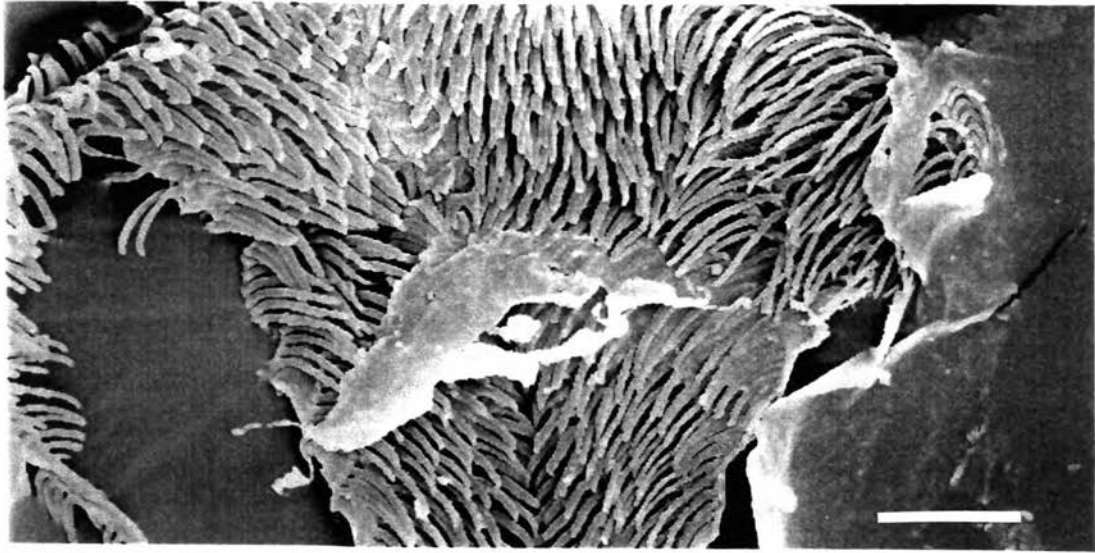
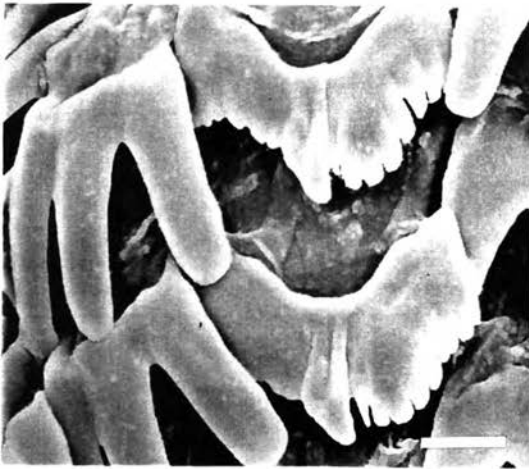


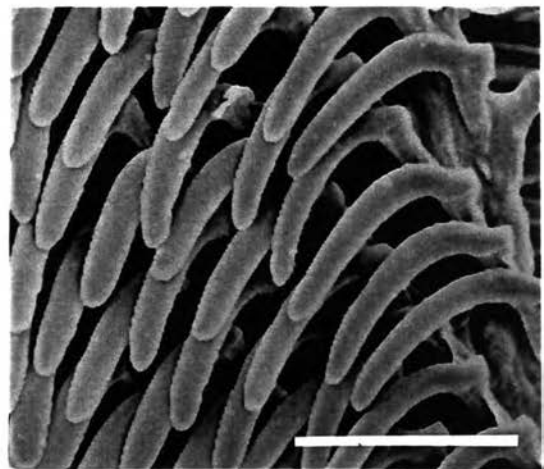
Fig. 4-27 *Salinator* sp.; a) shell, b) distribution in upper Gulf of Thailand, c) nerve ganglion, d) penial complex, and e) female reproductive organ, scale bar = 1 cm in (a) and (c)-(e) are 1 mm.



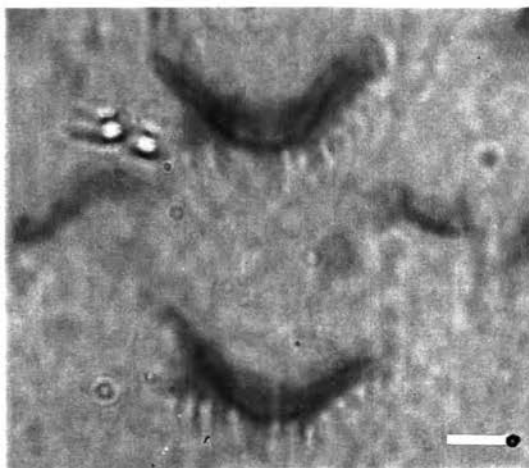
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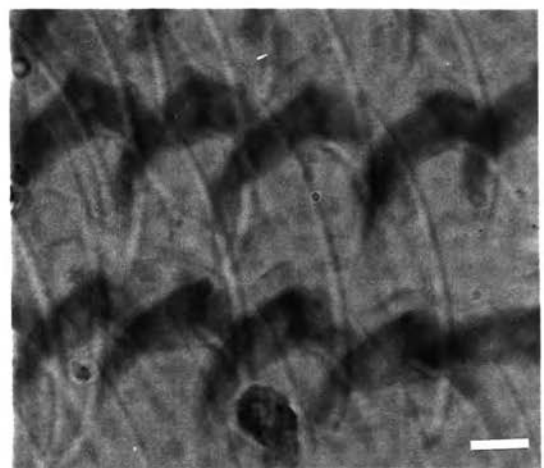
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Fig. 4-28 Radula of *Salinator* sp. : a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 100  $\mu\text{m}$  in (a) and 10  $\mu\text{m}$  in (b) - (e).



*Onchidium* sp. 1

(Fig. 4-29, 4-30)

Preserved animal is 31.0 - 48.4 mm long and 21.0 – 30.0 mm wide. Body is soft, round to oval elongate when relaxed state. Notum is gray colored with 2 longitudinal pale brown or pale red bands in some specimens. Foot is 27.5 – 46.0 mm long and 13.9 – 21.9 mm wide (about 3/5 of body width), with many fine transverse lines and white or yellow color. Head and tentacles are black colored. Lower tentacles are broad and flatten. Notum has many size of notal papillae. Some papillae have a dorsal eye. Hyponotum is smooth, white or pale gray, with mottling dark spots. Male opening is located near right of the tentacular base. Pneumostome and anus are located in midline and posterior of body. The anus is covered by tip of foot. Female opening is closed to anus (Fig. 4-29 a).

The formula of radula is (79-95) + 1 + (79-95) with tricuspid central tooth of pointed cusps and equal in size; base is triangular and wide. Lateromarginal teeth base is subquadrangular and long. The crown is unicuspid, long and rounded (Fig. 4-30).

Reproductive system composed of flat, oval ovotestis and a short hermaphroditic duct. Albumen gland is large and lobed. Mucous gland is large and unlobed. Bursa copulatrix is spherical and very large (Fig. 4-29 e). Penial complex composed of penis, anterior vas deferens, penial retractor muscle, penial sheath and penial gland. Penial retractor muscle is about a half of penial sheath. Penial gland has a large muscular sac (Fig. 4-29 d).

Nervous system composed of round, unlobed cerebral, parietopleural, pedal and visceral ganglia. Cerebral ganglia is the largest with diameter 0.4 – 1.0 mm. Pedal ganglia is as large as cerebral ganglia. Pleural and parietal ganglia are fused and closed to cerebral ganglia. Visceral and right paritopleural ganglia is about a half sized of cerebral ganglia which about 3 times longer than left parietopleural ganglion. Commissure of right parietopleural and visceral ganglia is about 2 times longer than the left (Fig. 4-29 c).

Habitat notes: *Onchidium* sp. 1 live on mud surface, under large litter in mangrove and nipa palm forest.

Distribution in upper Gulf of Thailand: Trat, Chantaburi, Chonburi, Chachoengsao, Samutprakan, Samutsongkram and Phetchaburi Provinces.

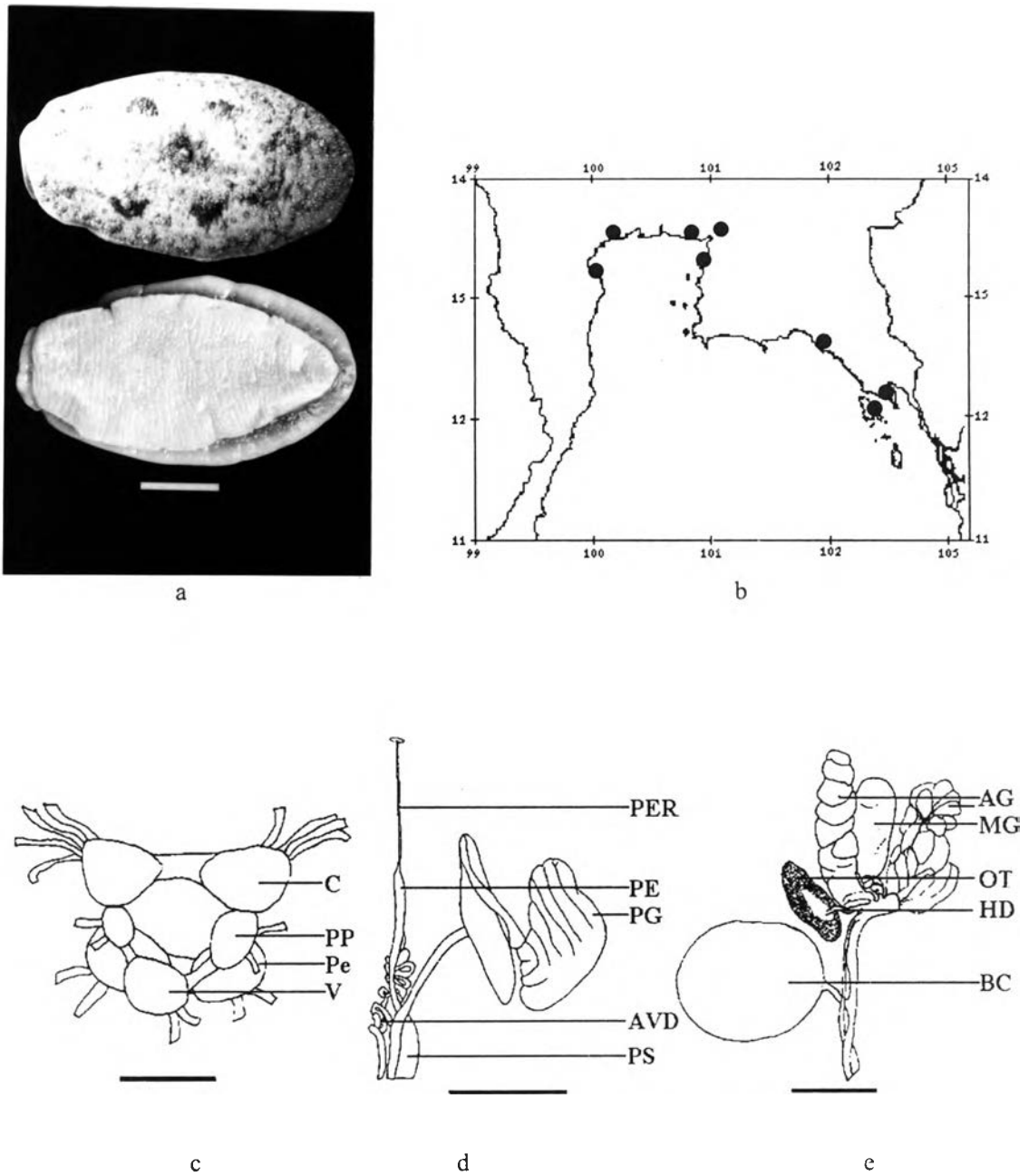
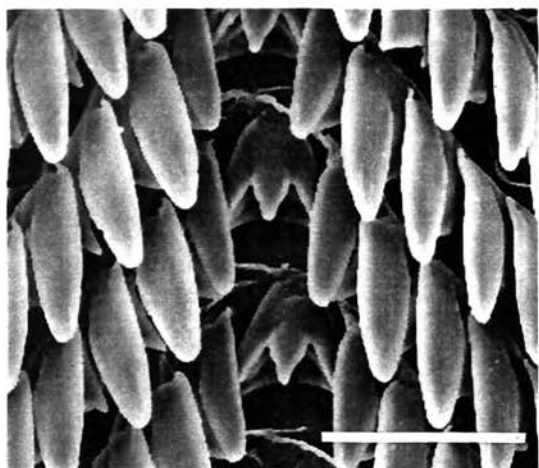


