CHAPTER V

TAXONOMIC REVIEW OF THE TREE SNAIL *AMPHIDROMUS* ALBERS, 1850 (PULMONATA: CAMAENIDAE) IN THAILAND: II. SUBGENUS *SYNDROMUS* PILSBRY, 1900

5.1 Introduction

Southeast Asia is one of the most abundance of colourful land snail region, which occupying various types of habitat from ground to mountaintop. The Camaenidae is one of these mysterious snails, comprises of a huge, conspicuous and diverse arboreal genera found in this region. One of these is the *Amphidromus* Albers, 1850.

Amphidromus is known for it fascinating variety genus of nearly 90 species and innumerable shell colour patterns, and the chiral morphology. It is classified into 2 subgenera, *Amphidromus (Syndromus)* Pilsbry, 1900 shares around a half of the genus, which currently containing about 45 species (Laidlaw & Solem, 1961; Richardson, 1985). They distribute widely ranged from Assam of India to Indochina, Malaysian peninsular, many islands of Sundaland and the Philippines (Solem, 1959; Laidlaw & Solem, 1961; Benthem Jutting, 1950). Almost of the *Syndromus* species had been named before nineteen century, based exclusively on a few shell and vague localities (Dohrn, 1861; Pfeiffer, 1861; Morlet, 1884; 1891a, b; Fulton, 1896; Pilsbry, 1900). Because of it high variation in shell colour and form, the taxonomy of this snail usually becoming problematic and subjected to reviews several times as in Fulton (1896), Pilsbry (1900) and Laidlaw & Solem (1961). These literatures are rather satisfaction. However, remaining some inapplicable to the recent collected specimens owing to the large number of local variation and wide range of individual variation. This complexity being expressed in variation especially in shell color patterns; several distinct patterns are often present in a single population, while the similar patterns also reappear in different species or varieties (Solem, 1965). Solem (1983) and Sutcharit & Panha (2005) noted that basic genitalia characteristics are high efficient for *Amphidromus* classification. The previous dissections of the *Amphidromus (Syndromus)* species concentrated on the genital structure are far from complete. Only the scattered useful dissection of *A. (S.) porcellanus* (Mousson, 1849), *A. (S.) cognatus* Fulton, 1907 and *A. (S.) poecilochrous jaeckeli* Laidlaw, 1954 were gradually added to the reviews (Bishop, 1977; Minato, 1979; Solem, 1983; Smith & Djajasasmita, 1988).

In the present study, large sets of specimens are considered mainly on the shell variations, reproductive characteristics and systematic revision of the species and subspecies. In addition to assess the shell banding pattern system used in the *Amphidromus (Syndromus)* and propose this will ensure a solid classification with in it. We are concentrated on the *A. (S.) areolatus* (Pfeiffer, 1861), *A. (S.) flavus* (Pfeiffer, 1861), *A. (S.) semitessellatus* (Morlet, 1884), *A. (S.) xiengensis* (Morlet, 1891) and *A. (S.) fultoni* Ancey, 1897. This revision will be the most useful or practicable way of dealing with the multifarious individual and highly variations of *Amphidromus (Syndromus)*.

5.2 Systematic Accounts

Camaenidae Albers, 1850
Genus *Amphidromus* Albers, 1850
Amphidromus (Syndromus) Pilsbry, 1900

Type species: By subsequent designation of *Helix contraria* Müller, 1774, in Zilch (1960: 623).

Diagnosis: Shell rather small, thin, always sinistral, elongate conic, varices absent and usually variegation in colour pattern. Shell height 25 to 40 mm. Genitalia characteristic of camaenid, shorter epiphallic caecum than *Amphidromus (Amphidromus)* s. str. and flagellum wanting.

Remark: The name "*Syndromus*" was firstly nominated as "Sinistral Division (or Section *Syndromus*)" for *Amphidromus*, which has a sinistral coiling (Pilsbry, 1900). Later, Adole Zilch (1960) recognized this name as *Amphidromus (Syndromus)* and specified *A. (S.) contrarius* as the type species. Approximately 45 species currently included in the subgenus.

Laidlaw and Solem (1961) had informally divided those recognized species into 6 supraspecific groups using the geographic and morphological data. Four of six species reported in Thailand were grouped into *A. xiengensis* group (Group XIV). Others two species were placed into the unclassified subgenera (*sensu* Laidlaw and Solem, 1961), which will be clarified when obtained enough specimens. However, all of them contain several curious colour forms or varieties, which have not been explore the genital anatomy. Here, we attempt to clarify those described species and colour forms with the recent information on the reproductive characteristics and shell banding patterns, and reported the new geographical races.

Most of *Amphidromus (Syndromus)* could be characterized by certain five banding patterns. We proposed the following banding categories and defined their arrangements by using *A. (S.) xiengensis xiengensis* as standard

shell model. Using the species descriptions and type figures of the less species from Fulton (1896), Pilsbry (1900), Bartsch (1917; 1918; 1919), Benthem Jutting (1950) and Laidlaw & Solem (1961) for improve and test the reliablity of the bands. The criteria for define those five bands was followed the conventional procedures use in *Euhadra* (Pilsbry, 1928), *Cepaea* (Cain & Curry, 1963), *Partula* (Murray & Clarke, 1966) and *Theba pisana* (Cowie, 1984) for describing the colour polymorphism.

Each shell is divided into five sections started from the uppermost of last whorl to the lowermost near the umbilicus (Fig. 2). Band 1 is a subsutural band, which is lining just below the suture. It is usually thin and often omitted in some species. Band 2 and 3 are the supra-peripheral bands, started from the posterior angle of aperture to under the band 1. Band 2 locates just below band 1; band 3 locates above the posterior angle of aperture. These two bands are usually separated with a narrowly gap in the middle. They are usually modified as dotts, blotches, or divided into several bandlets. Band 4 is the sub-peripheral band, which is located lower the posterior angle of the aperture or below the periphery. This band usually attached at the bottom of band 3. The last band 5 is the umbilical band, usually covered entirely the umbilical area. It is sometime modified as a narrow band, which offers some opened area between the umbilicus and the fifth band.

Key to the species and subspecies of *Amphidromus (Syndromus)*

1a Shell monochrome yellowish colour; with or without reddish umbilical areas; with or without parietal band and/or columella bands 2

1b. Shell usually variegated colour, either bands number 1 to 5 presence, modified or absent 3

2a. Shell ovate conic, completely golden yellow colour and the genitalia without vagina pouch. ..... *A. (Syndromus)* sp.

2b. Shell slightly elongate conic, usually with reddish umbilical area; with or without reddish sub-peripheral and/or columella bands; vaginal pouch well developed. ..... *A. (S.) flavus*

3a. Each band usually well separations. 4

3b. Supra-peripheral bands (band 2 and 3), sub-peripheral band (band 4) and columella band (band 5) usually merged and modified to dark brown vertical streak with fork or flamulate near reddish subsutural band (band 1). ..... *A. (S.) areolatus*

4a. Vaginal pouch absent. 5

4b. Vaginal pouch well developed. 6

5a. Penis small, short and cylindrical; longitudinal penial pilasters well developed. Subsutural band (band 1) absent, sub-peripheral band (band 4)

and columella band (band 5) frequently absent. Aperture angulation. .... *A. (S.) semitessellatus*

5b. Penis large, long, cylindrical and penial wall smooth. Subsutural band (band 1) reddish or brownish (except colour form namely '*tryoni*'). .... *A. (S.) xiengensis xiengensis*

6a. Penial sculptures well developed with swollen and obliquely pilasters. Aperture ovate. Supra-peripheral bands (band 2 and 3) usually with diffused brownish blotches. Earlier whorls with tinted pink. .... *A. (S.) xiengensis* ssp.

6b. Penial sculptures with small longitudinal pilasters. Aperture rounded. Subsutural band (band 1) absent or replaced with dark yellow band. Umbilical area narrows to wide and with reddish colour. ..... *A. (S.) fultoni*

***Amphidromus (Syndromus) areolatus* (Pfeiffer, 1861)**
(Figure 5.3A, B)

Bulimus areolatus Pfeiffer, 1861: 194.

Amphidromus areolatus—Fulton, 1896: 81. Pilsbry, 1900: 198, 199, pl. 63, figs 85, 86. Laidlaw and Solem, 1961: 564. Solem, 1965: 624, 625, pl. 1, figs 1-4.

Material examined: Phu Kiew Wildlife Sanctuary, Chaiyaphum: CUMZ 2534 (3); Nam Nao National Park, Phetchabun: CUMZ 2391 (1).

Shell (Fig. 5.3A, B): Shell small, slightly thicken, ovate-conic, sinistral and umbilicus narrowly perforate. Apex acute with black spot on the tip. Whorls fairly convex to nearly flatten; last whorl rounded; suture wide and narrow. Periostracum transparent to corneus. Shell colour pattern with thin reddish subsutural band (band 1). Supra-peripheral bands (band 2 and 3) and sub-peripheral band (band 4) somewhat merged and modified to brown flames or stripes with fork above. Umbilical band (band 5) brownish attached to slanting stripes; columella area roseate. Aperture oblique or auriform; peristome thin, broadly expanded and shortly reflected. Parietal callus transparent columella straight.

Distribution (Fig. 5.1): The type locality was recorded only 'Siam' in Pfeiffer's (1861) description. Solem (1965) subsequently record localities from Nongkhor, Krabin, Sriracha, Pak Jong and Samet Island. In the recent study are recorded from Nam Nao National Park, Phetchabun and Phu Kiew wildlife sanctuary, Chaiyaphum.

Remark: We also collect the specimens from Khao Chong, Trang and Tale Sap as Solem's (1965) mentioned, and as *A. (S.) areolatus* should be moved to *A. (S.) fultoni* Ancey, 1897 (described later).

Amphidromus (Syndromus) flavus (Pfeiffer, 1861)

(Figures 5.3C-D, 5.5, 5.6)

Bulimus flavus Pfeiffer, 1861: 194.
Amphidromus flavus—Fulton, 1896: 81. Pilsbry, 1900: 197, 198, pl. 63 figs 92, 93. Laidlaw and Solem, 1961: 563, 564, 619.
Amphidromus fultoni Laidlaw, 1929: 262. (not Ancey, 1897).
Amphidromus fultonianus Laidlaw, 1930: 16.

Material examined: Wat Phu Sri, Luang Pra Bang, Laos: 2472 (3); 2533 (1).

Shell (Fig. 5.3C-D): Shell small, rather solid, conic or subfusiform, sinistral and umbilicus narrowly perforates. Apex acute with black spot on the tip. Whorls slightly convex, suture slightly depress; last whorl rounded and convex. Periostracum transparent. Shell colour pattern uniform yellowish, band 1 to 4 usually absent with attenuated reddish columella band (band 5), sometime with reddish umbilical area. Aperture sub-ovate to round; parietal callus thin and transparent. Peristome white; lip expanded and slightly thickens; columella straight.

Radula (Fig. 5.5A-C): Teeth arranged in V-shape rows, each rows containing about 170 (83-(11-14)-1-(12-14)-86) teeth. Central tooth monocuspid with spatulate shaped (Fig. 5.5A). Lateral teeth bicuspid, endocone small, and ectocone large with truncated cusps (Fig. 5.5A). Lateral teeth gradually transformed to tricuspid marginal teeth about tooth number 11 to 14 outwards (Fig. 5.5B). Marginal teeth tricuspid, endocone curved shaped, mesocone largest size with long and obtuse cusp, and ectocone smallest with pointed cusp (Fig. 5.5C).

Genitalia (Fig. 5.6A-C): Atrium (at) short (n=3). Penis (p) very large and swollen. Epiphallus (e) long; flagellum (fl) short and slightly smaller size than epiphallus. Vas deferens (vd) extending from free oviduct to the end of epiphallus. Penial retractor muscle (pr) short and slightly thickens (Fig. 5.6A).

Internal wall of penis corrugated with oblique penial pilasters (pp). Penial verge (pv) extremely large, slightly straight, elliptical shaped, and surface slightly smooth with very thin oblique scrape (Fig. 5.6B).

Vagina (v) cylindrical, approximately similar length of penis; proximally with a small vaginal pouch closed to atrium. Gametolytic duct (gd) long, cylindrical, almost the same diameter to vagina; distally connected to a spherical gametolytic sac (gs). Free oviduct (fo) short; oviduct (ov) enlarged and curled. Albumen gland (ag) enlarged (Fig. 5.6A). Hermaphroditic duct (hd) convoluted and connected between hermaphroditic gland (hg) and middle of talon (ta) (Fig. 5.6C).

Internally, vaginal wall possesses slightly smooth longitudinal pilasters (vp); distally perform weak crenulation pilasters. Vaginal pilasters at the vaginal pouch large, swollen and curled (Fig. 5.6B).

External feature: Living animal has long head-foot, lacking of pedal groove and undivided sole. Body covered with reticulate skin and greyish to blackish colour. Mantle edge greyish; mantle cavity mottle grey. Posterior tentacles long, drum stick shaped with brownish to greyish colour; anterior tentacles short and located infront of the head with a paler colour.

Distribution (Fig. 5.1): Type locality was recorded only 'Siam' (=Thailand) in Pfeiffer's (1861) description. The susequently distribution records were from Thailand: Tale Sap (=Songkla lake), Songkla (Laidlaw, 1929); Laos: Luang Prabang; Cochinchina (=southern Vietnam): Thu Dan Moth and Longho near Ving Long (Pilsbry, 1900); Malaysia: Tebing Tinggi, north of Kanggar, Perlis (Laidlaw and Solem, 1961).

Remark: In a present review, a few specimens collected from Luang Prabang of Laos were only the typical colour form. The bands 1 to 4 are obsolete, band 5 with red to reddish-brown or modified to a thin or nearly absent. In some others specimens are lacking of any bands, but have reddish columella area.

***Amphidromus (Syndromus) semitessellatus* (Morlet, 1884)**

(Figures 5.3E-L, 5.7, 5.8)

Bulimus semitessellatus Morlet, 1884: 387, 388, pl. 11, figs 2, 2a.
Amphidromus semitessellatus—Morlet, 1889: 128. Fulton, 1896: 87. Pilsbry, 1900: 194, pl. 60, figs 41-44. Laidlaw and Solem, 1961: 564. Solem, 1965: 625, 626, pl. 2, fig. 2.

Material examined: Khao Ang Rue Nai Wildlife Sanctuary, Chachoengsao: CUMZ 2375 (1), 2376 (4), 2377 (3), 2378 (1), 2379 (2), 2380 (1), 2384 (2), 2405 (1), 2410 (1), 2412 (5), 2436 (2), 2445 (50), 2446 (25),

2447 (28); Khao Kiew, Chonburi: CUMZ 2426 (8), 2542 (4); Kaeng Krajarn National Park, Phetchaburi: CUMZ 2307 (1), 2535 (1), 2541 (1).

Shell (Fig. 5.3E-L; Table 5.1): Shell small, thin, elongate conic, sinistral, and umbilicus imperforate. Apex acute with black spot on the tip. Whorls slightly convex; suture wide and shallow. Periostracum thin, corneus or green to yellowish. Shell colour pattern usually lacking of subsutural band (band 1) or replaced with dark yellow bands. Supra-peripheral bands (band 2 and 3) usually absent or present with a series of light brownish spots. Sub-peripheral band (band 4) and columella band (band 5) typically absent, but sometime present and with brownish bands. Aperture half-ovate; parietal callus transparent. Peristome whitish; columella straight and perpendicular; lip slightly thickened and expanded.