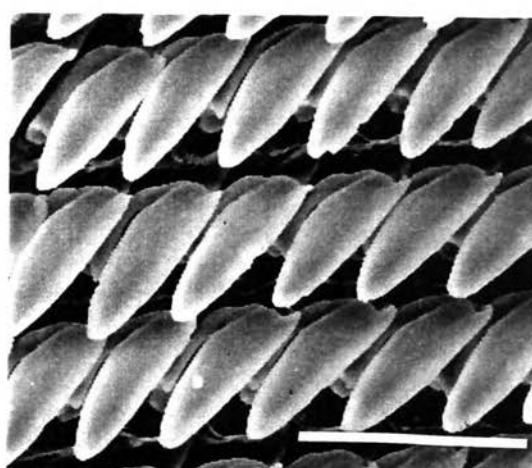
Fig. 4-29 *Onchidium* sp. 1; a) dorsal view of body, b) distribution in upper gulf of Thailand, c) nerve ganglia, e) penial complex and f) female reproductive system, scale bar = 1 cm in (a), 1 mm in (c) and 5 mm in (d), (e).



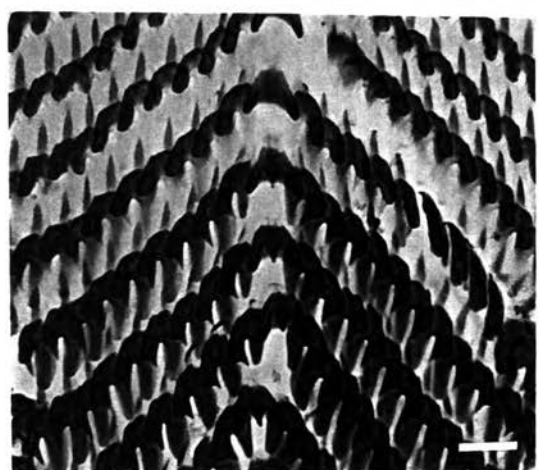
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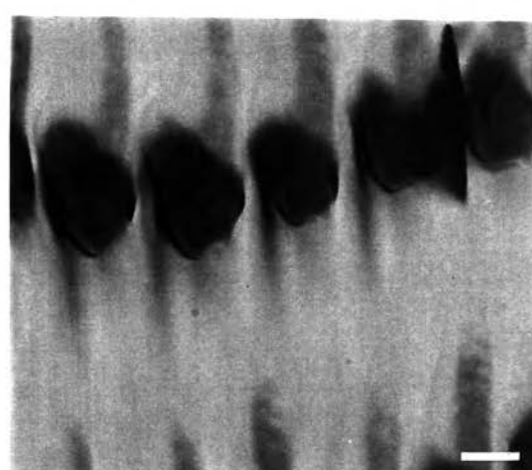
b



c



d



e

Fig. 4-30 Radula of *Onchidium* sp. I; a) radula rows, b) and d) central and lateral teeth, c) and e) marginal teeth. a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 500  $\mu\text{m}$  in (a), 50  $\mu\text{m}$  in (b) and (c) and 10  $\mu\text{m}$  in (d) and (e).

*Onchidium* sp. 2

(Fig. 4-31, 4-32)

Preserved animal is 20.87 mm long and 17.30 mm in wide. Body is soft, oval to round in shape when crawling. Notum is gray. Foot is 16.24 mm long and 10.84 mm wide (about 3/5 of body width), with many fine transverse grooves and white color. Head and tentacles are black colored. Lower tentacles are broad and flatten. Notum has many sizes of notal papillae. Posterior end of notum has finger like notal papillae. Hyponotum is smooth. Male opening near right tentacular base. Pneumostome and anus are positioning in the midline, anus covered by tip of foot. Female opening closed to anus (Fig. 4-31a).

The formula of radula is (56)+1+(56). Central tooth is tricuspid crown with pointed cusps and equal in size. Lateral teeth have long, slender and pointed unicuspid crown. Marginal teeth have bicuspid crown; endocone is short, slender and pointed; mesocone is large long and rounded (Fig. 4-32).

Reproductive system composed of flat, oval ovotestis. Albumen gland and mucous gland is large and lobed. Bursa copulatrix is spherical with short bursa duct (Fig. 4-31e). Penial complex composed of penis with anterior vas deferens, penial retractor muscle, penial sheath and penial gland. Penial retractor muscle is about a 1/7 of penial sheath. Penial gland without a large muscular sac (Fig. 4-31d).

Habitat notes: *Onchidium* sp. 2 live on rock surface in seaward zone.

Distribution in upper Gulf of Thailand: Chonburi Province.

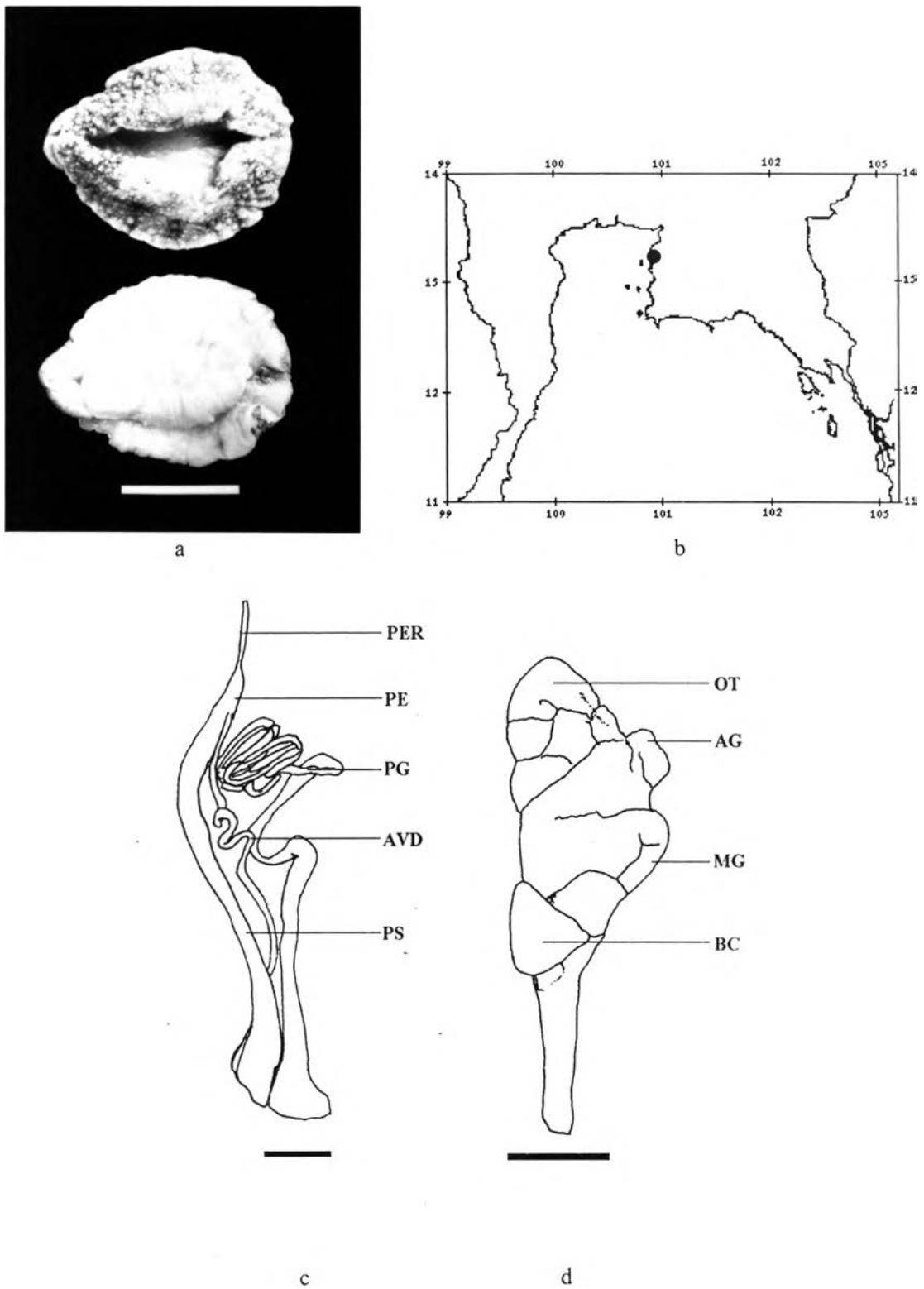


Fig. 4-31 *Onchidium* sp. 2; a) shell, b) distribution in upper Gulf of Thailand, c) penial complex, and d) female reproductive organ, scale bar = 1 cm in (a) and 1 mm in (c) – (e).