Radula (Fig. 5.7A-C): Teeth arranged in V-shape rows, each rows containing about 148 (75-(18-20)-1-(17-21)-72) teeth. Central tooth tricuspid with small and pointed ectocone (Fig. 5.7A). Lateral teeth bicuspid, endocone large and slightly truncated cusp, and ectocone with curved cusp (Fig. 5.7A). Lateral teeth gradually transformed to tricuspid marginal about tooth number 17 to 21 outwards (Fig. 5.7B). Marginal teeth tricuspid, endocone with sharp cusp, mesocone large with long and obtuse cusp, and ectocone smallest sized with pointed cusp (Fig. 5.7C).

Genitalia (Fig. 5.8A-F): Atrium (at) long (n=5). Penis (p) conical shaped with enlarged at penial verge base. Epiphallus (e) slightly short; flagellum (fl) slightly long. Vas deferens (vd) extending from free oviduct to the end of epiphallus. Penial retractor muscle (pr) slightly long and attached proximal to epiphallus (Fig. 5.8A, D).

Internal wall of penis corrugated, exhibiting a series of thickened and swollen longitudinal penial pilasters (pp), which form a fringe around penial verge tip. Penial verge (pv) small, cylindrical shaped and surface with a scatter scrapes or nearly smooth (Fig. 5.8B, E).

A spermatophore long, pentagonal in cross-section and with thin prominent keels, running the length of sperm sac at each angle (Fig. 5.8C). Anterior (sperm sac) straight with distally coiled section and without the extended section.

Vagina (v) slender, cylindrical shaped and longer than penis. Gametolytic duct (gd) extends from vagina, proximally enlarged, distally tapering to small tube and connected to gametolytic sac (gs). Free oviduct (fo) relatively short; oviduct (ov) compact and enlarged to form lobule alveoli. Albumen gland (ag) large and curved ligulate (Fig. 5.8A, D). Hermaphroditic

duct (hd) convoluted and connected between hermaphroditic gland (hg) and near the tip of talon (ta) (Fig. 5.8F).

Internal wall of vagina possesses longitudinal vaginal pilasters (vp). Proximally, pilasters smooth and continuous ridges; distally corrugated around free oviduct opening (Fig. 5.8B, E).

External feature: Living individuals has general characteristic as described in *A. (S.) flavus*. The body colour is whitish grey and mantle edge brownish; mantle cavity is slightly blackish or scatters dark spots.

Distribution (Fig. 5.1): The type locality was recorded as Elephant chain mountains, Stung-Trang; Kampot, Kampong-Son of Cambodia and Srakeo in Thailand in Morlet's (1884) description. Subsequently were recorded from Thailand: Sam Roi Yot, Phetchaburi and Srakeo (Laidlaw and Solem, 1961; Solem, 1965). The present collection were from Khao Ang Rue Nai, Chacheongsao; Khao Kiew, Chonburi; Kaeng Kracharn and Pala-u waterfall, Phetchaburi; Koh Wieng, Chumporn.

Remark: The shell banding variations are considerable. The juvenile specimens from Khao Luang, Sukhothai have shell pattern resembles to the species description of Morlet (1884), with a brownish subsutural bands (band 1), supra-peripheral bands (band 2, 3) absent or split into several thin banlets and sub-peripheral band, and columella band presents, but not reached to the lip.

The specimens from Kaeng Kracharn and Pala-u waterfall, Phetchaburi perform almost similar to this species description, but performed the yellowish-green periostracum (Fig. 5.3E). This character is resembling to the *A. (S.) furcillatus* (Mousson, 1848), which is limited the distribution in Java, Bali, Andaman and Nicobar islands (Pilsbry, 1900; Benthem Jutting, 1950; Laidlaw and Solem, 1961). However, the latter species has larger shell size than Kaeng Kracharn and Pala-u specimens and nevertheless of the distributional recorded on Indochina. This can be attributed to the same colour patterns also reappear in different lineage and the future molecular genetic study may clarify this issues.

Shell collected from Khao Kiew, Chonburi show pale greenish-yellow periostracum. The structural bands usually have pale brownish colours. Subsutural band (band 1) is usually absent. The supra-peripheral bands (band 2, 3) are absent or presenting with the pale brownish blotches (Fig. 5.3K, L). Several specimens have no supra-peripheral bands (band 2, 3), and sub-peripheral band (band 4) and columella band (band 5) scarcely presence.

Table 1. Shell size variation in *Amphidromus (Syndromus)* spp. Catalogue numbers of specimens are indicated in parentheses.

Species, Locality and CUMZ nos.	Number of adult shell examined	Ranges, Mean ± SD in mm of:			Whorl Ranges
		Shell Height	Shell Width	h/d Ratio	
A. (S.) xiengensis xiengensis Morlet, 1891					
Tham Chieng Dao, Chiengmai (2274, 2275, 2276)	32	23.39-35.80 29.49±2.31	13.07-18.18 15.27±0.09	1.80-2.16 1.93±0.08	$5^5/_8$ -$6^7/_8$
Huy Kon Kom, Chiengrai (2402, 2440)	25	20.80-26.54 24.52±1.50	12.28-14.47 13.26±0.67	1.69-1.96 1.85±0.07	$5^6/_8$ - $6^2/_8$
Mae Yom, Phrae (2366, 2368)	16	23.16-31.07 26.97±1.86	12.24-14.97 13.17±0.07	1.84-2.24 2.05±0.10	$5^7/_8$ - $7^1/_8$
Doi Phu Nang, Prayao (2363)	5	24.25-28.46 25.86±2.16	12.39-14.27 13.10±0.74	1.88-2.10 1.97±0.08	6 - $6^4/_8$
A. (S.) xiengensis ssp. Plieu National Park, Chanthaburi (2360, 2367, 2369, 2414)	69	16.46-31.73 25.81±3.46	10.25-15.35 13.21±1.15	1.61-2.31 1.95±0.13	5 - 7
A. (S.) fultoni Ancey, 1897					
Ban Takun, Suratthani (2403)	9	24.68-29.38 26.73±1.51	12.78-14.10 13.45±0.38	1.86-2.13 1.99±0.08	6 -7
Kaho Poo-Khao Ya, Patthalung (2408, 2425)	12	24.32-31.53 27.61±2.19	12.96-15.47 14.08±0.93	1.84-2.04 1.96±0.07	6 - $6^4/_8$
Khao Auk Taru, Patthalung (2423, 2429)	11	23.70-28.57 26.87±1.50	11.81-13.59 12.80±0.63	1.90-2.68 2.10±0.10	6 - $6^4/_8$
A. (Syndromus) sp. Koh Kra, Nakhonsri-thammarat (2386, 23877)	27	25.23-35.96 30.60±2.38	14.49-18.92 16.43±1.09	1.69-2.00 1.86±0.07	$5^7/_8$ - $6^7/_8$
A. (S.) glaucolarynx (Dohrn, 1861)					
Tubsathorn, Kanchanaburi (2248, 2252, 2395, 2398)	50	18.66-25.51 21.44±1.53	11.86-15.07 13.31±0.74	1.46-1.76 1.61±0.07	$5^2/_8$ - $6^6/_8$

The specimens collected from Khao Ang Rue Nai, Chachoengsao performed a wide range of the shell banding patterns. At least four types of banding patterns are considerable. 1) Shell is uniform whitish with absent of all bands (Fig. 5.3F). 2) Only the sub-peripheral band (band 4) and columella band (band 5) presence (Fig. 5.3G), or both of them are modified to brownish spotty or dash-like shaped (Fig. 5.3H). 3) The supra-peripheral bands (band 2, 3) are modified to the narrowly brownish stripes; sub-peripheral band (band 4) and columella band (band 5) perform spotty or dash-like shaped (Fig. 5.3I). 4) Rarely specimens performed a blackish subsutural band (band 1) and the presenting of others four bands (Fig. 5.3J). This pattern resembles to those of the typical colour pattern of *A. (S.) xiengensis xiengensis*. Unfortunately, we have no the preserved specimens for examination the reproductive organ. Further population genetic study will be realize whether the sympatric species with *A. (S.) xiengensis* unless the colour polymorphism of the *A. (S.) semitessellatus*.

Amphidromus (Syndromus) xiengensis Morlet, 1891

Diagnosis: Shell small, thick to thin, conic to elongate conic, sinistral and umbilicus narrowly rimate to perforate. Apex acute with brown or black spot on the tip. Whorls slightly convex; suture wide and shallow. Periostracum thin and corneous colour. Typically variegated shell colour pattern from presenting of five bands, modification of some bands or absent of any bands. Aperture sub-ovate and whitish inside; parietal callus transparent. Peristome whitish; lip expanded and slightly thickens. Columella thicken and perpendicular.

External feature: Living animals have general characteristic similar to *A. (S.) flavus*. The body colour is greyish to whitish; mantle edge is greyish to creamy; mantle cavity is spread with blackish spots.

Distribution: *Amphidromus (S.) xiengensis* s. lat. has the widely distribution ranging from the northern (type locality) to eastern and southern peninsula Thailand. The previous recorded were from Thailand: Xieng-moi Plateau (type locality), Pinh bank, Lampoon, Chiengdao, Doi Hua Mot, Kao Sabab, Lomsak, Wang Dao, Trat and Phitsanuloke; Laos: Luang Prabang and Prang; Cambodia: Laos Mountain (Fulton, 1896; Pilsbry, 1900; Blanford, 1903; Laidlaw and Solem, 1961).

Remark: Morlet (1891a, b) described *A. (S.) xiengensis* based on shell colour pattern of a number of specimens collected from 'Ménam-Pinh, Xieng-

Mai' (= Ping River, Chiengmai Province, northern Thailand). Specimens collected from Chiengmai closely match the holotype of *A. (S.) xiengensis* Morlet, 1891 are clearly referable to the *A. (S.) xiengensis xiengensis*, which appears to be restricted to that areas. Specimens from other areas previously referred to *A. (S.) xiengensis* s. lat. by Solem (1965) and Panha (1996) actually represent different species or subspecies, which include in the following described subspecies.

The *A. (S.) xiengensis* s. lat. can be divided in to two subspecies according to shell colour pattern and the genitalia characters (described later). The northern Thailand population undoubtedly represent the nominotypical subspecies. The others two subspecies are from eastern and southern Thailand, which perform a fundamental *A. (S.) xiengensis* colour patterns. They show not only strikingly in modification of shell colour pattern, but also the distinguishable genital characters from each other. Recent study demonstrated that the shell banding patterns are still primarily characteristic, which useful for discrimination of that taxa, however, only on shell banding may lead to errors of polymorphism. In spite of the suggested close relationship, there are a number of morphological differences among the three subspecies and the important characters especially the genitalia, which are useful to assess the intraspecific relationships are described below.

Amphidromus (Syndromus) xiengensis xiengensis Morlet, 1891

(Figures 5.3 M-T, 5.9A-C, 5.10A-C)

Amphidromus xiengensis Morlet, 1891: 27. Morlet, 1891a: 232, 240, 241, pl. 5, fig. 4. Pilsbry, 1900: 194, 195, pl. 63, figs 75, 76. Blandford, 1903: 279. Laidlaw and Solem, 1961: 564, 565. Solem, 1965: 626, 627, pl. 2, figs 7-13.

Amphidromus porcellanus var. *xiengensis*—Fulton, 1896: 79

Amphidromus contrarius var. *multifasciata* Fulton, 1896: 78, pl. 7, fig. 5.

Amphidromus xiengensis var. *multifasciatus*—Pilsbry, 1900: 195, pl. 63, fig. 77. Solem, 1965: 626.

Amphidromus xiengensis var. *clausus* Pilsbry, 1900: 195, 196, pl. 63, figs 79-82 (Lectotype figs 81, 82). Solem, 1965: 626, pl. 2, figs 11-13.

Amphidromus xiengensis var. *tryoni* Pilsbry, 1900: 196, 197, pl. 63, fig. 78.

Amphidromus flavus var. *proximus* Fulton, 1896: 81; pl. 6, fig. 4.

Amphidromus xiengensis var. *proximus*—Pilsbry, 1900: 198, pl. 63, fig. 94. Laidlaw and Solem, 1961: 565, 652.

Material examined: Huy Kon Kom, Chiengrai: CUMZ 2402 (16), 2440 (17); Chieng Dao, Chiengmai: CUMZ 2274 (14), 2275 (16), 2275 (7), 2392

(2), 2413 (1), 2437 (4), 2465 (2); Doi Phu Nang, Prayao: CUMZ 2363 (6), 2366 (1), 2389 (1); Kaeng Sue Ten, Phare: CUMZ 2361 (2), 2365 (2), 2368 (4), 2411 (4), 2448 (9), 2464 (3), 2488 (4); Kwae Nio Dam, Phitsanulok: CUMZ 2393 (2);

Shell (Fig. 5.3M-T): Shell morphology almost similar in species description. Shell colour pattern typically with reddish to brown subsutural band (band 1). Supra-peripheral bands (band 2 and 3) perform brownish concurrent blotches which continuous until the lip. Sub-peripheral band (band 4) and columella band (band 5) brownish. The earlier whorls have similar pattern as in last whorl, but some are fading.

Radula (Fig. 5.9A-C): Teeth arranged in V-shape rows, each rows containing about 149 (71-(10-12)-1-(10-12)-77) teeth. Central tooth monocuspid and spatulate shaped; rarely tricuspid shaped with minute ectocone (Fig. 5.9A). Lateral teeth bicuspid with deep groove, endocone small and truncate cusp, and ectocone large with long and curved cusp (Fig. 5.9A). Lateral teeth gradually transformed to tricuspid marginal teeth about tooth number 10 to 12 outwards (Fig. 5.9B). Marginal teeth tricuspid with curved shape, endocone and mesocone large with obtuse cusp and ectocone small with pointed cusp (Fig. 5.9C).

Genitalia (Fig. 5.10A-C): Atrium (at) slightly long (n=5). Penis (p) large, swollen and conical shaped. Epiphallus (e) slightly long and seemingly perform a spiral form; flagellum (fl) short and smaller than epiphallus. Vas deferens (vd) a narrow tube, extending from free oviduct to the end of epiphallus. Penial retractor muscle (pr) thin and long (Fig. 5.10A).

Internal wall of penis nearly smooth with very thin corrugated penial pilasters (pp) at proximally. Penial verge (pv) extremely large, curved conical shaped, and surface perform irregular furrow or nearly smooth (Fig. 5.10B).

Vagina (v) long, cylindrical with about twice the length of penis (Fig. 5.A). Gametolytic duct (gd) long and slender cylindrical tube; distally tapering to a small tube and connected to gametolytic sac (gs). Free oviduct (fo) slightly long; oviduct (ov) curled (not fully growth). Albumen gland (ag) small and curved shaped. Hermaphroditic duct (hd) convoluted and connected between hermaphroditic gland (hg) to near the tip of talon (ta) (Fig. 5.10C).

Proximally, internal wall of vagina possesses swollen and slightly smooth longitudinal pilasters (vp); distally transformed to a little irregular crenellations ridges (Fig. 5.10B).

Distribution (Fig. 5.1): *Amphidromus (S.) xiengensis xiengensis* has distribution ranged in the northern Thailand and possibly in Laos and

Myanmar. The recent study was recorded in Chiengmai: Tam Chieng Dao; Chiengrai: Huy Kon Kom; Phare: Mae Yom Dam; Phayao: Doi Phu Nang National Park; Phitsanulok: Kwae Noi Dam.

Remark: All the available evidences as a basic of shell banding, genital, radula morphology and distribution information are pointed to included the four varietals names of *A. (S.) xiengensis* (*sensu* Fulton, 1896; Pilsbry, 1900; Laidlaw and Solem, 1961) as a colour polymorphism of this subspecies. Those colour forms probably reflect the genetic diversity within a population. Although, it needs to test in the genetic knowledges, however, the useful molecular analyses among those differences colour phase could emphasised either intraspecific genetic variations or others.

We examined a large numbers of specimens of *A. (S.) xiengensis xiengensis* exhibits the considerable variability in shell colour pattern, which can be roughly divided using banding system into three groups. They are consistent with the Fulton (1896), Pilsbry (1900) and Laidlaw and Solem (1961) supposition of varieties names. 1) A typical colour and '*clausus* Pilsbry, 1900' forms have 5 bands as in the description (Fig. 5.3M), but the supra-peripheral bands (band 2 and 3) of '*clausus*' form are not reaching to the lip (Fig. 5.3P). 2) '*multifasciatus* Fulton, 1896' has modification of the supra-peripheral bands (band 2 and 3) splited into several thin brownish bandlets (Fig. 5.3N, O). 3) '*proximus* Fulton, 1896' (=*tryoni* Pilsbry, 1900), this colour form has quite different from the typical colour form by absent of the subsutural band (band 1) and supra-peripheral bands (band 2 and 3) on the last two whorls. The sub-peripheral band (band 4) and columella band (band 5) usually present (Fig. 5.3Q-T), but rarely with only columella band (Fig. 5.3R).

The shells from Doi Phunang (Fig. 5.3S) tended to have smaller shell size and paler colour than Huy Kon Kom (Fig. 5.3T); Chiengdao (Fig. 5.3P); Mae Yom specimens (Fig. 5.3M, N, Q, R). However, usually we found those three colour forms were sympatry. Therefore, these differences could be attributed to the geographical variation of *A. (S.) xiengensis xiengensis*.

***Amphidromus (Syndromus) xiengensis* subspecies**
(Figures 5.3 U-Z, 5.4 A-E, 5.9D-F, 5.10D-F)

Material examined: Plieu Waterfall, Chanthaburi: CUMZ 2357 (1), 2358 (15), 2360 (4), 2362 (1), 2364 (9), 2367 (35), 2369 (20), 2371 (2), 2372 (6), 2373 (7), 2374 (15), 2382 (7), 2383 (2), 2403 (5), 2414 (4), 2433 (6); Makok Waterfall, Chanthaburi: CUMZ 2317 (4), 2350 (1), 2385 (1), 2432 (5), 2434 (2), 2435 (18), 2454 (5), 2455 (19), 2484 (5); Trong Nong Waterfall, Chanthaburi: CUMZ 2322 (16), 2344 (11), 2370 (4), 2457 (26); Khao Soi

Dao, Chanthaburi: CUMZ 2315 (11), 2347 (4); Koh Chang, Trat: CUMZ 2381 (1), 2404 (1); Koh Kud, Trat: CUMZ 2427 (2); Wat Tam Klongtip, Chanthaburi: CUMZ 2348 (7); Ka Ting Waterfall, Chanthaburi: CUMZ 2438 (1); Khao Kloy, Rayong: CUMZ 2428 (1); Koh E-lar, Chonburi: CUMZ 2416 (24), 2450 (12), 2473 (12), 2483 (2), 2493 (1); Wat Khao Sukim, Chanthaburi: CUMZ 2312 (1), 2343 (25).

Shell (Figs 5.3 U-Z, 5.4 A-E): Shell slightly thin, elongate conic, sinistral and sealed umbilicus. Apex acute with black spot on the tip; following whorls with roseate colour. Shell colour pattern lacking of subsutural band (band 1) or unobvious brownish. Supra-peripheral bands (band 2 and 3) brownish green blotches, which usually fused or perform unclear separation. Sub-peripheral band (band 4) and columella band (band 5) brownish; rarely with reddish umbilicus area. Whorls and last whorl slightly convex; suture depressed. Aperture sub-ovate and angulation; parietal callus transparent. Peristome whitish; lip expanded and minute reflected.

Radula: Each row containing about 129 (63-(20-24)-1-(22-25)-65) teeth. Central tooth monocuspid with slightly wide groove (Fig. 5.9D). Laterals teeth bicuspid and marginal teeth tricuspid, which similar to those described in the nominotypical subspecies (Fig. 5.9 D, E). Marginal teeth start from tooth 20 to 25 outwards, and outermost marginal teeth tricuspid (Fig. 5.9F).

Genitalia (Fig 5.10d-F): Atrium (at) slightly short (n=5). Penis (p) large, cylindrical shaped and somewhat swollen at penial verge base. Epiphallus (e) and flagellum (fl) short and slender. Vas deferens (vd) connected between free oviduct and the end of epiphallus. Penial retractor muscle (pr) rather thick and large (Fig. 5.10D).

Internal wall of penis with slightly smooth and oblique penial pilasters (pp). Penial verge (pv) extremely large, slightly curved shaped, and smooth surface (Fig. 5.10E).

The female reproductive organs are almost similar to that of the previous described subspecies. The vagina (v) is similar length to the penis. The vaginal pouch is closed to the atrium. The pilasters inside the pouch are well developed (Fig. 5.10E, F).

Distribution (Fig. 5.1): *Amphidromus (S.) xiengensis* subspecies has widely distributed in eastern Thailand and possibly in Cambodia. The recent recorded were ranging from Chanthaburi: Plieu National Park, Makok waterfall, Trongnong waterfall; Wat Tam Klongtip, Wat Khao Sukim, Kra

Thing waterfall, Khao Soi Dao; Chonburi: Koh E-lar; Trat: Koh Kud, Koh Chang; Rayong: Khao Kloy.

Remark: These unique populations perform the *A. (S.) xiengensis* colour pattern. It obviously differs from the nominotypical subspecies by having the diffused or unclear separation of supra-peripheral bands, lacking of reddish subsutural band and columella area, and having a roseate apex. Additionally, this subspecies have a well developed vaginal pouch, and a swollen and slightly oblique arrangement of penial pilasters, which are disappeared in the nominotypical subspecies.

Amphidromus (S.) xiengensis ssp. is likely to have much diverse of shell colours and banding patterns both within and between populations. The specimens from the type locality (Plieu waterfall), Makok and Trong Nong waterfall are generally present three types of shell colour: whitish, yellowish and purplish colour, which combination with multiples types of banding patterns (Fig. 5.3U-Y). The specimens from Koh E-lar have slightly thicken shell, whitish shell colour and with greyish to brownish blotches of the four bands (Fig. 5.4C, D). The specimens from Khao Soi Dao and Kra Thing waterfall have slightly elongated shell. The banding patterns of supra-peripheral bands (band 2, 3) spirally split into several thin bandlets; the supra-peripheral band (band 2) disappear on the last whorl and supra-peripheral band modified to a narrowly line at the bottom of the band 3; the sub-peripheral band (band 4) and columella band (band 5) are frequently fainted or perform light brownish bands (Fig. 5.4 A, B). The specimens from Koh Kud and Koh Chang have slightly convexing last whorls and ovate aperture than the typical specimen (Fig. 5.3Z). The shell from Wat Khao Sukim and Wat Tam Klongtip show similar in banding patterns with typical specimens, however, most of shells from Wat Khao Sukim have an extra thin reddish stripe between the sub-peripheral band (band 4) and columella band (band 5). Two shells from Wat Tam Klongtip have no to faint of the columella band (band 5) (Fig. 5.4E).

We also compare the genital anatomy among those populations. There is no obviously morphological different among them. This new subspecies mostly distributed in the eastern part of Thailand, while the nominotypical subspecies found in the northern part of peninsular Thailand.

Amphidromus (Syndromus) fultoni Ancey, 1897

(Figures 5.4F-L, 5.11, 5.12)

Amphidromus fultoni Ancey, 1897: 62, 63. Pilsbry, 1900: 197, pl. 63, figs 83, 84. Laidlaw and Solem, 1961: 565, 620. Solem, 1965: 627. Richardson, 1985: 18.

Material examined: Ban Takun, Suratthani: CUMZ 2356 (6), 2420 (3), 2430 (3), 2449 (5), 2456 (20), 2470 (7), 2471 (4), 2474 (27), 2491 (8); Kiriratnikom, Suratthani: CUMZ 2421 (5), 2466 (3); Wat Tam Khao Kiep, Chumporn: CUMZ 2314 (4), 2415 (22); Sra Morakot, Karbi: CUMZ 2346 (6), 2439 (1); Wat Tam Lord, Lansaka, Nakhonsrithammarat: CUMZ 2334 (2); Pang Nga Bay, Pangnga: CUMZ 2400 (23), 2431 (3), 2458 (4); Khao Phanomwang, Kanchanadit, Suratthani: CUMZ 2406 (1), 2419 (4), 2424 (7); Khao Poo-Khao Ya, Patthalung: CUMZ 2408 (14), 2425 (18), 2452 (2); Tam Su-mano, Srinakharin, Patthalung: CUMZ 2417 (2).

Shell (Fig. 5.4F-L): Shell thin, elongate conic and sealed umbilicus. Shell colour pattern lacks of subsutural band (band 1) or replaced with dark-yellow band. Supra-peripheral bands (band 2 and 3) with brownish concurrent blotches. Sub-peripheral band (band 4) and columella band (band 5) brownish, and with reddish umbilicus area. Whorls and last whorl slightly convex; suture depressed. Aperture ovate; parietal callus transparent. Peristome whitish; lip shortly expanded and not reflected.

Radula (Fig. 5.11A-C): Each rows containing about 170 (82-(16-19)-1-(16-19)-87) teeth. Central tooth monocuspid with slightly long, slender and truncate cusp (Fig. 5.11A). Laterals teeth bicuspid and marginal teeth tricuspid, which are closely resemble to those described in the nominotypical subspecies. Marginal teeth started from tooth numbers 16 to 19 (Fig. 5.11B) outwards. Ectocone of outermost teeth sometime bifurcating cusps (Fig. 5.11C).

Genitalia (Fig. 5.12A-C): Atrium (at) slightly short (n=10). Penis (p) somewhat enlarged, swollen, cylindrical and swollen at penial verge base. Epiphallus (e) slightly short; flagellum small and rather long. (Fig. 5.). Vas deferens (vd) narrow tube. Penial retractor muscle (pr) rather thick and very short (Fig. 5.12A).

Internal wall of penis nearly smooth with a few and thin corrugated penial pilasters (pp) closed to the genital orifice. Penial verge (pv) extremely large with cylindrical shaped and surface slightly smooth with irregular furrow (Fig. 5.12B).

The female reproductive organs are almost similar to that of the nominotypical subspecies (Fig. 5.12A, C). However, it has a swollen vaginal pouch closed to the atrium and the well developed pilasters inside a pouch allow this subspecies to be recognized (Fig. 5.12B).

Distribution (Fig. 5.1): The type locality was recorded only 'Cochichine' (= southern Vietnam) in Ancey (1897) description. Subsequently recorded were only from Khao Prab, Bandon District, Suratthani of the southern peninsular Thailand (Solem, 1965). The recent distribution recorded are from the southern Thailand ranging from Chumphon: Khao Kreb; Suratthani: Ban Takun, Khirirat Nikhom, Khao Phanom Wang; Pangnga: Pangnga Bay; Nakhonsrithammarat: Krung Ching waterfall, Wat Tam Lord; Patthalung: Khao Poo-Khao Ya, Tam Sumano; Trang; Krabi: Sara Morakot.

Remark: This species is the negligently, unknown the type material and type locality quite vague species; since it was nominated by Ancey in 1897. Later, Solem (1965) found that a juvenile specimen collected from Khao Prab, Suratthani has similar banding pattern as the type figures and the extensive collections are clearly indicated *A. (S.) fultoni* distributed in the southern peninsular Thailand.

The basic of banding patterns of *A. (S.) fultoni* have almost the same opinion as in *A. (S.) xiengensis xiengensis*. However, it can be distinguish from the *A. (S.) xiengensis* by ovate aperture, lacking of the reddish subsutural band (band 1) and reddish umbilical area. The reproductive organ with vaginal pouch and unique vaginal pilasters inside the pouch which it does not occurs in *A. (S.) xiengensis xiengensis*. Also, this species is mainly distributed in the southern peninsular Thailand, while *A. (S.) xiengensis* usually found in the northern and eastern Thailand. The most northern limits in distribution of this subspecies are possibly at Khao Kriap, Chumphon, because of the north habitat were occupied by *A. (S.) semitessellatus* and *A. glaucolarynx*

The specimens from Khirirat Nikhom (Fig. 5.4I) are slightly distinct from the typical subspecies from Ban Takun (Fig. 5.4F, J) by having a diffused of brownish blotches of the supra-peripheral bands (band 2 and 3), and with dark-yellow at the position of subsutural band. Specimens from Khao Kriap (Fig. 5.4G), Krung Ching waterfall, Wat Tam Lord (Fig. 5.4H) and Khao Poo-Khao Ya (Fig. 5.4K) are almost similar to the typical specimens from Ban Takun. All the specimens from Pangnga Bay have smaller shell size, lacking of band 1 to band 3; sub-peripheral band (band 4) and columella band (band 5) modified to thin brownish bands. Most of the specimens from Sar Morakot (Fig. 5.4L) perform shell colour pattern similar to those of the Ban Takun, however, some specimens have missing or faintly of the sub-peripheral band (band 4) and columella band (band 5); only some small reddish columella area present.

Amphidromus (Syndromus) species

(Figures 5.4M, N, 5.12, 5.13)

Material Examined: Koh Kra (Kra Island) (8° 23' 55" N 100° 44' 2" E), Nakhonsrithammarat Province: CUMZ 2386 (19), 2387 (18), 2401 (10), 2422 (29).

Diagnosis: *Amphidromus (S.) principalis* Panha new species is obviously distinguished from other species in having more ovate conic shell, without any bands, entirely uniform golden yellow colour and umbilicus open. The reproductive organ of is no vagina pouch, the penial verge slightly small with conical shaped and slightly smooth vaginal pilasters.

Shell (Fig. 5.4M, N): Shell ovate conic, glossy, smooth, sinistral and umbilicus rimate. Apex obtuse with brown to black spot on the tip. Shell colour pattern uniform golden yellow without any banding pattern. Last whorl with dark yellow colour, which paler in earlier whorls. Spire conic with slightly depress suture. Aperture ovate; peristome white, narrowly expanded and not reflected. Columella white, straight and perpendicular.