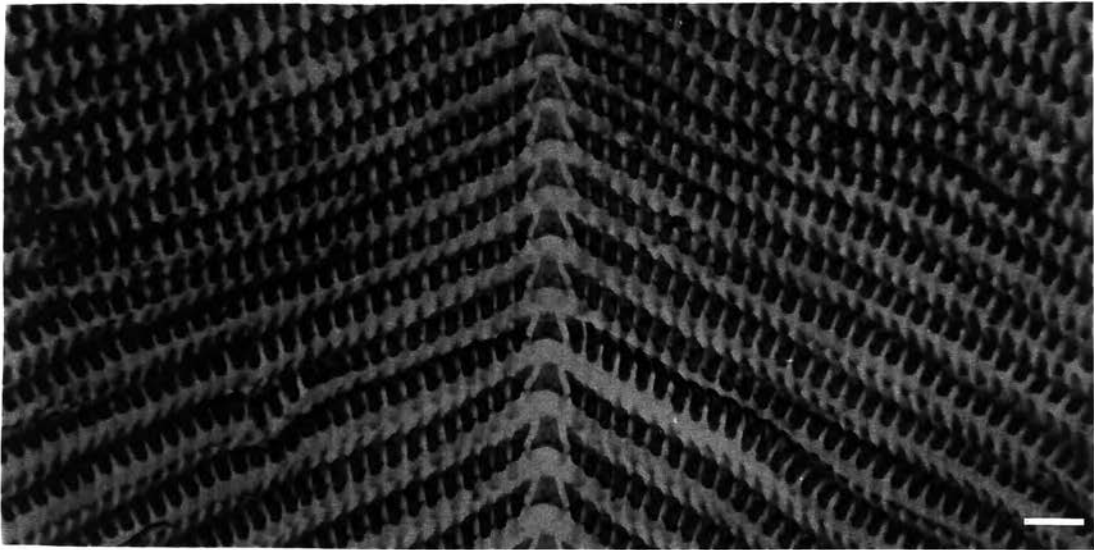
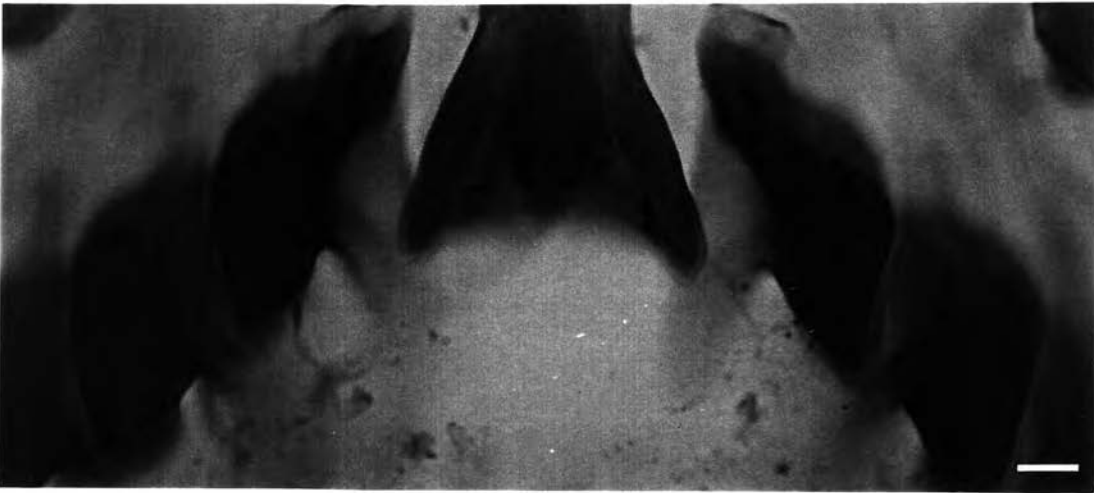
*a**b**c*

Fig. 4-32 Radula of *Onchidium* sp. 2: a) radula rows, b) central and lateral teeth, c) marginal teeth. scale bars are 100  $\mu\text{m}$  in (a) and 10  $\mu\text{m}$  in (b) and (c).

*Platevindex* sp.

(Fig. 4-33, 4-34)

Preserved animal is 15.11 – 46.84 mm long and 9.2 – 32.16 mm wide. Body is rigid, rounded to oval. Notum is gray to dark brown. Foot is 11.33 – 36.04 mm long and 1.49 – 14.94 mm wide (about 2/5 of body width), with many fine transverse grooves and white or yellow colored. Head and tentacles are black colored. Lower tentacles are broad and flatten. Notum has many small notal papillae. Some papillae have a dorsal eye. Hyponotum is smooth and white or pale gray color, with mottling dark spots. Male opening located near the right tentacular base. Pneumostome and anus are located in the midline and posterior of the body. The anus is covered by the posterior part of foot. Female opening is closed to anus (Fig. 4-33a).

The formula of radula is (106-118)+1+(106-118). Central tooth has tricuspid crown, each cusp are similar in size. Lateromarginal teeth have unicuspid crown long and blunt (Fig. 4-34).

Reproductive system composed of lobed round ovotestis and short hermaphroditic duct. Albumen gland is large and lobed. Bursa copulatrix is large and spherical (Fig. 4-33e). Penial complex composed of penis, penial retractor muscle, anterior vas deferens and penial sheath. Penial retractor muscle is about 1/3 of penial sheath. Penial gland is absent (Fig. 4-33 d).

Nervous system composed of round unlobed cerebral, parietopleural, pedal and visceral ganglia. Cerebral ganglia is the largest with diameter 0.6 – 0.9 mm. Pedal ganglia is as large as cerebral ganglia. Pleural and parietal ganglia are fused and closed to cerebral ganglia. Visceral and paritopleural ganglia is about a half sized of cerebral ganglia with about 3 times longer than left parietopleural ganglion. Commissure of right parietopleural and visceral ganglia is about 2 times longer than the left (Fig. 4-33 c).

Habitat notes: *Platevindex* sp. lives on mud surface, under large litter in mangrove and nipa palm forest.

Distribution in upper Gulf of Thailand: Trat, Chantaburi, Chonburi, Chachoengsao, Samutprakan, Samutsongkram and Phetchaburi Provinces.

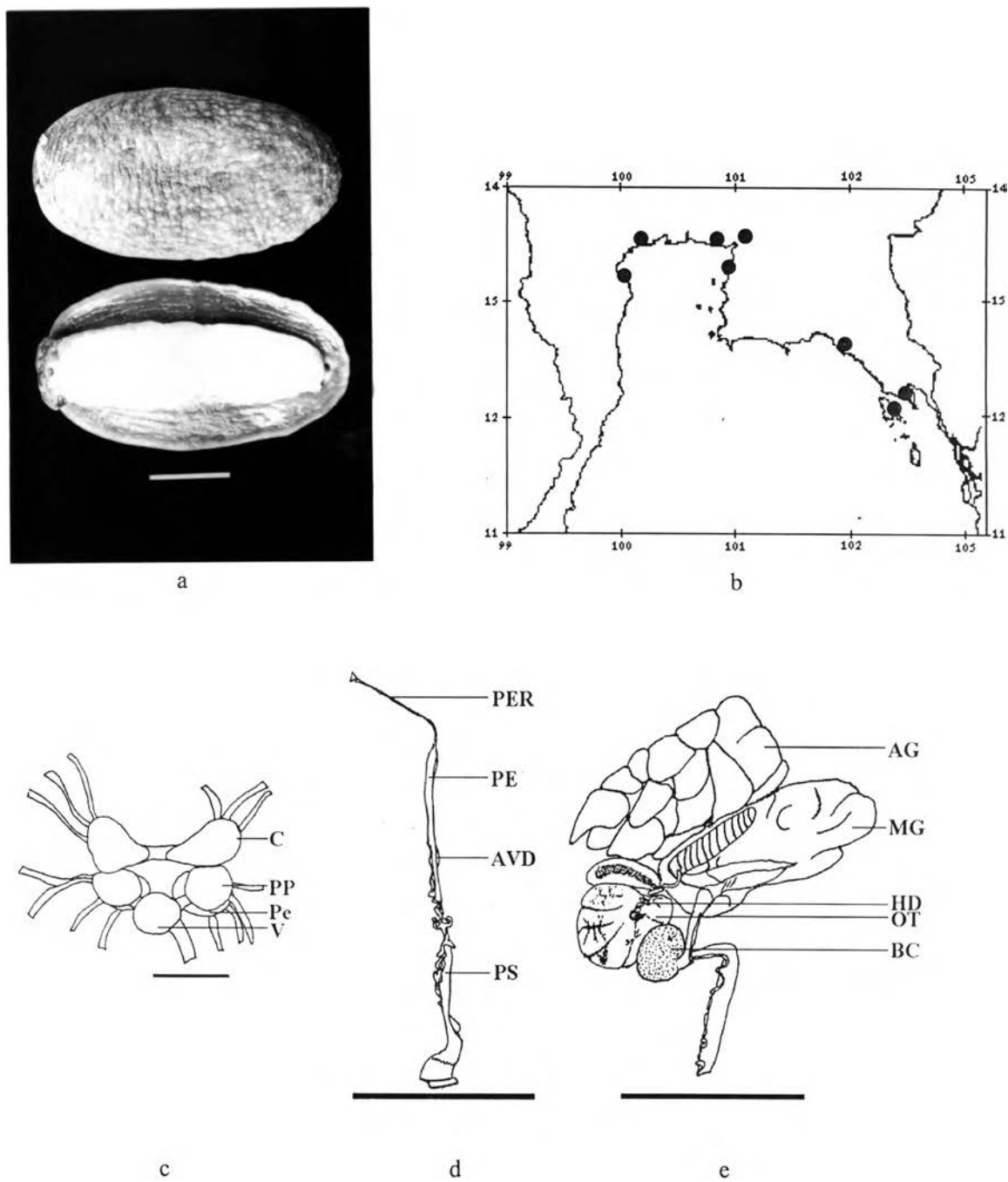
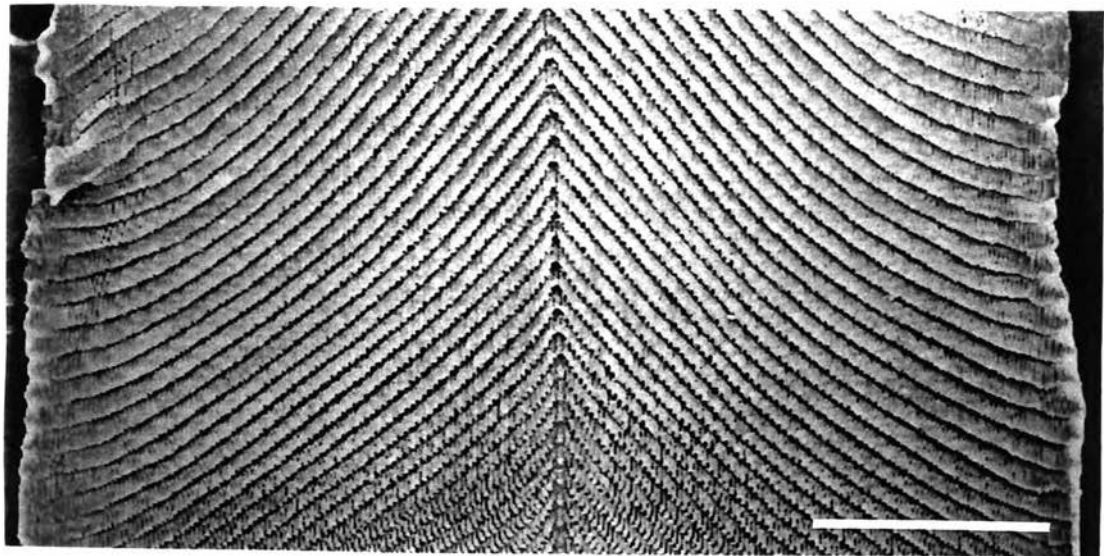
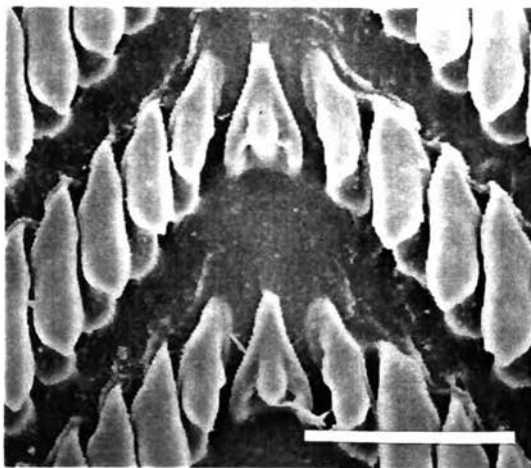


Fig. 4-33 *Platevindex* sp.; a) shell, b) live snail, c) distribution in upper Gulf of Thailand, d) nerve ganglion, e) penial complex, and f) female reproductive organ, scale bar = 1 cm in (a) and 1 mm in (c) – (e).

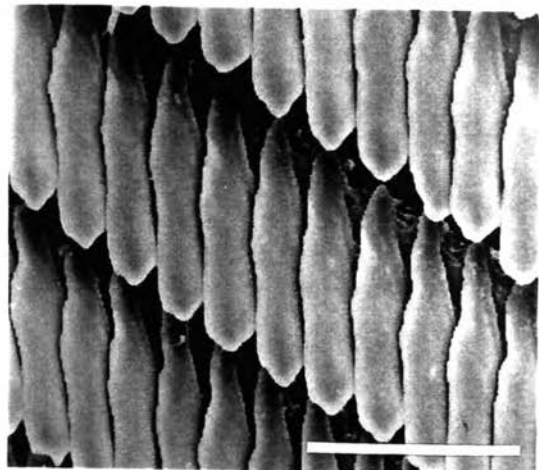




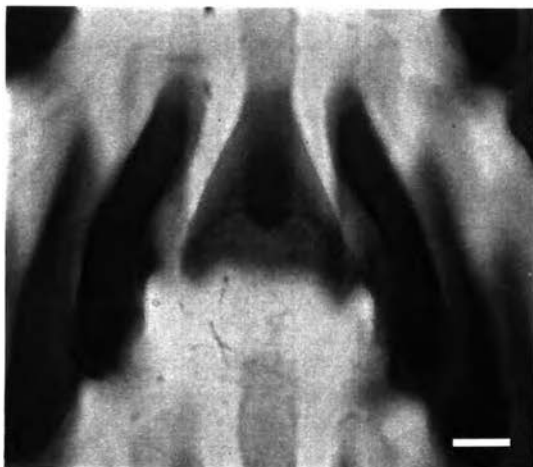
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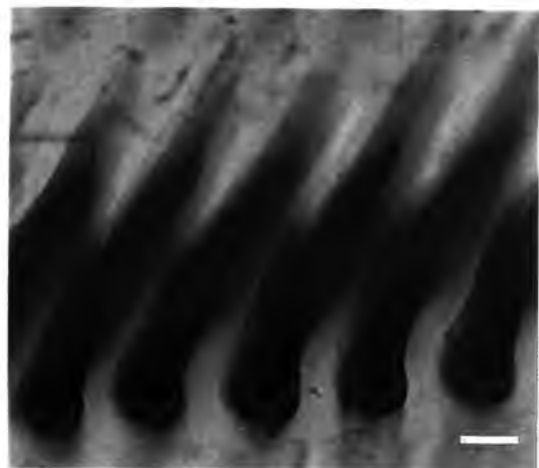
b



c



d



e

Fig. 4-34 Radula of *Platavindex* sp. ; a) radula rows, b) and d) central and lateral teeth. c) and e) marginal teeth, a) - c) are SEM photograph, d) and e) are LM photograph, scale bars are 500  $\mu\text{m}$  in (a), 50  $\mu\text{m}$  in (b) and (c) and 10  $\mu\text{m}$  in (d) and (e).

The shell characters of ellobiids and amphibolids were measured and transformed by many parameters (table 4-1).

Table 4-2 Mean ratio of shell characters in 12 ellobiids and 1 amphibolids (mean  $\pm$  SD.).

Abbreviations are shown in page!3.

Species	AL/AW	AL/BWL	AL/SL	SL/SW	SW/AL	SRL/BWL
<i>A. elongata</i>	2.97 $\pm$ 0.28	0.78 $\pm$ 0.04	0.59 $\pm$ 0.05	2.56 $\pm$ 0.26	0.67 $\pm$ 0.04	0.32 $\pm$ 0.06
<i>Ca. aurisfelis</i>	2.37 $\pm$ 0.18	0.92 $\pm$ 0.02	0.80 $\pm$ 0.02	1.80 $\pm$ 0.16	0.70 $\pm$ 0.54	0.15 $\pm$ 0.01
<i>Ca. mustelina</i>	2.74 $\pm$ 0.18	0.93 $\pm$ 0.08	0.82 $\pm$ 0.03	1.68 $\pm$ 0.07	0.73 $\pm$ 0.03	0.14 $\pm$ 0.11
<i>Cy. siamensis</i>	3.90 $\pm$ 0.46	0.94 $\pm$ 0.03	0.89 $\pm$ 0.03	2.02 $\pm$ 0.10	0.56 $\pm$ 0.02	0.06 $\pm$ 0.06
<i>E. aurisjudae</i>	2.75 $\pm$ 0.24	0.75 $\pm$ 0.05	0.64 $\pm$ 0.05	2.62 $\pm$ 0.28	0.61 $\pm$ 0.07	1.73 $\pm$ 0.04
<i>E. aurismidae</i>	2.57 $\pm$ 0.13	0.85 $\pm$ 0.02	0.73 $\pm$ 0.02	1.78 $\pm$ 0.07	0.77 $\pm$ 0.03	0.19 $\pm$ 0.04
<i>L. punctigera</i>	2.27 $\pm$ 0.20	0.78 $\pm$ 0.04	0.67 $\pm$ 0.03	1.66 $\pm$ 0.11	0.91 $\pm$ 0.07	0.17 $\pm$ 0.05
<i>L. siamensis</i>	2.23 $\pm$ 0.26	0.77 $\pm$ 0.04	0.66 $\pm$ 0.04	1.74 $\pm$ 0.13	0.88 $\pm$ 0.09	0.17 $\pm$ 0.04
<i>Laemodonta</i> sp.	2.00 $\pm$ 0.14	0.80 $\pm$ 0.04	0.73 $\pm$ 0.03	1.64 $\pm$ 0.05	0.84 $\pm$ 0.04	0.10 $\pm$ 0.02
<i>M. siamensis</i>	3.44 $\pm$ 0.31	0.92 $\pm$ 0.02	0.86 $\pm$ 0.03	1.61 $\pm$ 0.07	0.73 $\pm$ 0.02	0.08 $\pm$ 0.03
<i>Py. plicata</i>	2.11 $\pm$ 0.21	0.84 $\pm$ 0.04	0.70 $\pm$ 0.04	1.35 $\pm$ 0.05	1.07 $\pm$ 0.07	0.21 $\pm$ 0.04
<i>Py. trigona</i>	2.08 $\pm$ 0.26	0.80 $\pm$ 0.03	0.65 $\pm$ 0.03	0.96 $\pm$ 0.04	1.61 $\pm$ 0.09	0.22 $\pm$ 0.04
<i>Salinator</i> sp.	1.45 $\pm$ 0.08	0.78 $\pm$ 0.04	0.72 $\pm$ 0.03	1.06 $\pm$ 0.05	1.32 $\pm$ 0.05	0.09 $\pm$ 0.03

The radula, reproductive and central nervous system of mangrove pulmonates are compared and shown in table 4-2, 4-3 and 4-4, respectively.

Table 4- 3 Comparative radular morphology of mangrove pulmonates.

Species	Crown of central tooth	Crown of lateral teeth	Crown of marginal teeth
<i>A. elongata</i>	Unicuspid, rounded	about 2 times larger than CT, bicuspid (pointed and rounded)	same as LT
<i>Ca. aurisfelis</i>	Unicuspid, pointed	about 2 times larger than CT, unicuspid (rounded)	as large as LT, bicuspid (Pointed and rounded)
<i>Ca. mustelina</i>	Unicuspid, narrow, rounded	about 3 times larger than CT, unicuspid (rounded)	as large as LT, bicuspid (Pointed and rounded)
<i>Cy. siamensis</i>	Unicuspid, pointed	about 6-8 times larger than CT, bicuspid (pointed and rounded)	about 1/3 longer than LT, bicuspid (pointed and rounded)
<i>E. aurisjudae</i>	Unicuspid, narrow, rounded	about 5-7 times larger than CT, unicuspid (rounded)	about 1/2-1/3 larger than LT, unicuspid ( rounded)
<i>E. aurismidae</i>	Unicuspid, narrow, rounded	about 2-4 times larger than CT, unicuspid (rounded)	about 1/2-1/3 larger than LT, 2- 4 cusps (rounded)
<i>L. punctigera</i>	Unicuspid, long, slightly pointed	about 4-5 times larger than CT, tricuspid (pointed, rounded)	about 2 times larger than LT, tricuspid (pointed, rounded)
<i>L. siamensis</i>	Unicuspid, rounded	about 2-3 times larger than CT, bicuspid (pointed, rounded)	as large as LT, bicuspid (pointed, rounded)
<i>Laemodonta</i> sp.	Unicuspid, long, narrow, rounded	about 4 times larger than CT, unicuspid (rounded)	about 1-2 times larger than LT, bicuspid (pointed and rounded)
<i>M. siamensis</i>	Tricuspid, rounded	about 2 times larger than CT, unicuspid (rounded)	about 1-1 1/2 times larger than LT, multicuspid (pointed)
<i>Py. plicata</i>	Unicuspid, rounded	about 3-4 times larger than CT, unicuspid (rounded)	about 2 times larger than LT, bicuspid (rounded)
<i>Py. trigona</i>	Unicuspid, narrow, rounded	about 5-6 times larger than CT, unicuspid (slightly pointed)	as large as larger than LT, bicuspid (rounded)
<i>Si. laciniosa</i>	Unicuspid, pointed	about 4 times larger than CT, tricuspid (pointed)	about 1/2 larger than LT, tricuspid (pointed)
<i>Salinator</i> sp.	Multicuspid, rounded	as large as CT, tricuspid (rounded)	about 1/2 larger than LT, unicuspid (rounded)
<i>Onchidium</i> sp.1	Tricuspid, pointed	about 1/2-1 times larger than CT, unicuspid (rounded)	
<i>Onchidium</i> sp.2	Tricuspid, pointed	as large as CT, unicuspid (rounded)	as large as LT, bicuspid (pointed and rounded)
<i>Platevindex</i> sp.	Tricuspid, pointed	as large as CT, unicuspid (rounded)	

\* CT = central tooth, LT = lateral teeth, MT = marginal teeth

Table 4-4 Comparative reproductive systems of mangrove pulmonates.