Radula (Fig. 5.13A-C): Teeth arranged in anteriorly pointed V-shape, each rows containing about 145 (72-(18-21)-1-(18-21)-72) teeth. Central tooth tricuspid, spatulate shaped with minute ectocone or nearly vestigial (Fig. 5.13A). Lateral teeth bicuspid with wide groove, endocone obtuse cusp, ectocone large with truncate cusp (Fig. 5.13A). Lateral teeth gradually transformed to tricuspid marginal about tooth number 18 to 21 outwards (Fig. 5.13B). Marginal teeth tricuspid, endocone and mesocone obtuse cusps. Outermost teeth, ectocone perform multiple and sharped cusp. Ectocone of outermost teeth with multiples and sharped cusp (Fig. 5.13C).

Genitalia (Fig. 5.14A-C): Atrium (at) slightly long (n=10). Penis (p) short and cylindrical shaped. Epiphallus (e) slightly long; flagellum (fl) short and large. Vas deferens (vd) narrow tube, extending from free oviduct (fo) to the end of epiphallus. Penial retractor muscle (pr) relatively long and inserted near proximal end of epiphallus (Fig. 5.14A).

Internal wall of penis corrugated into a series of thin and longitudinal penial pilasters (pp), which form a thin fringe around the conical penial verge. Penial verge (pv) surface slightly smooth or with thin irregular furrow (Fig. 5.14B).

Vagina (v) slender, cylindrical shaped and about twice of penis length (Fig. 5.A). Gametolytic duct (gd) long, proximally slightly large, and distally continuously tapering to small tube and ended at globose gametolytic sac (gs).

Free oviduct (fo) short; oviduct (ov) and albumen gland (ag) enlarged. Hermaphroditic gland (hg) contracted, form numerous small lobules; convoluted hermaphroditic duct (hd) connected closed to the tip of talon (ta) (Fig. 5.14C).

Internally, vaginal wall possesses swollen and nearly smooth of longitudinal vaginal pilaster (vp). Vaginal pouch absent (Fig. 5.14B).

External Feature: Living animals have general characteristic as described in *A. (S.) flavus*. However, this new species has entirely whitish creamy body; rarely old adult snails have a pale brown head foot. The mantle edge, mantle cavity and lung ventilation are usually creamy or on pigments.

Distribution (Fig. 5.1): *Amphidromus (Syndromus)* species is known only from the type locality. Koh Kra locates at about 30 km off east coast of Pak Phanang District, Nakhonsrithammarat.

Remark: This unknown species is obviously distinguished from other species in having more ovate conic shell, without any bands, entirely uniform golden yellow colour and umbilicus open. The reproductive organ of is no vagina pouch, the penial verge slightly small with conical shaped and slightly smooth vaginal pilasters.

The type locality is a granite mountain and composed of the two small surrounding islands. The forestation type on the island is a dry forest. This new species was commonly found on almost tree species at the sea level up to 120 m at the peak of the mountains. At the collecting time (April, 2000), the weather was moist and snails were active. They crawling on the tree leaves, trunks, branches or branches let at height about 1 to over 10 meters above the ground. We also explore others two surrounding islands, but absent of *Amphidromus* species only others ground dwelling species was observed. We also compared with the closed population of *A. (S.) fultoni* from Wat Tam Lord, Lan Saka Didtrict, Nakhonsrithammarat. However, a new species clearly difference from that population both in shell and genital characters.

The banding variations of around 200 specimens collected from the type locality are not observed, only the shell measurement variations are observed.

Amphidromus (Syndromus) glaucolarynx (Dohrn, 1861)

(Figures 5.4O-Y, 5.15, 5.16)

Bulimus glaucolarynx Dohrn, 1861: 207, pl. 2, fig. 7.
Bulimus schomburgki var. *fasciata* Martens, 1867: 80, pl. 21, figs la-b.

Amphidromus peerieri Rochebrune, 1882: 71.

Amphidromus glaucolarynx var. *fasciata*—Fulton, 1896: 90, pl. 7, fig. 3. Pilsbry, 1900: 181, pl. 60, figs 46-48.

Amphidromus glaucolarynx—Fulton, 1896: 90. Pilsbry, 1900: 180-182. Blandford, 1903: 278-279. Hass, 1952: 24. Zilch, 1953: 132. Laidlaw and Solem, 1961: 524, 525. Solem, 1965: 618, pl. 2, fig. 1.

Amphidromus glaucolarynx albicans Möllendorff, 1902: 157. Zilch, 1953: 132, pl. 22, figs 2, 3. Laidlaw and Solem, 1961: 524, 525. Solem, 1965: 525, 598.

Amphidromus glaucolarynx fasciata—Laidlaw and Solem, 1961: 524, 525, fig. 17.

Amphidromus glaucolarynx var. *perrieri*—Pilsbry, 1900: 181-182.

Material examined: Nam Naou National Park, Phetchaboon: CUMZ 2265 (3S); Mae Sod, Tak: CUMZ 2239 (1D); Thi Lo Su Waterfall, Umphang, Tak: CUMZ 2254 (1D+2S); Tam Sing Nangnon, Umphang, Tak: CUMZ 2399 (1S); Pa Charoen Waterfall, Tak: CUMZ 2247 (1D); Kanchanaburi: CUMZ 2268 (4D+4S), 2272 (1S); Nam Phu Ron, Thong Pha Phum, Kanchanaburi: CUMZ 2261 (2D+3S), 2262 (4D+2S), 2263 (5D+1S), 2264 (6D+4S), 2328 (1S), 2460 (11D+24S), 2463 (8D+6S), 2467 (4D), 2476 (5D+8S); Tubsathorn, Kanchanaburi: CUZM 2240 (2D+10S), 2248 (14D+12S), 2249 (5D+8S), 2250 (1D+1S), 2251 (16D+8S), 2252 (10D+8S), 2255 (2D+2S), 2257 (1D+3S), 2258 (17D+17S), 2269 (7D+7S), 2270 (10D+10S), 2395 (2D+14S), 2396 (1D), 2398 (6S), 2498 (1D+4S), 2499 (7D+8S), 2500 (20D+29S); Chong Khao Khat, Kanchanaburi: CUMZ 2267 (2D+2S); Khao dong Kamen, Kanchanaburi: CUMZ 2497 (1D+5S); Erawan Waterfall, Kanchanaburi: CUMZ 2244 (1D+1S), 2245 (2D+4S), 2253 (1S); Sai Yok Noi Waterfall, Kancahanburi: CUMZ 2256 (1S); Kaeng Kracharn National Park, Phetchaburi: CUMZ 2238 (1S), 2241 (3D+3S), 2259 (6D+4S), 2266 (1D+2S), 2453 (4D+3S), 2469 (2D); Pa La-ue Waterfall, Phetchaburi: CUMZ 2342 (1S); Tam Pha Khayang, Ranong: CUMZ 2246 (2D), 2260 (18D), 2482 (1D).

Shell (Fig. 5.4O-Y): Shell ovate conic to slightly obtuse, rather thin, dimorphic coiling and umbilicus rimate. Apex slightly obtuse, usually black to dark purple; following whorls with tinted pink. Whorls little convex; suture wide and shallow. Shell colour pattern with slightly thin to thick greenish subsutural band (band 1). Supra-peripheral bands (band 2, 3) always fused and perform dark blotches. Sub-peripheral band (band 4) usually fused with columella band (band 5) and modified a thick band or dark blotches. Umbilicus area varying from wide to narrow with brown to whitish colour; greenish or brownish inside umbilicus. Aperture semi-ovate and angulation;

parietal callus thin or purplish. Peristome dark brown or purplish; lip expanded, slightly thickened and shortly reflected. Columella straight and perpendicular.

Radula (Fig. 5.15A-F): Radula teeth arranged in V-shaped rows, each row containing about 137 (68-1-68) teeth. Central tooth monocuspid with long spatulate shaped (Fig. 5.15A, D). Lateral teeth bicuspid; endocone similar shape and size to central tooth (at teeth 1st to 5th); ectocone attached at teeth base and bifurcating cusps. Lateral teeth, endocone oblique spatulate shaped with truncate cusp. Ectocone progressively splitting, frae very small and pointed cusp; mesocone large and spatulate with truncate cusp. Marginal teeth not clearly distinguished from marginal teeth (Fig. 5.15 B, E). Outermost teeth tricuspid in structure; endocone and ectocone pointed cusp otherwise separation into two or more cusps (Fig. 5.15C, F).

Genitalia (Fig. 5.16A-C): Atrium (at) short (n=5). Penis (p) long and slender cylindrical shaped. Epiphallus (e) long; flagellum (fl) short, distal end coiled and equal diameter to epiphallus. Appendix (ap) small and same length to flagellum. Vas deferens (vd) a narrow tube, connected between the end of epiphallus and free oviduct. Penial retractor muscle (pr) long and originated proximal to epiphallus (Fig. 5.16A).

Internal wall of penis corrugated into a series of thickened and swollen penial pilasters (pp). Ridges perform reticulation of pilasters and form fringe around penial verge. Penial verge (pv) slightly small, ovate shaped and with slightly wrinkled surface (Fig. 5.16B).

Vagina (v) slightly long, cylindrical with a swollen pouch closed to atrium (Fig. 5.16A). Gametolytic duct (gd) about the same diameter to vagina and distally connected to gametolytic sac (gs). Free oviduct (fo) quite short; oviduct (ov) and albumen gland (ag) large and curled. Hermaphroditic gland (hg) contracts forms; a convoluted hermaphroditic duct (hd) connected to the tip of talon (ta) (Fig. 5.16C).

Vaginal pouch large, inside with well developed of slightly transverses ridges. Internally vagina possesses longitudinal vaginal pilasters (vp). Proximally with smooth pilasters and distally perform very distinct with chain of portude knobs, which is lining on the vaginal pilasters (Fig. 5.16B).

External feature: Living animals have long head-foot, lacking pedal groove and undivided sole. Head-foot covers with reticulate skin and greyish to blackish. Mantle edge brownish to purplish grey; mantle cavity blackish to mottle blackish. Posterior tentacles long and blackish with drum stick shaped in full extension; anterior tentacle short with paler colour.

Distribution (Fig. 5.1): The type locality was recorded only "Siam" (=Thailand) in Dohrn (1861). The subsequently records were from Thailand: Lampang, Lumphun, Kamphaengphet, Phitsanuloke, Nakhonratchasima, Sakeo and Phetchaburi; Cambodia: Perk Scholl (Fulton, 1896; Pilsbry, 1900; Haas, 1952; Laidlaw and Solem, 1961; Solem, 1965). Here, we reported the addition localities from Phetchabun; Kamphangphet; Tak; Kanchanaburi; Phetchaburi; Ranong.

Remark: We have chance to examined large sets of *A. glaucolarynx* collected from various localities both shell and soft part anatomy. The results clearly showed the infra-subspecies recognition as follow Pilsbry (1900) and Laidlaw and Solem (1961) classification. The variety *fasciatus* von Martens, 1867 could not distinguish from the typical by the shell colour patterns, only slightly smaller shell size can be recognized (Fulton, 1896; Pilsbry, 1900). Laidlaw and Solem (1961) have compared the type specimen of the *perrieri* Rochebrune, 1882 with *fasciatus*. They mentioned that almost identical in shell size and colour pattern to the *fasciatus* specimens, and placed this as a synonyms of the *fasciatus*.

Typically, *A. glaucolarynx* have a thin greenish subsutural band (band 1). The supra-peripheral bands (band 2 and 3) are fused together and performed dark blotches. The supra-peripheral bands (band 2 and 3) and sub-peripheral band (band 4) usually separated with a narrowly whitish space, which is frequently faded or disappeared around near the lip (Fig. 5.4O). The specimens Kaeng Kracharn and Pala-u waterfall, Huay Ya and Mae Sod (Fig. 5.4O-R) have almost similar to the typical specimens and relatively larger shell size than Thong Phaphum specimens (Fig. 5.4S). Most of specimens collected from Chong Khao Kad show typical colour pattern, only a few of these perform variety '*albicans* Möllendorff, 1902'. They have white lip and columella, and lost of the tinted pink on the spire. Further, comparison with the lectotype SMF 28259 (*sensu* Zilch, 1953) suggested that the *albicans* is probably the unusual form or genetic variability of *A. glaucolarynx*.

The specimens from Prakrayang cave show slightly squatter shell, supra-peripheral bands (band 2 and 3) perform curved dark blotched than the typical form (Fig. 5.4T). The specimens from Sai Yok waterfall show slightly distinct characters from the typical specimens. Shell is more ovate and bright purplish apertural lip. Colour pattern is slightly wide yellow-greenish subsutural band (band 1); the fusion of supra-peripheral bands (band 2, 3) and sub-peripheral band (band 4) and columella band (band 5) usually perform yellowish-brown colour with blurred of dark blotches (Fig. 5.4X, Y).

Specimens from Tubsathorn show a unique colour patterns from others examined specimens by lacking of dark blotches, last whorl more convex, slightly ovate shell, spire short and suture slightly depress. Shell banding is

usually absent or sometime present with light brown colour subsutural band (band 1). The supra-peripheral bands are usually separated, band 2 is modifies to a thin and dark line, and band 3 can be vary from a narrow dark brown bands to thick light brown or absent (Fig. 5.4U-W).