Species	Ovotestis shape	Sperm groove	Bursa shaped	Anterior vas deferens
<i>A. elongata</i>	Cone shaped	Closed	Spherical	As long as penial sheath, not adhere to the penial sheath
<i>Ca. aurisfelis</i>	Cone shaped	Closed	Spherical	Slightly shorter than penial sheath, not adhere to the penial sheath
<i>Ca. mustelina</i>	Cone shaped	Closed	Spherical	As long as penial sheath, not adhere to the penial sheath
<i>Cy. siamensis</i>	Cone shaped	Closed	Spherical	Longer than penial sheath, not adhere to the penial sheath
<i>E. aurisjudae</i>	Leaf like shaped	Closed	Spherical	As long as penial sheath, adhere to the penial sheath
<i>E. aurismidae</i>	Leaf like shaped	Closed	Spherical	Longer than penial sheath, adhere to the penial sheath
<i>L. punctigera</i>	Cone shaped	Closed	Spherical	As long as penial sheath, adhere to the penial sheath in some part
<i>L. siamensis</i>	Cone shaped	Closed	Spherical	As long as penial sheath, not adhere to the penial sheath
<i>Laemodonta</i> sp.	Cone shaped	Closed	Spherical	Longer than penial sheath, not adhere to the penial sheath
<i>M. siamensis</i>	Cone shaped	Closed	Elongated and pointed	Shorter than penial sheath, not adhere to the penial sheath
<i>Py. plicata</i>	Cone shaped	Opened	Spherical	As long as penial sheath, adhere to the penial sheath
<i>Py. trigona</i>	Cone shaped	Opened	Spherical	As long as penial sheath, adhere to the penial sheath
<i>Si. laciniosa</i>	Cone shaped	Closed	Spherical	-
<i>Salinator</i> sp.	Cone shaped	Closed	Spherical	Very long, not adhere to the penial sheath
<i>Onchidium</i> sp1.	Lobed, spherical shaped	Closed	Spherical	As long as penial sheath, adhere to the penial sheath
<i>Onchidium</i> sp2	Lobed, spherical shaped	Closed	Spherical	As long as penial sheath, adhere to the penial sheath
<i>Platevindex</i> sp.	Lobed, spherical shaped	Closed	Spherical	As long as penial sheath, adhere to the penial sheath

Table 4-5 Comparative nerve ganglia of mangrove pulmonates.

Species	Cerebral ganglia	Visceral ganglia	Left parietal ganglia	Fusion of ganglia
<i>A. elongata</i>	Rounded, lobed	Rounded, unlobed	Undivided	None
<i>Ca. aurisfelis</i>	Rounded, lobed	Rounded, unlobed	Undivided	None
<i>Ca. mustelina</i>	Rounded, lobed	Rounded, unlobed	Undivided	None
<i>Cy. siamensis</i>	Rounded, lobed	Rounded, unlobed	Undivided	None
<i>E. aurisjudae</i>	Rounded, unlobed	Rounded, unlobed	Divided to anterior and posterior part	None
<i>E. aurismidae</i>	Rounded, unlobed	Rounded, unlobed	Divided to anterior and posterior part	None
<i>L. punctigera</i>	Rounded, lobed	Rounded, unlobed	Undivided	None
<i>L. siamensis</i>	Rounded, lobed	Rounded, unlobed	Undivided	None
<i>Laemodonta</i> sp.	Rounded, lobed	Rounded, unlobed	Undivided	None
<i>M. siamensis</i>	Rounded, lobed	Rounded, unlobed	Undivided	None
<i>Py. plicata</i>	Rounded, lobed	Rounded, bilobed	Undivided	None
<i>Py. trigona</i>	Rounded, lobed	Rounded, bilobed	Undivided	None
<i>Si. laciniosa</i>	Rounded, unlobed	Rounded, unlobed	Undivided	Parietal and pleural ganglia fused
<i>Salinator</i> sp.	Rounded, unlobed	Rounded, unlobed	undivided	Cerebral and parietal ganglia fused
<i>Onchidium</i> sp1.	Rounded, unlobed	Rounded, unlobed	Undivided	Parietal and pleural ganglia fused
<i>Onchidium</i> sp2	Rounded, unlobed	Rounded, unlobed	Undivided	Parietal and pleural ganglia fused
<i>Platevindex</i> sp.	Rounded, unlobed	Rounded, unlobed	Undivided	Parietal and pleural ganglia fused

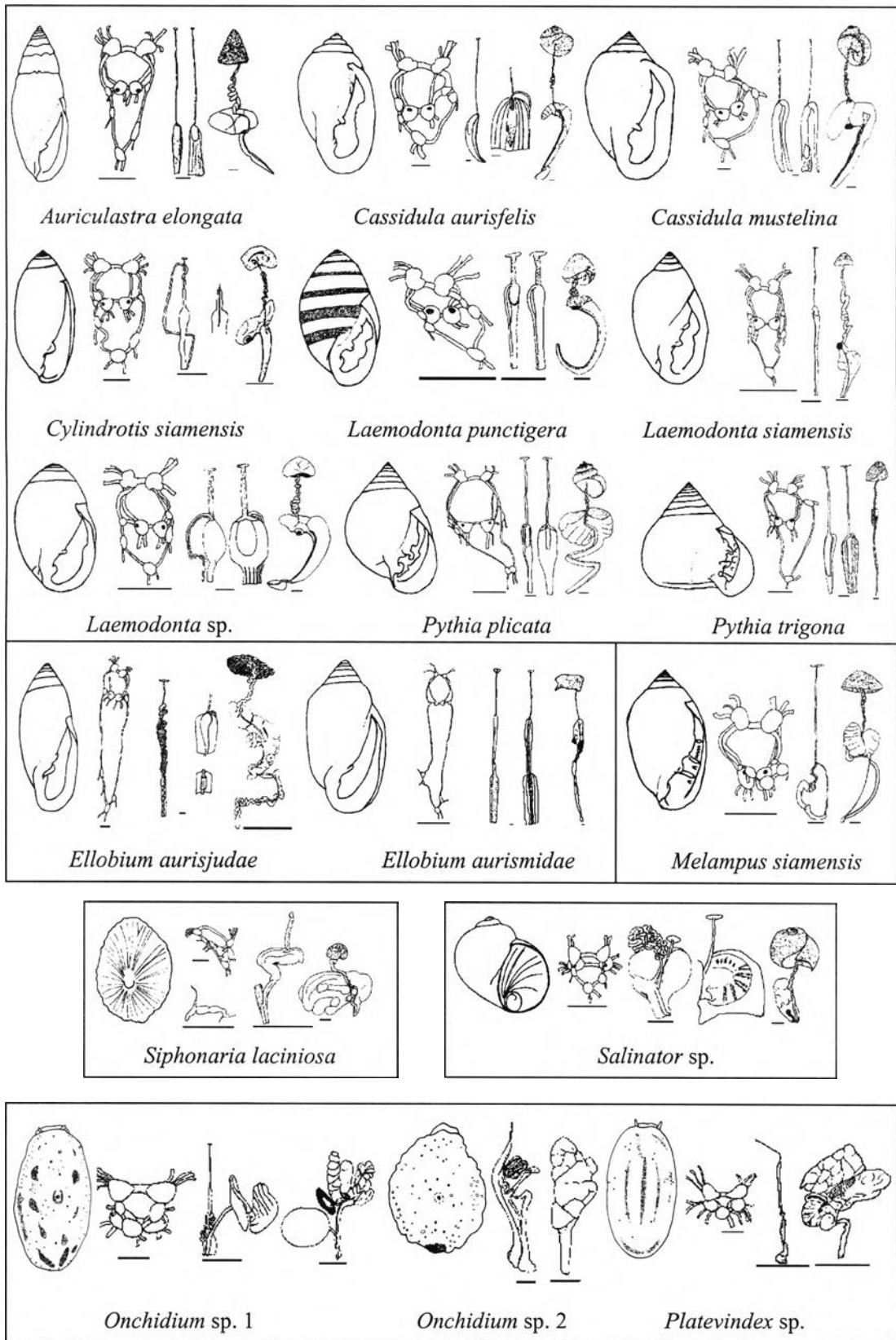
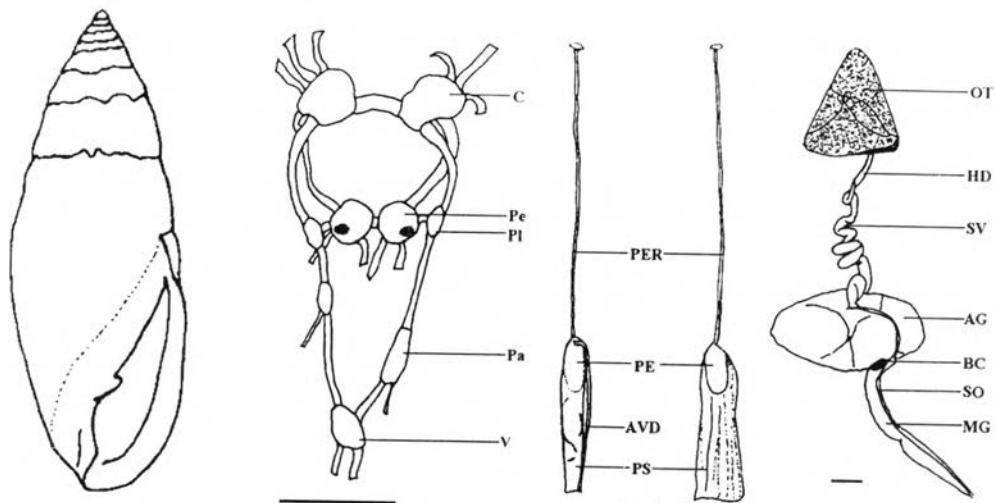
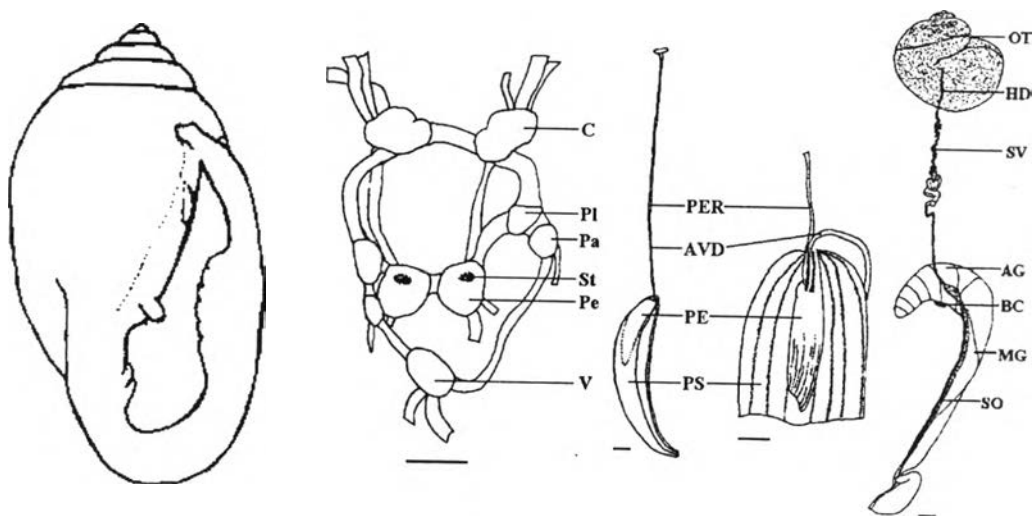


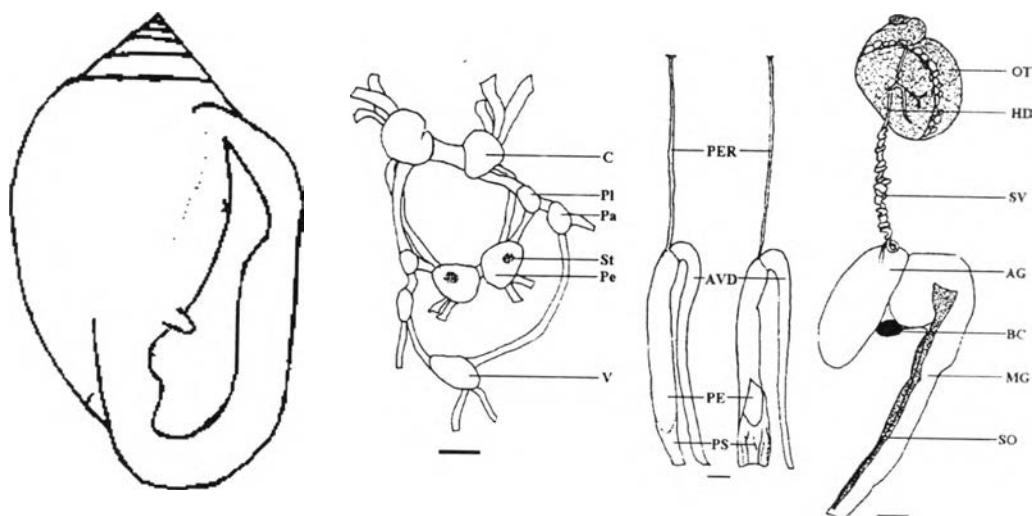
Fig. 4-35 Compare morphology of mangrove pulmonate. Upper one is Ellobiidae, middle right is Amphibolidae, middle left is Siphonariidae and lower one are Onchidiidae.



*Auriculastra elongata*

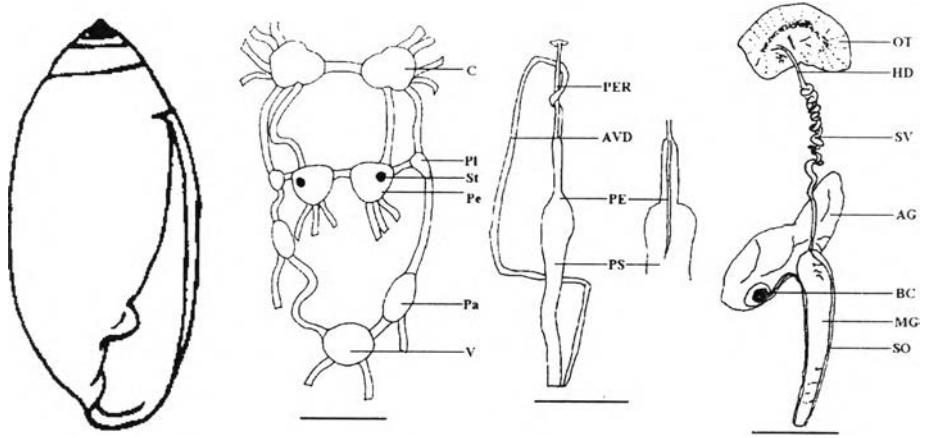


*Cassidula aurisfelis*

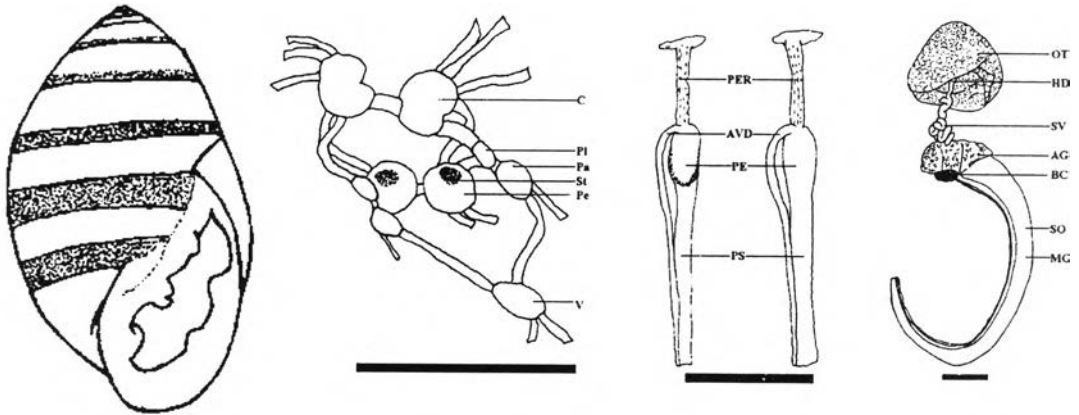


*Cassidula mustelina*

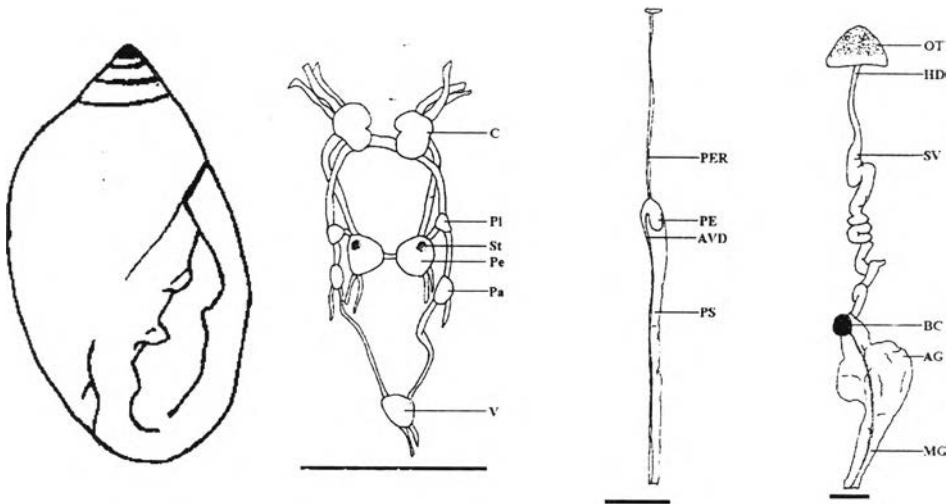
Fig. 4-36 Anatomy of Pythiinae



*Cylindrotis siamensis*



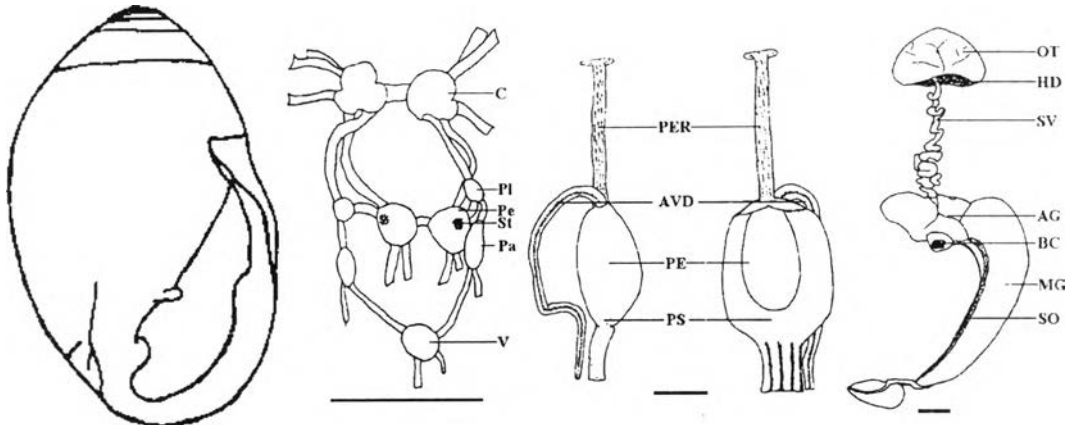
*Laemodonta punctigera*



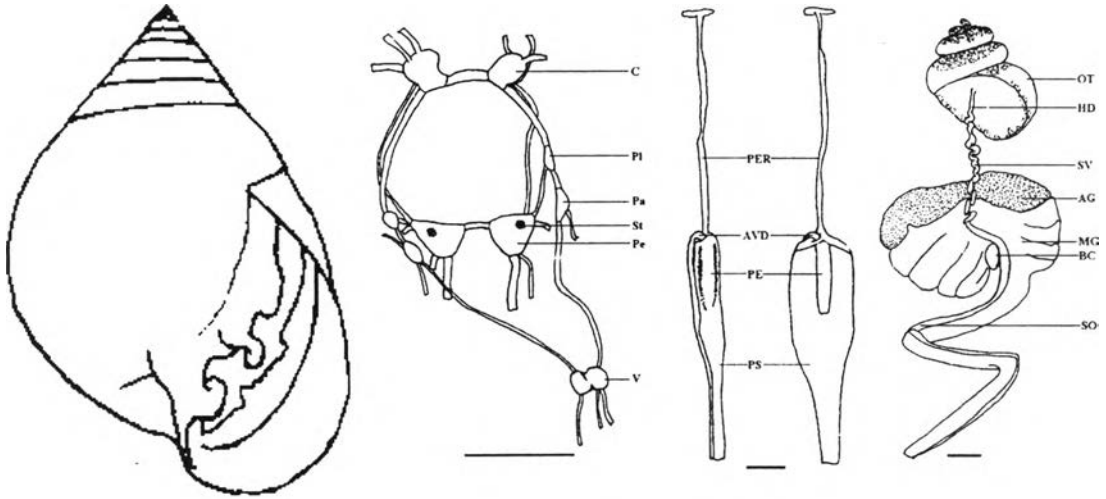
*Laemodonta siamensis*

Fig. 4-36 Anatomy of Pythiinae (cont.)

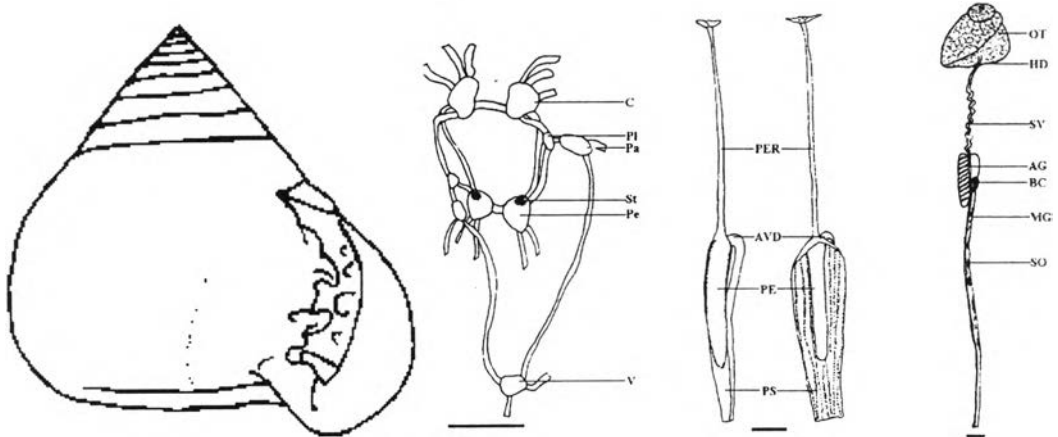




*Laemodonta* sp.