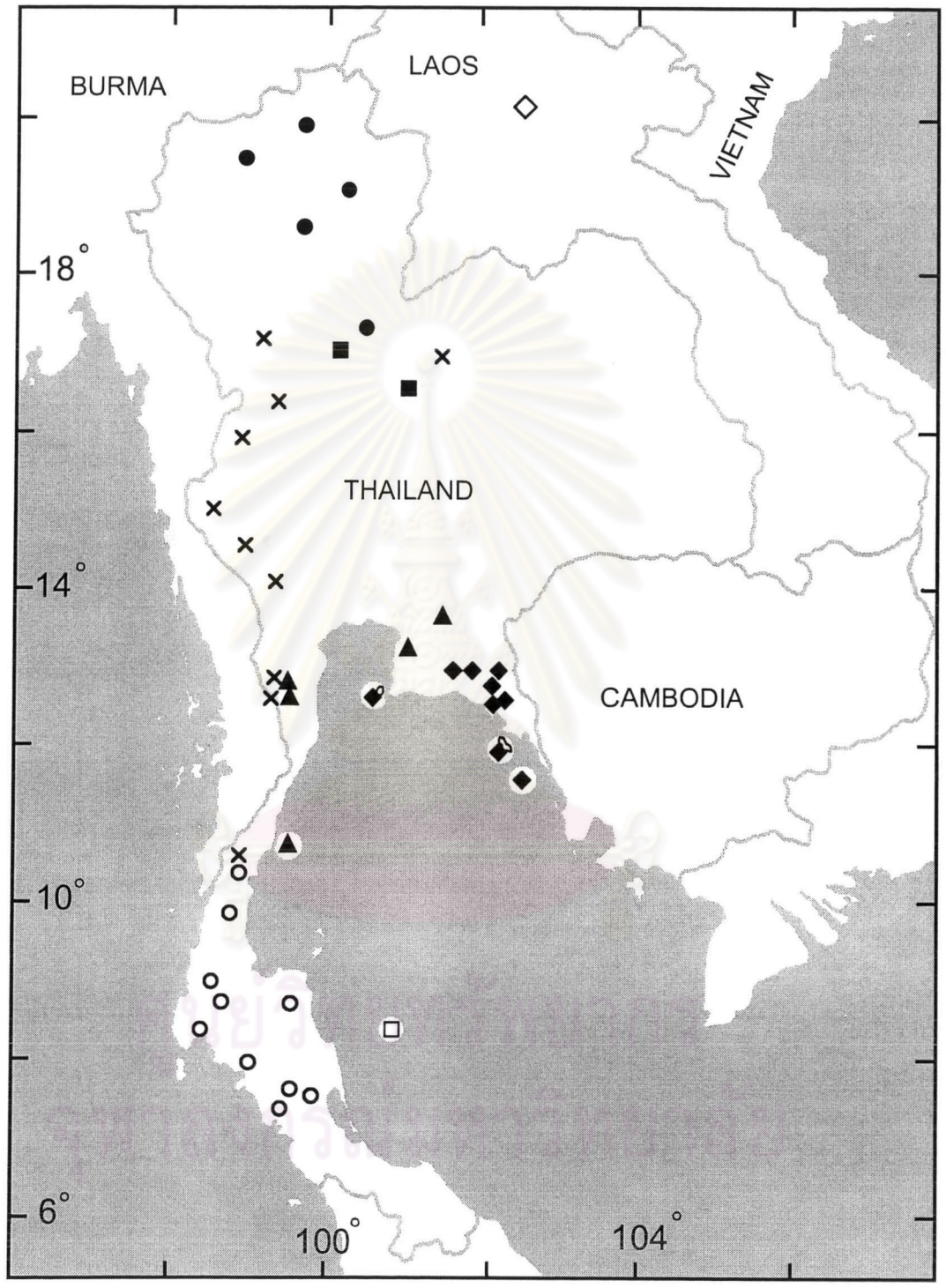

Figure 5.1 Distribution of *Amphidromus (Syndromus)* species. *A. (S.) areolatus* (■). *A. (S.) flavus* (◇). *A. (S.) semitessellatus* (▲). *A. (S.) xiengensis xiengensis* (●). *A. (S.) xiengensis* ssp. (◆). *A. (S.) fultoni* (○). *Amphidromus (Syndromus)* sp. (□). *A. (S.) glaucolarynx* (✖).

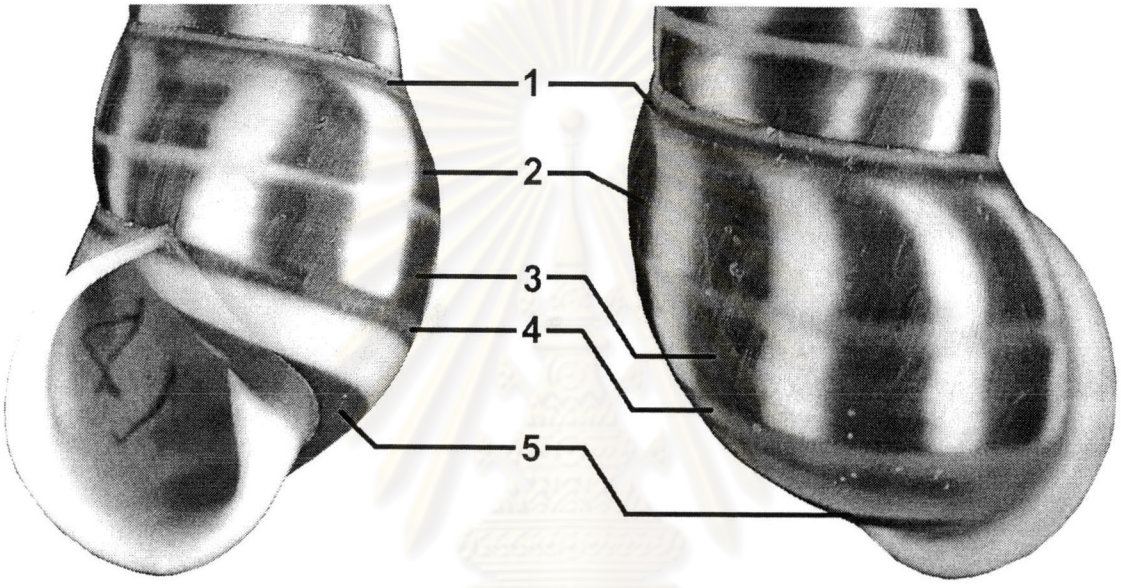

Figure 5.2 Numbering in banding pattern of *Amphidromus (Syndromus)*. Arrangement of the banding started from the suture to umbilicus; subsutural band (band 1), supra-peripheral bands (band 2 and band 3), sub-peripheral band (band 4) and columella band (band 5).

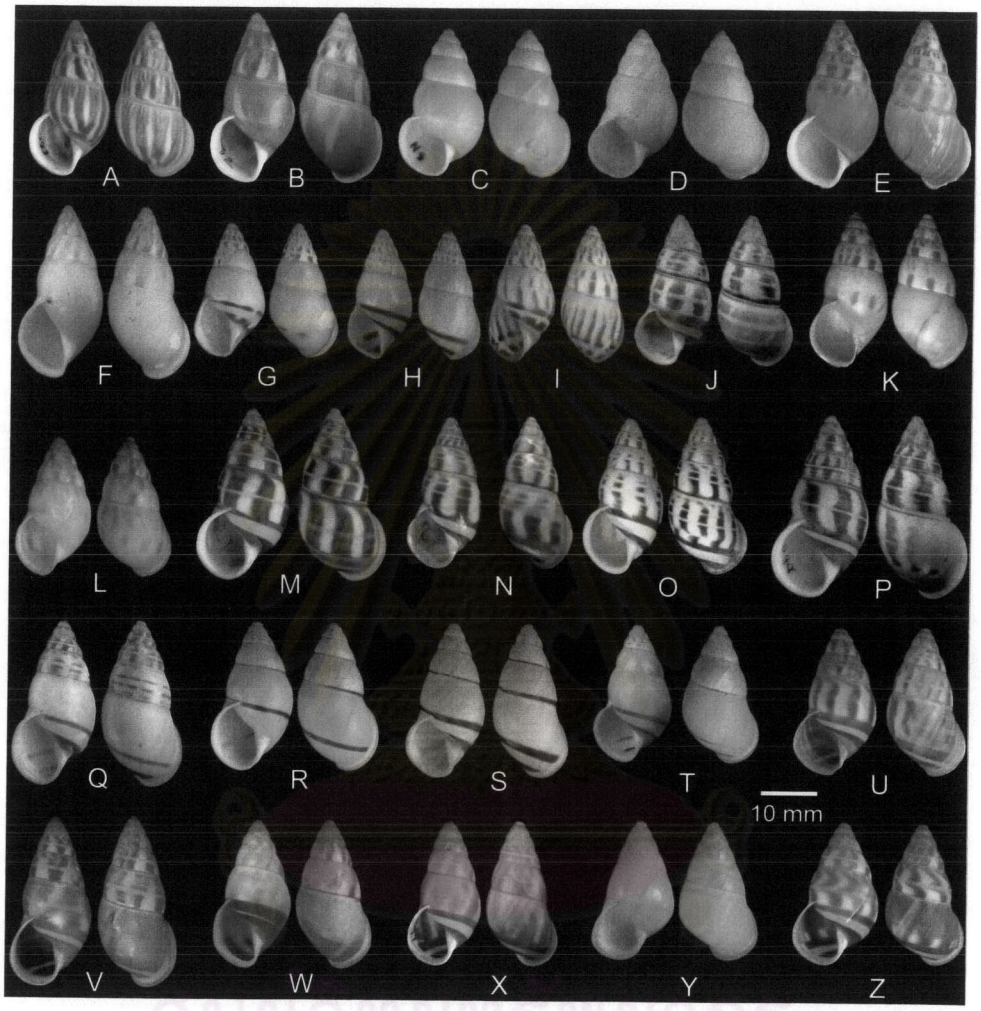

Figure 5.3 Shell characteristics of *Amphidromus (Syndromus)* species. **A, B.** *A. (S.) areolatus* from Phu Kiew, Chaiyaphum (2534). **C, D.** *A. (S.) flavus* from Luang Prabang, Lao (2472, 2533). **E-L.** *A. (S.) semitessellatus*, (**E**) from Kaeng Kracharn, Phetchaburi (2536), (**F-J**) from Khao Ang Rue Nai Wildlife Sanctuary, Chacheongsao (2376, 2446) and (**K, L**) from Khao Kiew, Chonburi (2542). **M-Q.** *A. (S.) xiengensis xiengensis*, (**M, N, Q, R**) from Mae Yom, Phare (2448), (**O, S**) from Doi Phu Nang, Prayao (2363), (**P**) from Tam Chiengdao, Chiengmai (2465) and (**T**) from Huy Kon Kom, Chiengrai (2440). **U-Z.** *A. (S.) xiengensis* ssp., (**U-W**) from Makok waterfall, Chanthaburi (2455, 2435), (**X-Y**) from Plieu waterfall, Chanthaburi (2372), (**Z**) from Koh Kud, Trat (2427).

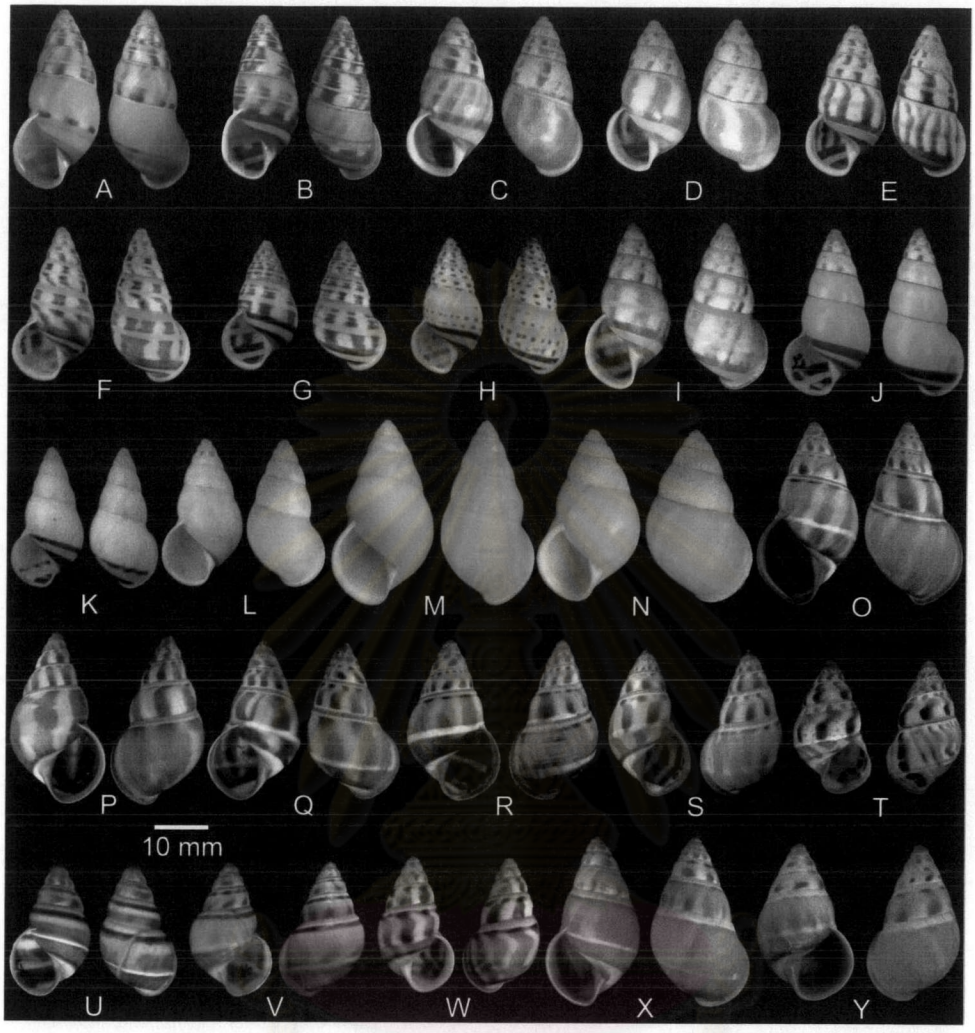

Figure 5.4 Shell characteristics of *Amphidromus (Syndromus)* species. **A-E.** *A. (S.) xiengensis anatoleus* (**A, B**) from Khao Soi Dao Wildlife Breeding Centre, Chanthaburi (2315), (**C, D**) from Koh E-lar, Chonburi (2473) and (**E**) from Wat Khao Sukim, Chanthaburi (2343). **F-L.** *A. (S.) fultoni*, (**F, J**) from Ban Takun, Suratthani (2474), (**G**) from Khao Kriap, Chumporn (2415), (**H**) from Wat Tham Lord, Nakhonsrithammarat (2334), (**I**) from Khirirat Nikhom, Suratthani (2421), (**K**) from Khao Poo-Khao Ya National Park, Patthalung (2425) and (**L**) from Sra Morakot, Krabi (2346). **M, N.** *Amphidromus (Syndromus)* sp. from Koh Kra, Nakhonsrithammarat (2543, 2478). **O-Y.** *A. (S.) glaucolarynx* (**O, P**) from Ban Krang Kaeng Kracharn National Park, Phetchaburi (2453), (**Q, R**) from Mae Sod, Tak (2319), (**S**) from Pong Phu Ron, Thong Phaphum, Kanchanaburi (2540), (**T**) from Tam Pra Krayang, Ranong (2260), (**U, V**) from Lin Tin, Thong Pha Phum, Kanchanaburi (2270), (**W**) from Chong Khao Kad, Sai Yok, Kanchanaburi (2267) and (**X-Y**) from Sai Yok Noi waterfall, Sai Yok, Kanchanaburi (2532).