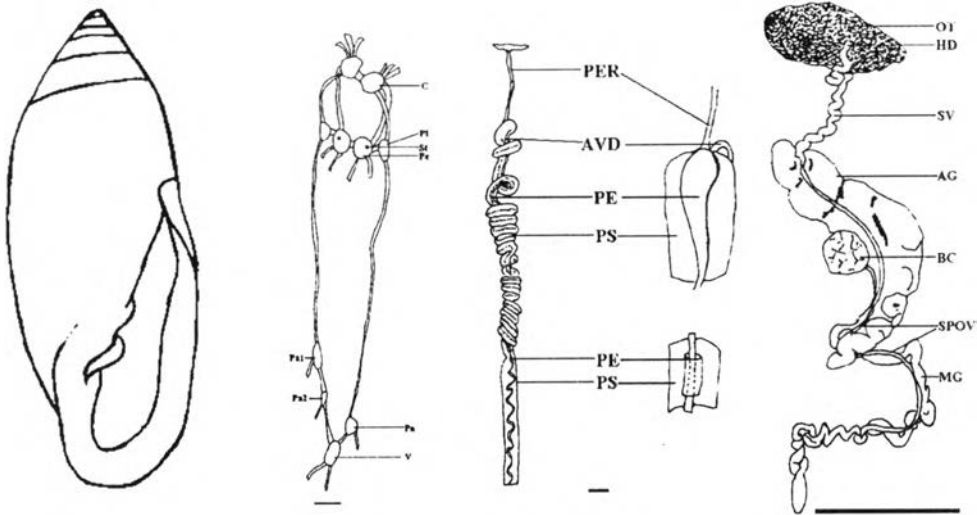


*Pythia plicata*

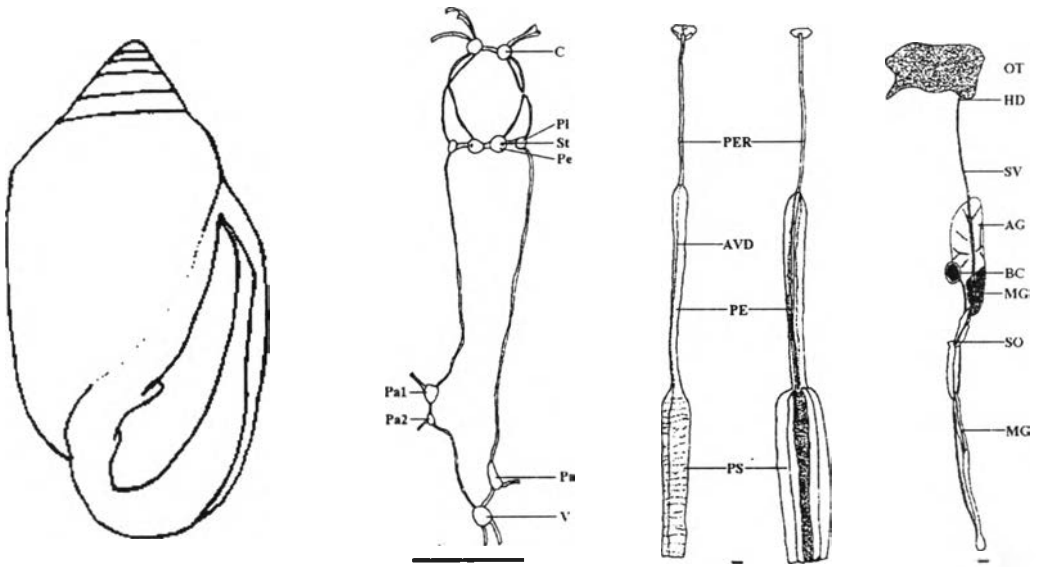


*Pythia trigona*

Fig. 4-36 Anatomy of Pythiinae (cont.)

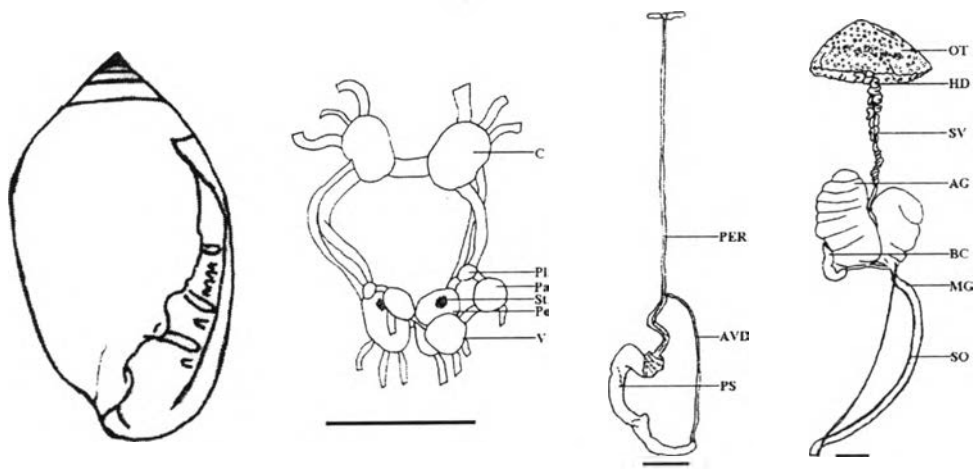


*Ellobium aurisjudae*



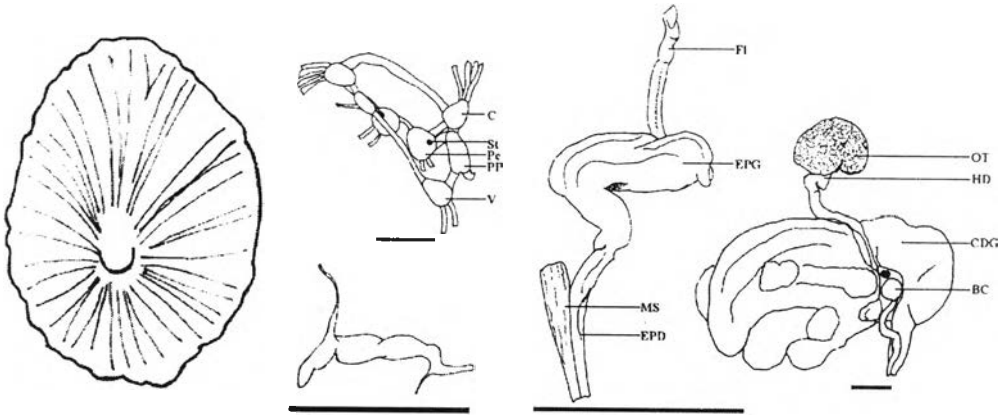
*Ellobium aurismidae*

Fig. 4-37 Anatomy of Ellobiinae



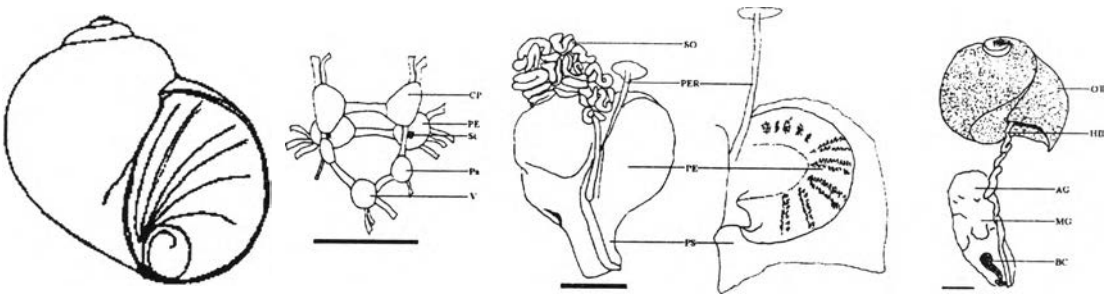
*Melampus siamensis*

Fig. 4-38 Anatomy of Melampinae



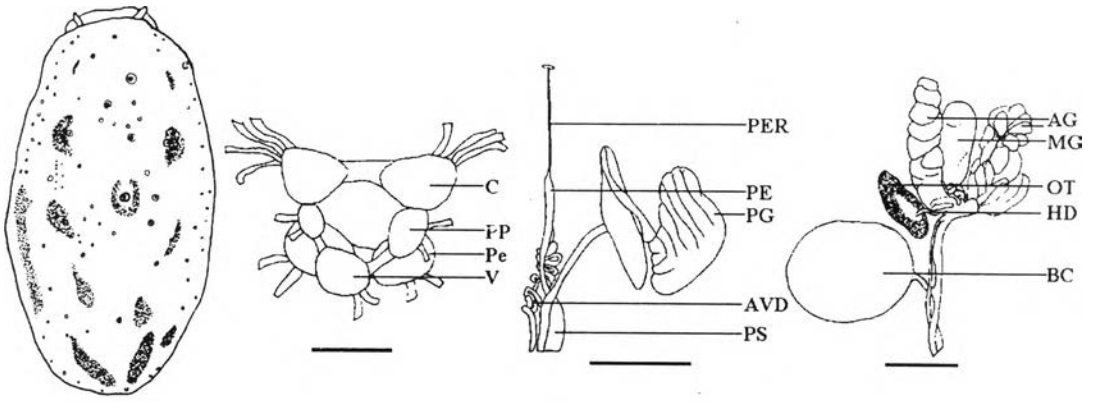
*Siphonaria laciniosa*

Fig. 4-39 Anatomy of Siphonariidae

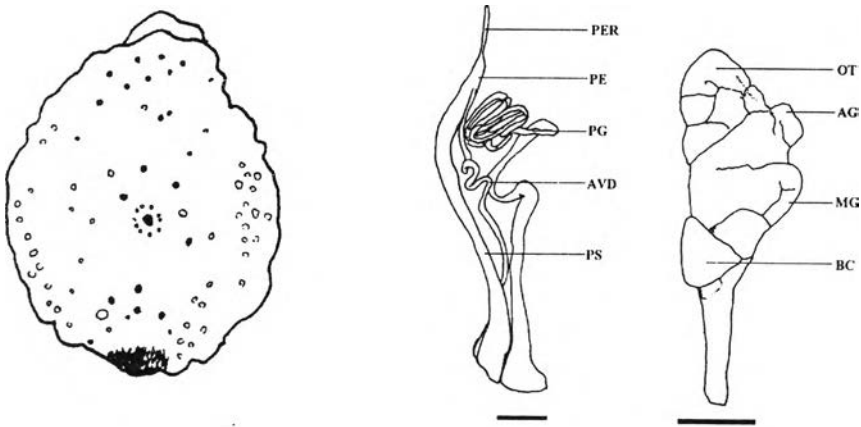


*Salinator* sp.

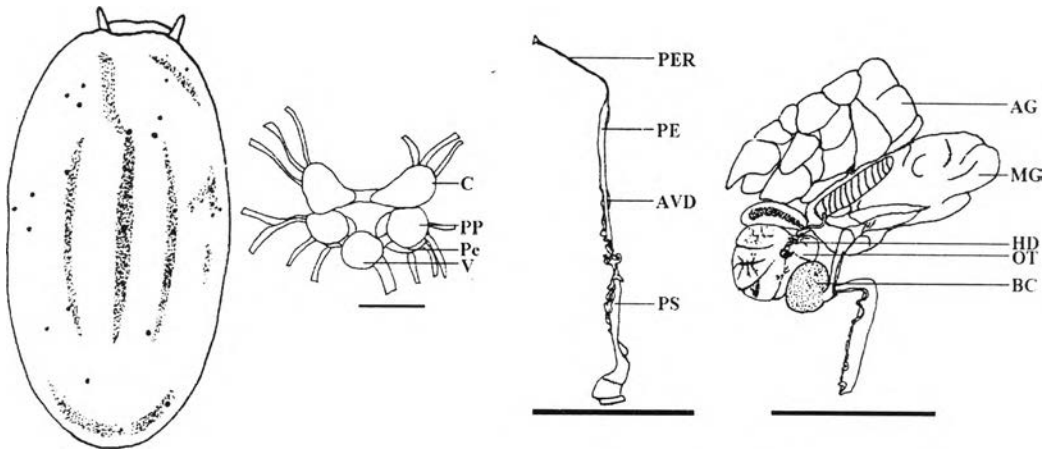
Fig. 4-40 Anatomy of Amphibolidae



*Onchidium* sp. 1



*Onchidium* sp. 2



*Platevindex* sp.

Fig. 4-41 Anatomy of Onchidiidae

Morphological and anatomical characteristics of land pulmonate snails in mangrove habitat of upper gulf of Thailand can be used to dichotomous key construction. The terminologies are present in page 13 – 15.

- 1) - Adult without shell \_\_\_\_\_ 2  
 - Adult with shell \_\_\_\_\_ 4
- 2) – Foot is broader than a half of hyponotum. Body is soft and thick. Notum has various size of tubercles \_\_\_\_\_ 3  
 - Foot is narrow (about 1/3 of hyponotum). Body is rigid and flat.  
 Notum has tubercles that similar in size \_\_\_\_\_ *Platevindex* sp.
- 3) - One tubercle has 1 dorsal eye \_\_\_\_\_ *Onchidium* sp. 1  
 - One tubercle has one or more dorsal eye \_\_\_\_\_ *Onchidium* sp. 2
- 4) - Shell cap-shaped \_\_\_\_\_ *Siphonaria laciniosa*  
 - Shell coiled \_\_\_\_\_ 5
- 5) - Aperture without tooth, thin shell \_\_\_\_\_ 6  
 - Aperture with teeth, thick and solid shell \_\_\_\_\_ 7
- 6) - Operculum present. Shell is thin but not transparent \_\_\_\_\_ *Salinator* sp.  
 - Operculum absent. Shell is thin and transparent \_\_\_\_\_ *Succinea* sp.
- 7) - Periostracum pale yellow, unicolored \_\_\_\_\_ 8  
 - Periostracum brown to dark brown, shell with or without band \_\_\_\_\_ 9
- 8) - Shell thin, fragile, spire very short (about 0.03 of shell length). Anterior vas deferens is about 2 times longer than penial sheath \_\_\_\_\_ *Cylindrotis siamensis*  
 - Shell thick and solid, spire is about 0.23 of shell length.  
 Anterior vas deferens is as long as penial sheath \_\_\_\_\_ *Auriculastra elongata*
- 9) - Shell is greatly compressed dorso-ventrally. \_\_\_\_\_ 10  
 - Shell is not compressed. \_\_\_\_\_ 11
- 10) - Shell length / shell width ratio is  $1.35 \pm 0.05$ , shell width / aperture width ratio is  $2.24 \pm 0.17$  \_\_\_\_\_ *Pythia plicata*  
 - Shell length / shell width ratio is  $0.96 \pm 0.04$ , shell width / aperture width ratio is  $3.32 \pm 0.3$  \_\_\_\_\_ *Pythia trigona*
- 11) - Shell sculpture have spiral and transverse striated or pitted \_\_\_\_\_ 12  
 - Shell sculpture is smooth, without striated or pitted \_\_\_\_\_ 14

- 12) - Shell thin, palatal tooth is long ridge, body whorl is about 10 times longer than spire length \_\_\_\_\_ *Laemodonta* sp.  
 - Shell thick and solid, palatal teeth are notch or bud, body whorl longer is about 5-6 times than spire length \_\_\_\_\_ 13
- 13) - Shell unicolored, parietal wall with 2 simple teeth, lower parietal tooth simple, sculpture with transverse and spiral striae. Radula have not reduction of marginal teeth \_\_\_\_\_ *Laemodonta siamensis*  
 - Shell has spiral bands, a bifurcated parietal tooth and sculpture pitted. Radula have reduction of marginal teeth \_\_\_\_\_ *Laemodonta punctigera*
- 14) - Palatal wall is smooth, without tooth \_\_\_\_\_ 15  
 - Palatal wall has teeth \_\_\_\_\_ 16
- 15) - Aperture length / body whorl length ratio is  $0.75 \pm 0.05$ , aperture length / shell length ratio is  $0.64 \pm 0.05$ , shell length / shell width ratio is  $2.62 \pm 0.28$  \_\_\_\_\_ *Ellobium aurisjudae*  
 - Aperture length / body whorl length ratio is  $0.85 \pm 0.02$ , aperture length / shell length ratio is  $0.73 \pm 0.02$ , shell length / shell width ratio is  $1.77 \pm 0.07$  \_\_\_\_\_ *Ellobium aurismidae*
- 16) - Palatal wall with more than a horizontal tooth \_\_\_\_\_ *Melampus siamensis*  
 - Palatal wall with a vertical tooth which indented edge \_\_\_\_\_ 17
- 17) - Suture is strongly indented. Shell length / shell width ratio is  $1.80 \pm 0.16$ . Aperture length / aperture width ratio is  $2.37 \pm 0.18$ . Radula with reduction of marginal teeth \_\_\_\_\_ *Cassidula aurisfelis*  
 - Shallowly suture or flat whorl, shell length/shell width ratio is  $1.68 \pm 0.07$ , aperture length / aperture width ratio is  $2.74 \pm 0.18$ . radula with not reduction of marginal teeth \_\_\_\_\_ *Cassidula mustelina*

Anatomical characters that were chosen for phylogenetic construction are recorded in table 4 – 6. The phylogenetic trees computed by PAUP from data in table 4-6 and shown in fig. 4 – 35.

Table 4 – 6 Data matrix of anatomical characters.

Species	Characters								
	1	2	3	4	5	6	7	8	9
<i>A. elongata</i>	0	0	0	1	2	1	3	1	2
<i>Ca. aurisfelis</i>	0	0	0	1	0	1	3	1	2
<i>Ca. mustelina</i>	0	0	0	1	0	1	3	1	2
<i>Cy. siamensis</i>	0	0	0	1	0	1	3	2	3
<i>E. aurisjudae</i>	3	0	1	1	3	0	1	1	3
<i>E. aurismidae</i>	3	0	1	1	3	0	1	1	3
<i>L. punctigera</i>	0	0	0	1	1	1	3	2	2
<i>L. siamensis</i>	0	0	0	1	1	1	3	2	2
<i>Laemodonta</i> sp.	0	0	0	1	0	1	3	2	3
<i>M. siamensis</i>	2	2	2	1	0	1	3	2	1
<i>Py. plicata</i>	0	0	0	0	0	0	3	1	3
<i>Py. trigona</i>	0	0	0	0	0	0	3	1	2
<i>Haminoeo symnestra</i>	0	0	0	0	3	0	3	3	1

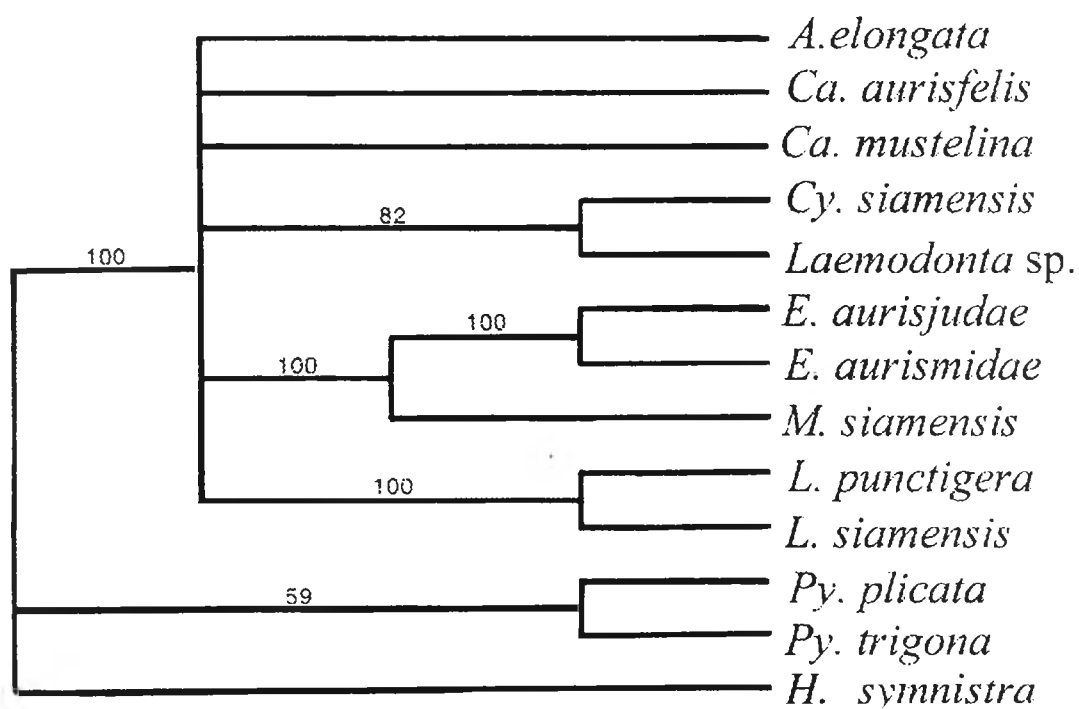


Fig. 4 – 42 Consensus tree of ellobiids generated from data in table 4 - 6. The numbers indicated the percentile of Majority rule value.

Data from table 4-7 are analyzed by heuristic method (PAUP program). The 22 family trees are reconstructed and consensus by majority rule 50% (Fig. 4- 42). The first node contains 3 branches, outgroup, *Pythia* spp., and others which are grouped by closed sperm groove. The 6 branches generated from the third group. The *Ellobium* - *Melampus* group is separated from others by derived character of monaully and the position of insertion of bursa duct. Other taxa in the last node are not grouped, except *Cylindrotis siamensis* and *Laemodonta* sp., which grouped by the ratio of left / right cerebropedal connectives length (about 1.1 – 1.5).