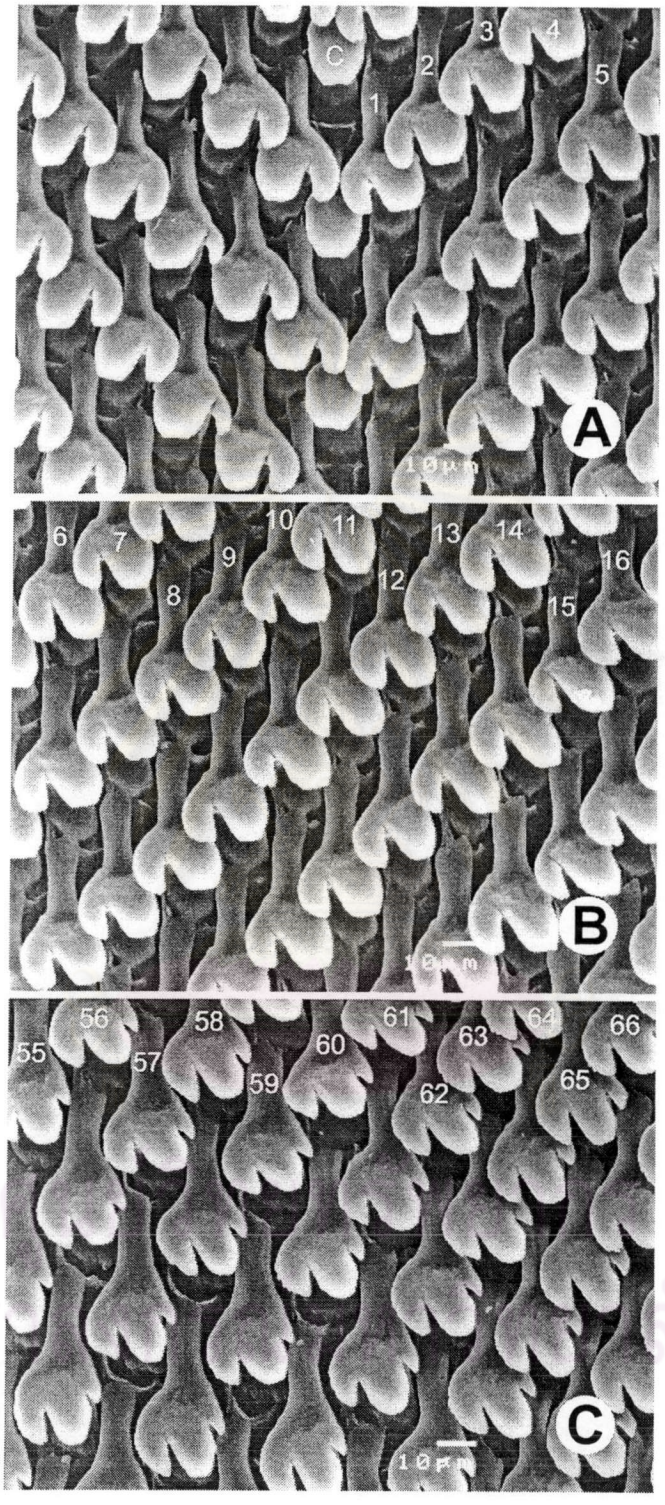

Figure 5.5 SEM images of the radula. **A-C.** *A. (S.) flavus* (2472, April 2002), (**A**) central tooth with the first to the forth lateral teeth, (**B**) lateral teeth with the tricuspid marginal teeth transition, and (**C**) outermost marginal teeth. Numbers indicated order of lateral and marginal teeth. Central tooth indicated by 'C'.

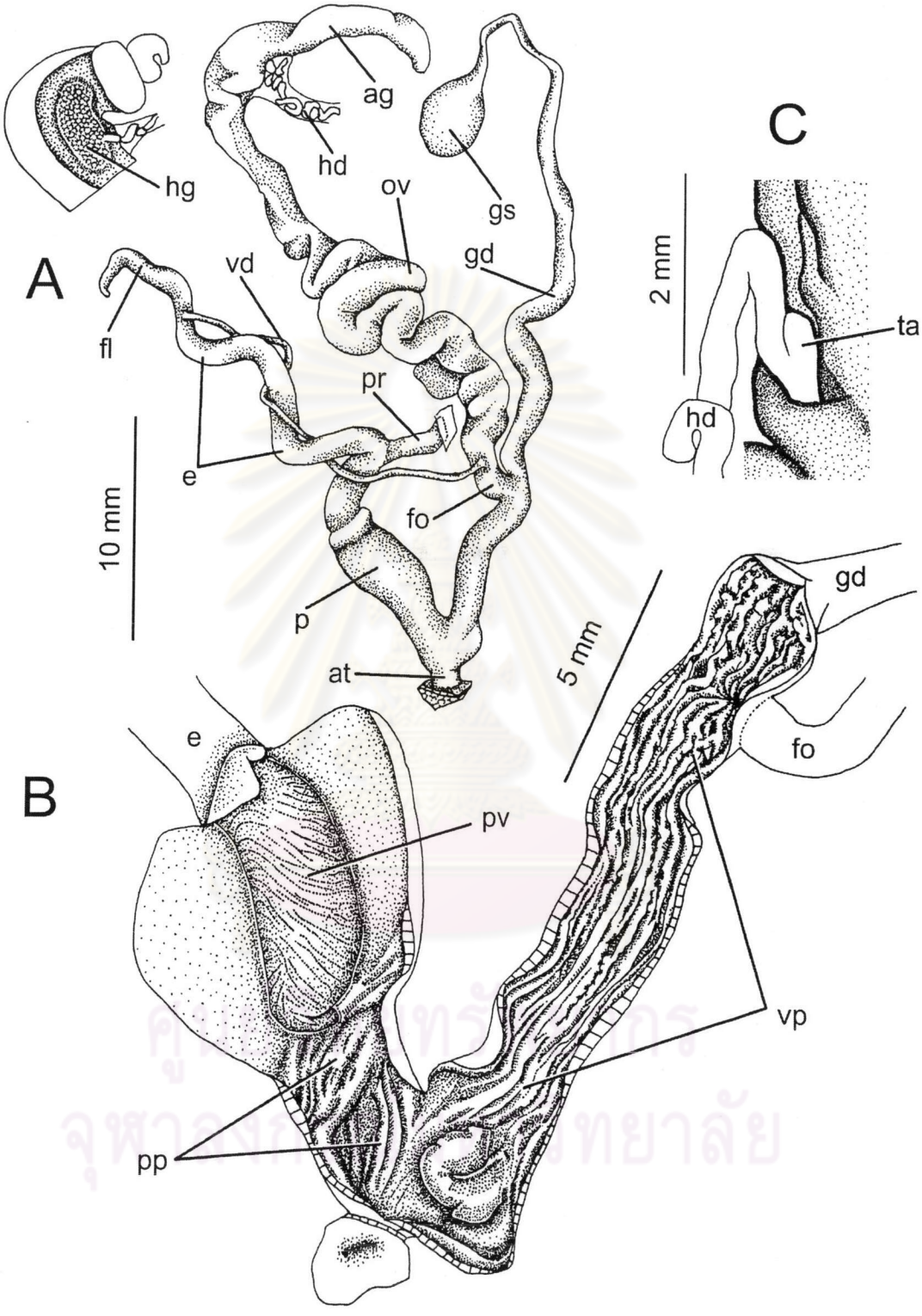

Figure 5.6 *Amphidromus (S.) flavus* (2472)–Anatomy. **A.** The whole genital system. **B.** Interior structure of penis, atrium and vagina chamber. **C.** Details of hermaphroditic duct and talon junction.

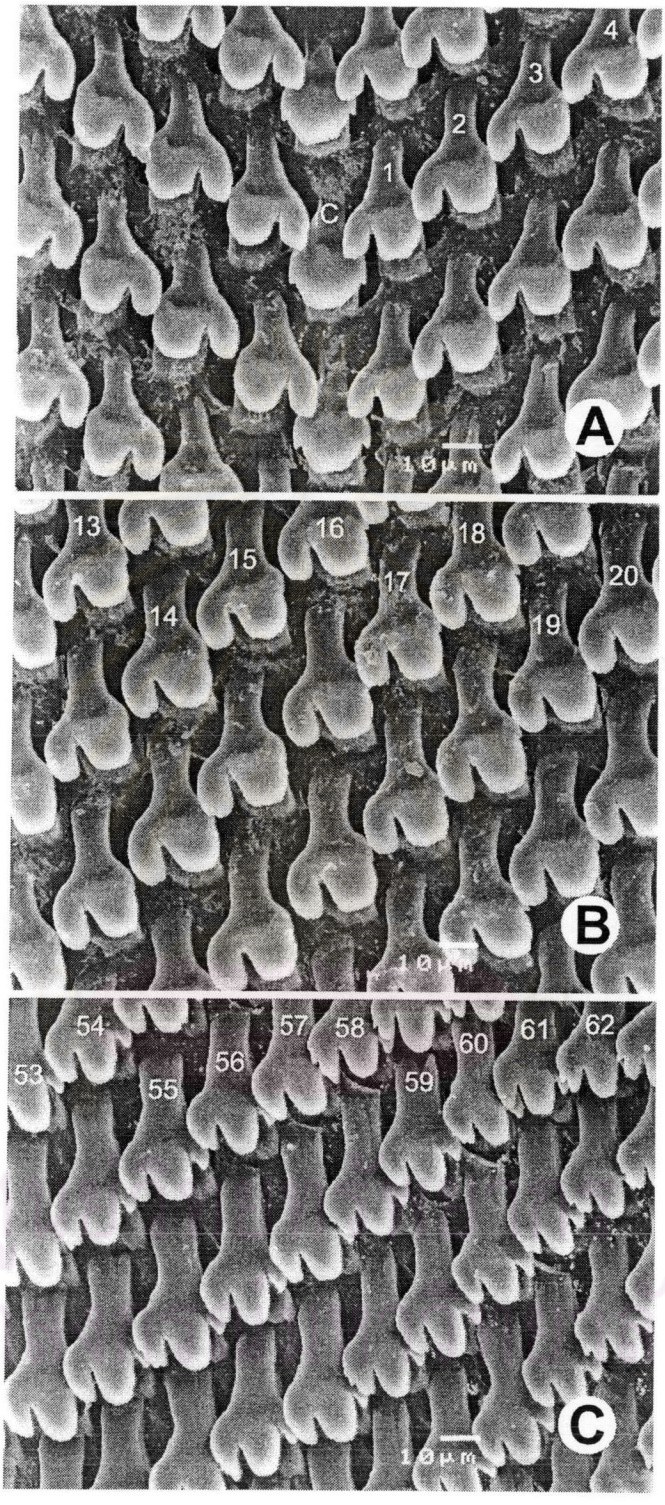

Figure 5.7 SEM images of the radula. **A-C.** *A. (S.) semitessellatus* (2535, September 2003), (**A**) central tooth with the first to the forth lateral teeth, (**B**) lateral teeth with the tricuspid marginal teeth transition, and (**C**) outermost marginal teeth. Numbers indicated order of lateral and marginal teeth. Central tooth indicated by 'C'.

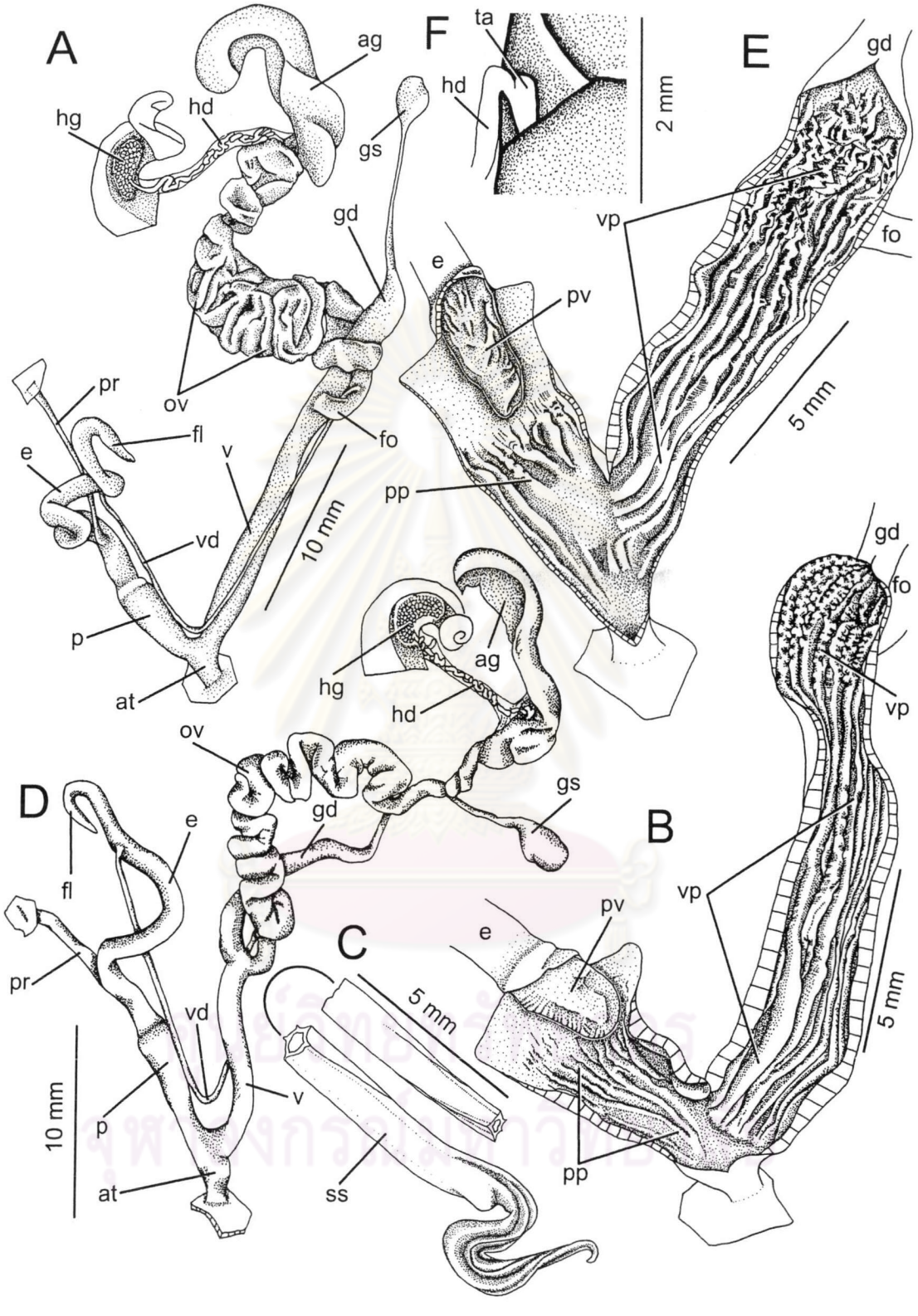

Figure 5.8 *Amphidromus (S.) semitessellatus*–Anatomy. **A-C** from Khao Ang Rue Nai wildlife sanctuary (2447) and **D-F** from Kaeng Kracharn (2535). **A, D.** The whole genital system. **B, E.** Interior structure of penis, atrium and vagina chamber. **C.** The spermatophore. **F.** Details of hermaphroditic duct and talon junction.

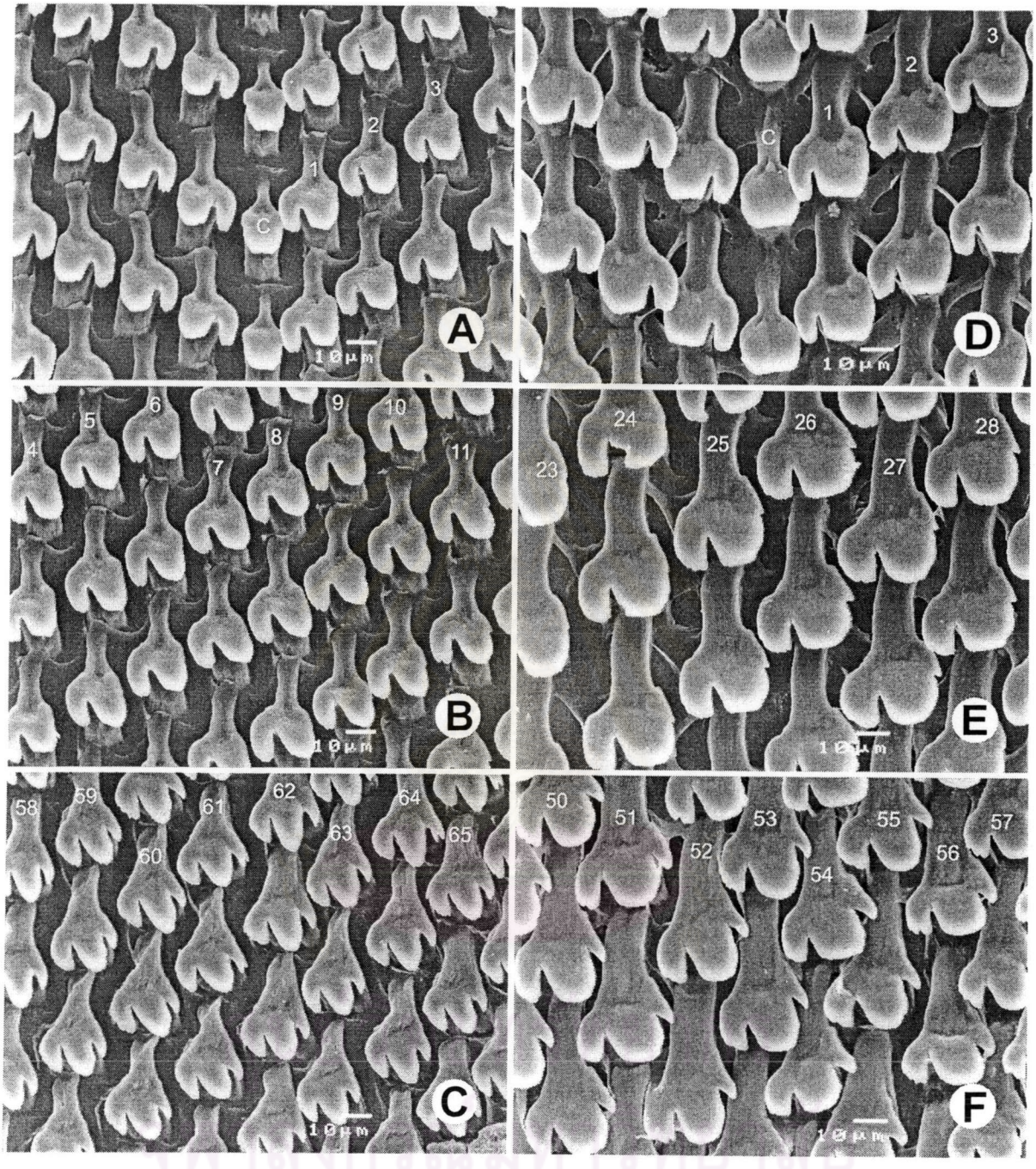

Figure 5.9 SEM images of the radula. **A-C.** *A. (S.) xiengensis xiengensis* (2465, April, 2001), (**A**) central tooth with the first to the forth lateral teeth, (**B**) lateral teeth with the tricuspid marginal teeth transition, and (**C**) outermost marginal teeth. **D-F.** *A. (S.) xiengensis* ssp. (2435, 19 September, 2001), (**D**) central tooth with the first to the fifth lateral teeth, (**E**) lateral teeth with the tricuspid marginal teeth transition, and (**F**) outermost marginal teeth. Numbers indicated order of lateral and marginal teeth. Central tooth indicated by 'C'. Numbers indicated order of lateral and marginal teeth. Central tooth indicated by 'C'.

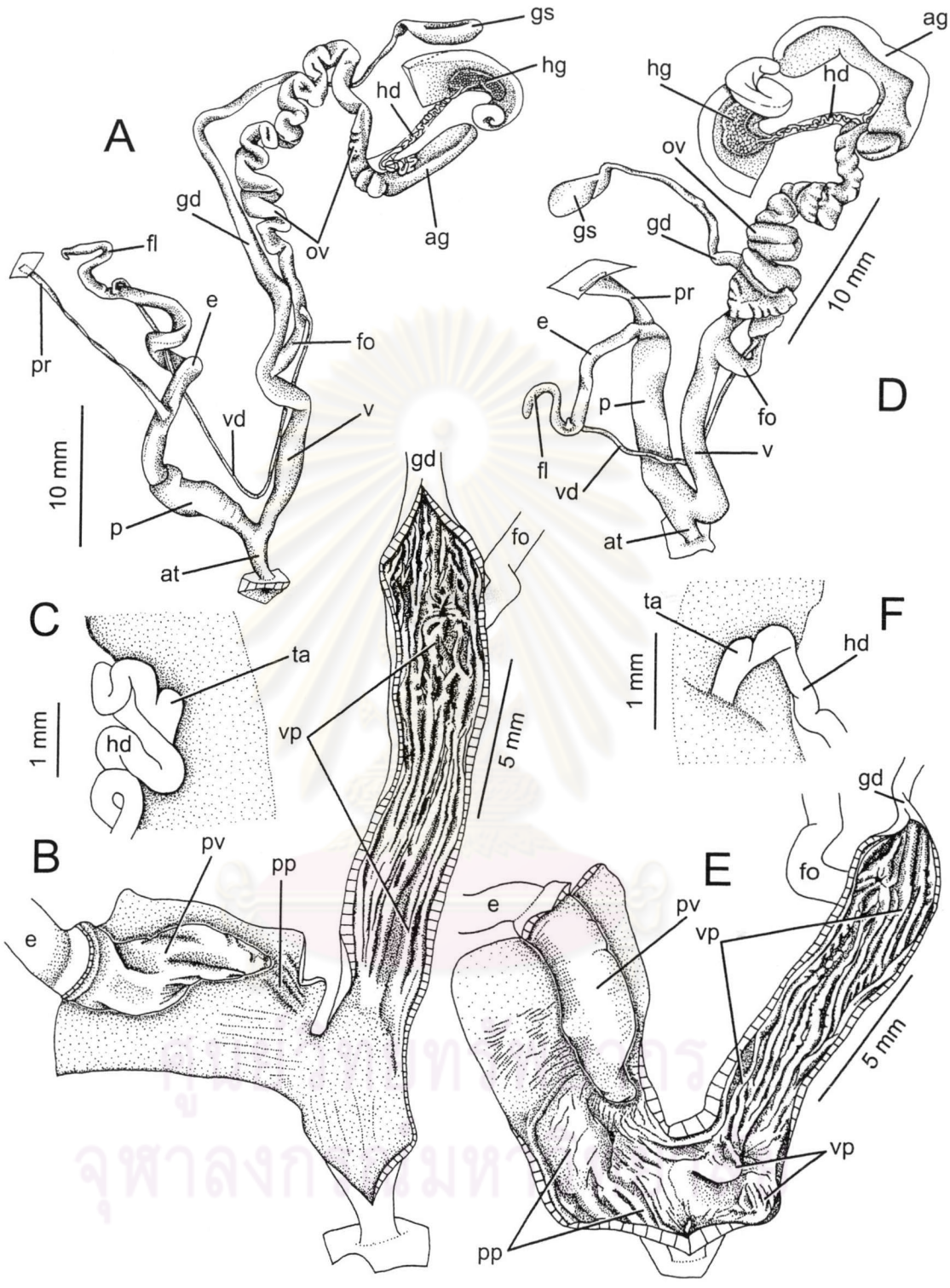

Figure 5.10 *Amphidromus (S.) xiengensis xiengensis* (2465)–Anatomy. **A.** The whole genital system. **B.** Interior structure of penis, atrium and vagina chamber. **C.** Details of hermaphroditic duct and talon junction. **D-F.** *Amphidromus (S.) xiengensis* ssp. (2435)–Anatomy, (**D**) the whole genital system, (**E**) interior structure of penis, atrium and vagina chamber, and (**F**) details of hermaphroditic duct and talon junction.

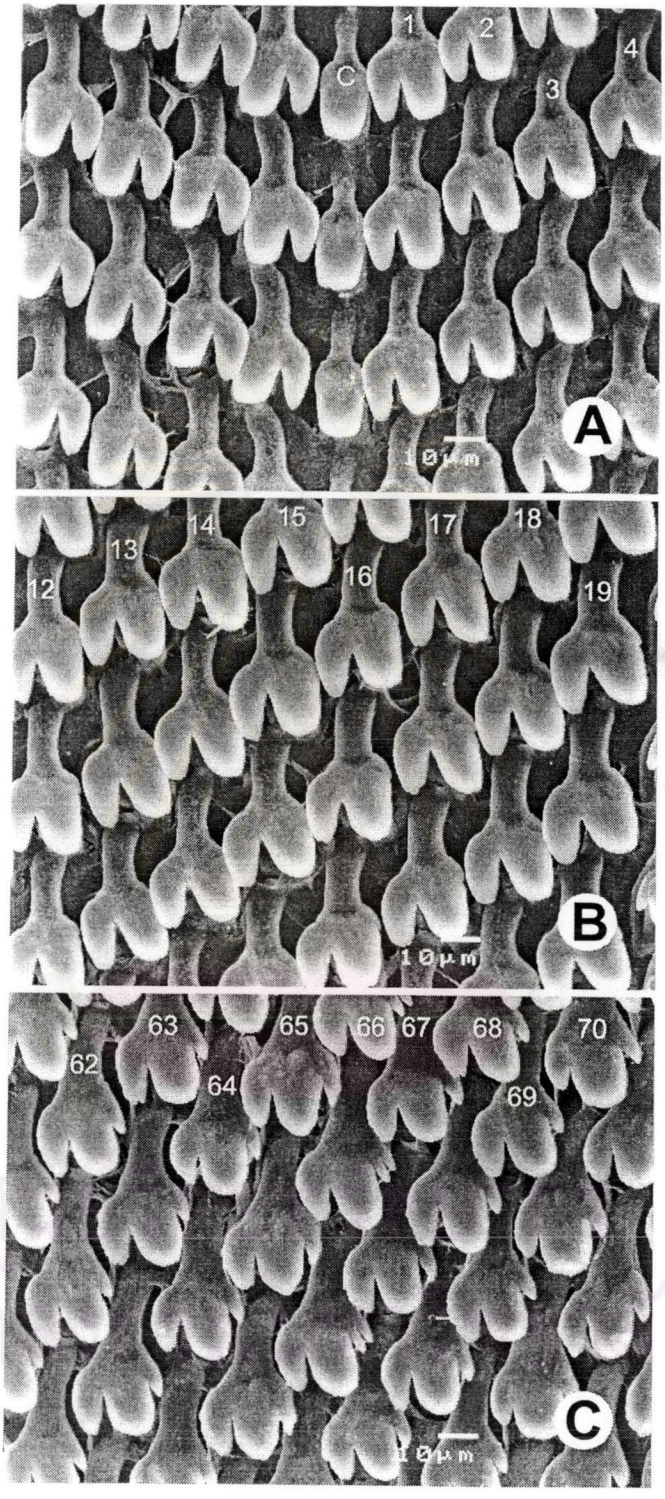

Figure 5.11 SEM images of the radula. **A-C.** *A. (S.) fultoni* (2474, 15 May, 2000), (**A**) central tooth with the first to the forth lateral teeth, (**B**) lateral teeth with the tricuspid marginal teeth transition, and (**C**) outermost marginal teeth. Numbers indicated order of lateral and marginal teeth. Central tooth indicated by 'C'.

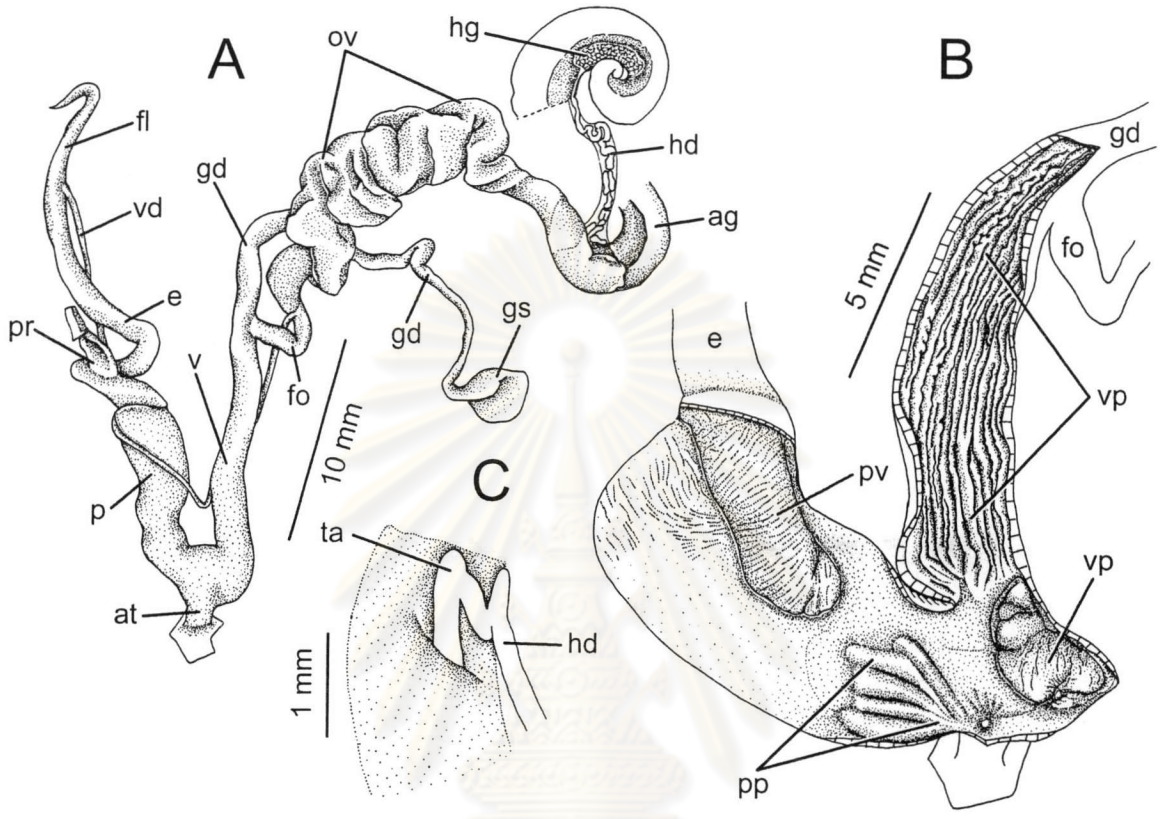

Figure 5.12 A-C. *Amphidromus (S.) fultoni* (2474)–Anatomy, (**A**) the whole genital system, (**B**) interior structure of penis, atrium and vagina chamber, and (**C**) Details of hermaphroditic duct and talon junction.

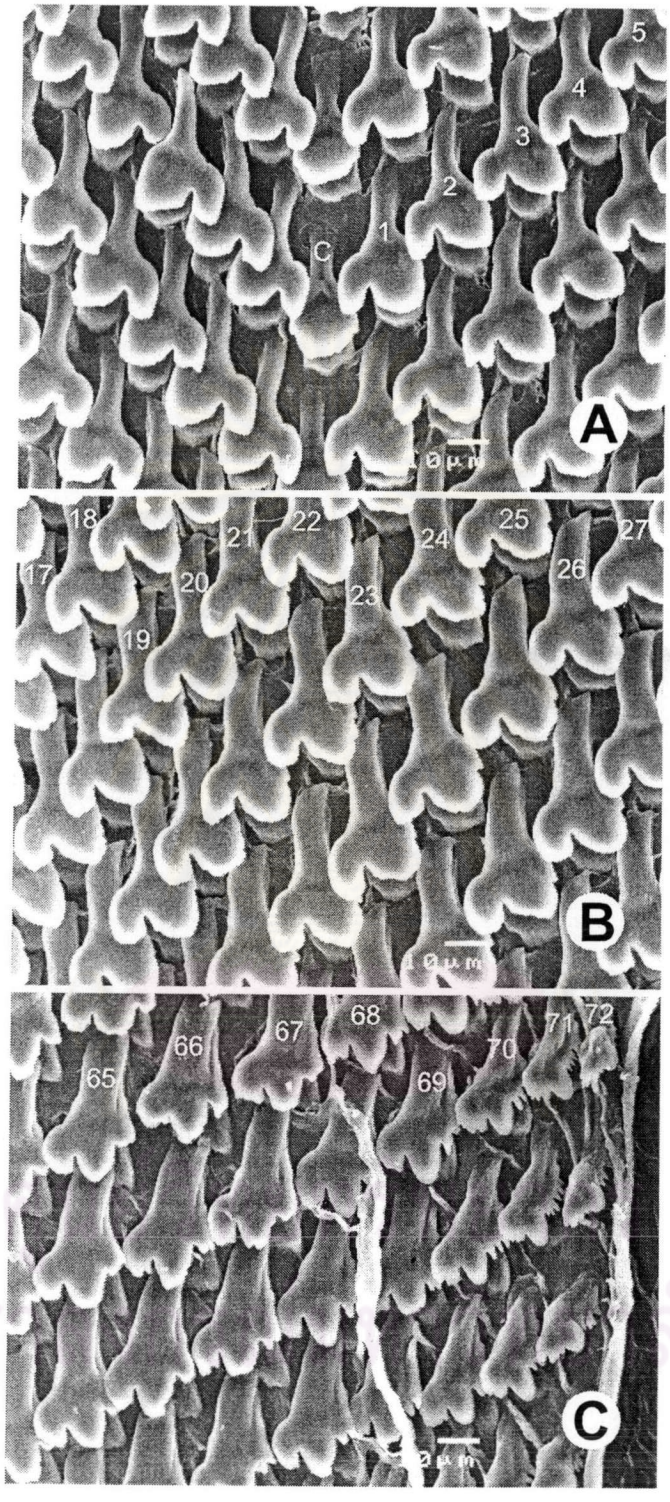

Figure 5.13 SEM images of the radula. **A-C.** *Amphidromus (Syndromus)* sp. (2478, April, 2000), (**A**) central tooth with the first to the forth lateral teeth, (**B**) lateral teeth with the tricuspid marginal teeth transition, and (**C**) outermost marginal teeth. Numbers indicated order of lateral and marginal teeth. Central tooth indicated by 'C'.

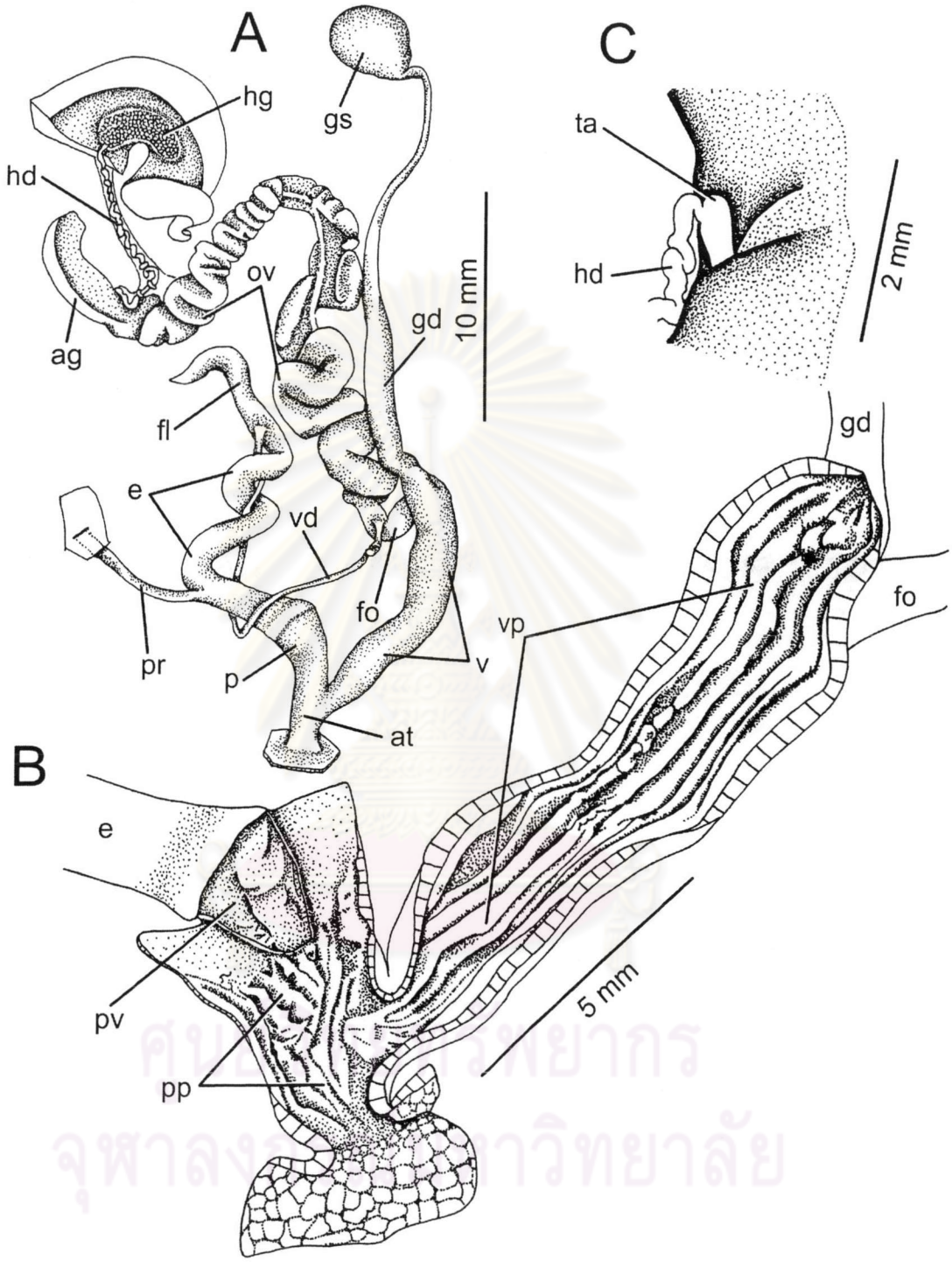

Figure 5.14 *Amphidromus (Syndromus)* sp. (2478)–Anatomy. **A.** The whole genital system. **B.** Interior structure of penis, atrium and vagina chamber. **C.** Details of hermaphroditic duct and talon junction.

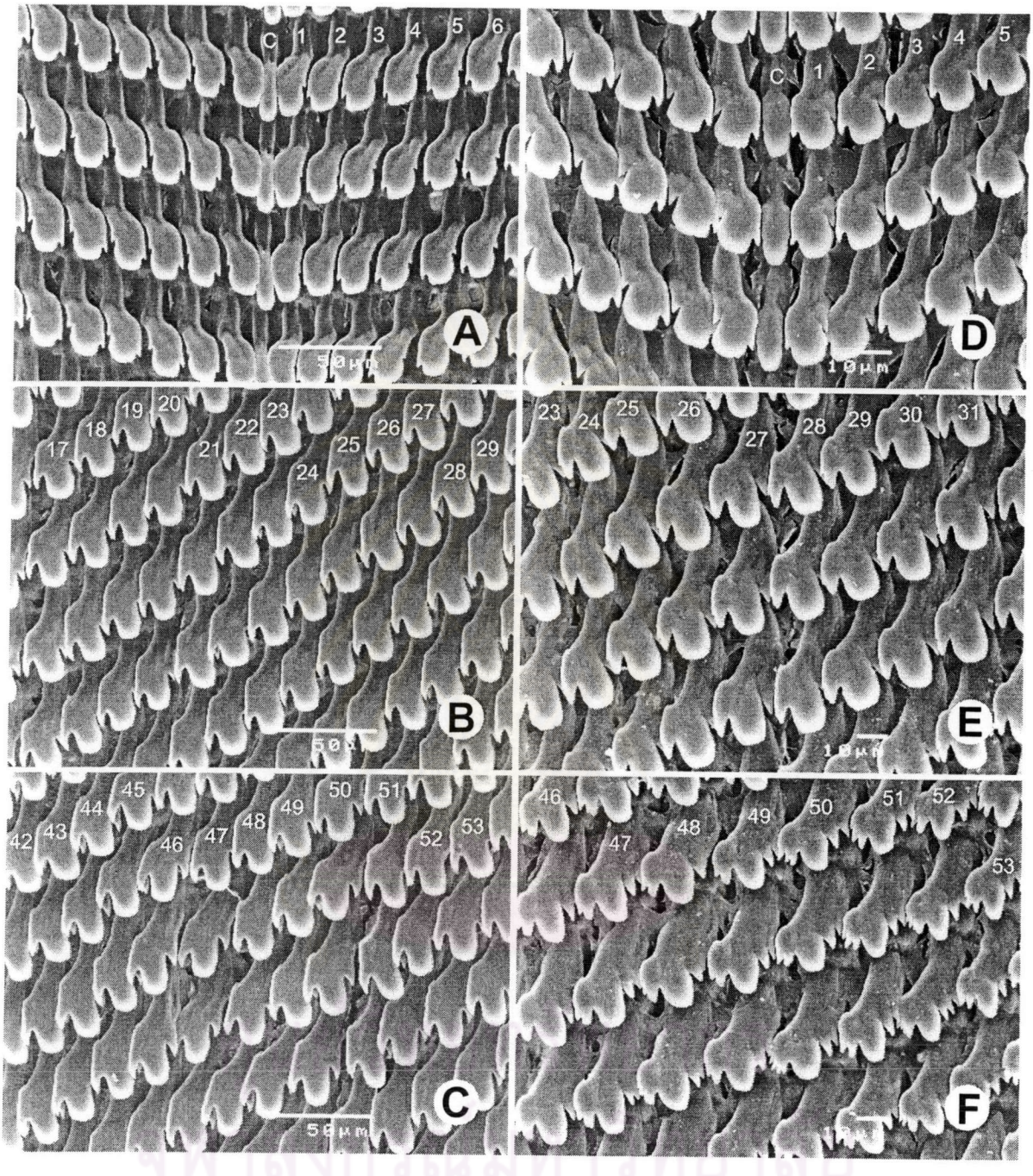

Figure 5.15 SEM images of the radula. **A-C.** *A. (S.) glaucolarynx* (2453, September, 2003), (**A**) central tooth with the first to the forth lateral teeth, (**B**) lateral teeth with the tricuspid marginal teeth transition, and (**C**) outermost marginal teeth. Numbers indicated order of lateral and marginal teeth. Central tooth indicated by 'C'.

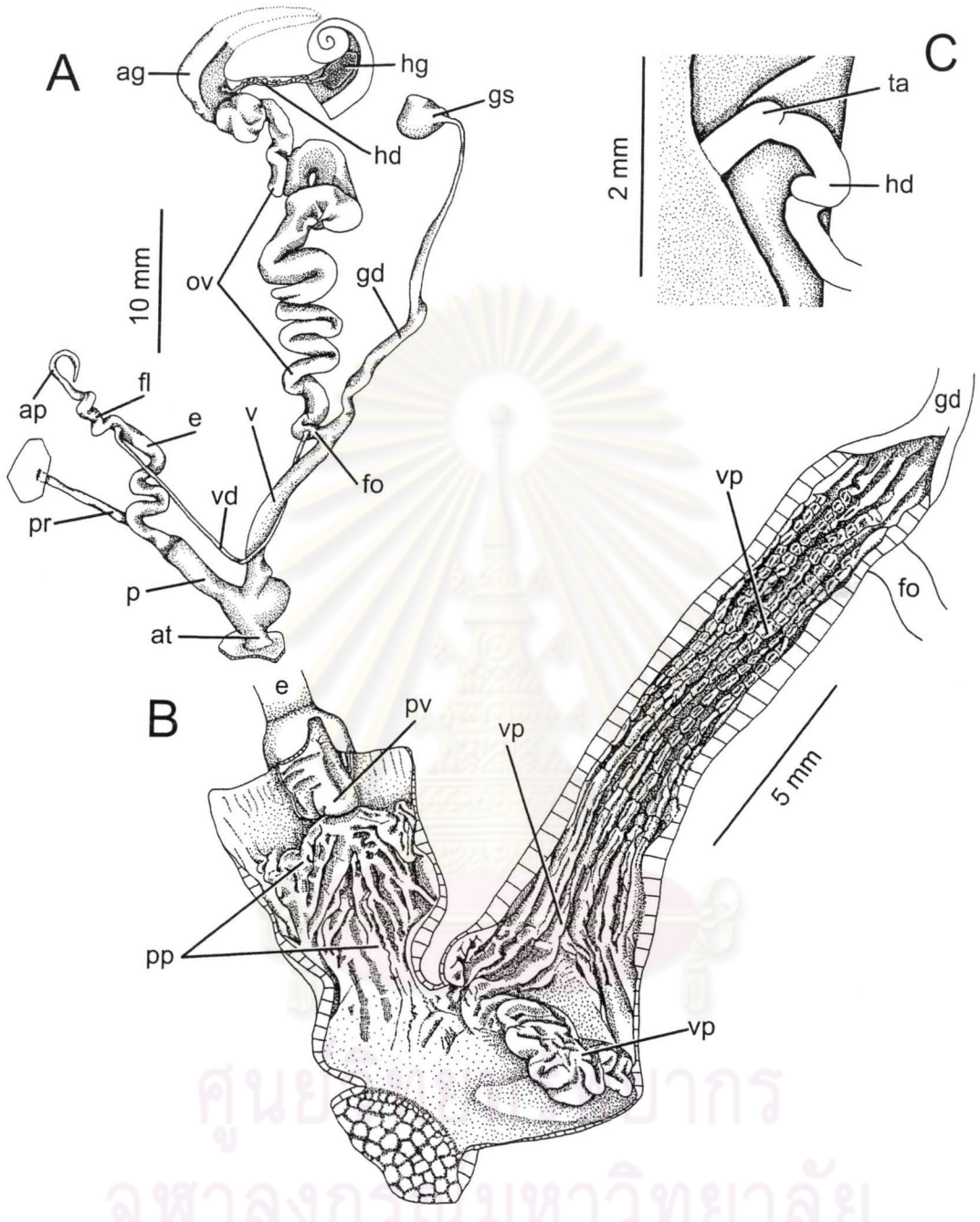

Figure 5.16 *Amphidromus (S.) glaucolarynx* (2453)–Anatomy. **A.** The whole genital system. **B.** Interior structure of penis, atrium and vagina chamber. **C.** Details of hermaphroditic duct and talon junction.