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DATA PAPER

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Antarctic Porifera database from the Spanish benthic expeditions

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Abstract

The information about the sponges in this dataset is derived from the samples collected during five Spanish Antarctic expeditions: Bentart 94, Bentart 95, Gebrap 96, Ciemar 99/00 and Bentart 2003. Samples were collected in the Antarctic Peninsula and Bellingshausen Sea at depths ranging from 4 to 2044 m using various sampling gears.

The Antarctic Porifera database from the Spanish benthic expeditions is unique as it provides information for an under-explored region of the Southern Ocean (Bellingshausen Sea). It fills an information gap on Antarctic deep-sea sponges, for which there were previously very few data.

This phylum is an important part of the Antarctic biota and plays a key role in the structure of the Antarctic marine benthic community due to its considerable diversity and predominance in different areas. It is often a dominant component of Southern Ocean benthic communities.

The quality of the data was controlled very thoroughly with GPS systems onboard the R/V Hesperides and by checking the data against the World Porifera Database (which is part of the World Register of Marine Species, WoRMS). The data are therefore fit for completing checklists, inclusion in biodiversity pattern analysis and niche modelling. The authors can be contacted if any additional information is needed before carrying out detailed biodiversity or biogeographic studies.

The dataset currently contains 767 occurrence data items that have been checked for systematic reliability. This database is not yet complete and the collection is growing. Specimens are stored in the author's collection at the Spanish Institute of Oceanography (IEO) in the city of Gijón (Spain). The data are available in GBIF.

Keywords
Porifera, Antarctic, Deep-Sea, Biodiversity, BENTART, Antarctic Peninsula, Bellingshausen Sea, Sponges, Benthic fauna

General description

The main objective of these surveys, within the Bentart, Gebrap and Ciemar projects, was to study benthic ecosystem biodiversity in the Bellingshausen Sea and Antarctic Peninsula, an area for which there is little information. Samples were taken for quantification of infauna and epibenthos paying particular attention to suprabenthos, meiofauna and demersal fish.

The preliminary data analysis showed that there was very little epibenthic and suprabenthic fauna in the Bellingshausen Sea compared to the northern areas (Antarctic Peninsula and South Shetland Islands).

As there are few collections available in the GBIF database the present collection improves scientific knowledge of the Porifera in the Antarctic Peninsula and Bellingshausen Sea and provides new and important information on the distributions of the species.

This phylum is an important part of the Antarctic biota and plays a key role in the structure of the Antarctic marine benthic community due to its considerable diversity and predominance in different areas. It is often a dominant component of Southern Ocean benthic communities.

The quality of the data was controlled very thoroughly and therefore the data are fit for completing checklists, inclusion in biodiversity pattern analysis and niche modelling. The database fills an information gap on deep-sea sponges from the Southern Ocean, for which there were previously very few data.

The dataset currently contains 767 occurrence data items that have been checked for systematic reliability. This database is not yet complete and the collection is growing. Specimens are stored in the author's collection at the Spanish Institute of Oceanography (IEO) in the city of Gijón (Spain). The data are available in GBIF.

Project details

Project title: Benthic biodiversity of the Bellingshausen Sea and Antarctic Peninsula: Porifera

Personnel: Pilar Rios and Javier Cristobo

Funding: This database has been supported through the following projects:

1. Estudios de la fauna y flora bentónica de los fondos de la zona sur de la isla Livingston (Shetlands del Sur), Antártida. (Project ANT93-0996).
2. Estudios de la fauna y flora bentónica de los fondos de la zona sur de la isla Livingston y áreas adyacentes (Shetlands del Sur, Antártida. (Project ANT94-1161-E).
3. Fauna y Flora Bentónicas de los fondos del Sur de la Isla Livingston y áreas adyacentes: estudio del material biológico y datos recogidos en las campañas nacionales del Bentos Antártico. (Project ANT95-1011).
4. Muestreos bentónicos en áreas volcánicas de la cuenca del Bransfield (Antártida). (Project ANT96-2440-E).
5. Ampliación del Proyecto: Fauna y flora bentónica de los fondos de la zona sur de isla Livingston y áreas adyacentes. Estudio del material biológico y datos recogidos en las dos campañas españolas de bentos antártico (Project ANT97-2097-E).

Estudio integrado de la biodiversidad bentónica del Mar de Bellingshausen y Península Antártica (Antártida del Oeste) (Segunda Campaña de Muestreo a bordo del BIO Hespérides) Project MCYT REN2003-01881/ANT.

Study area: The study area was the western sector of the Antarctic (Bellingshausen Sea, Peter I Island and Antarctic Peninsula), in particular the continental shelf, upper slope and deep-sea basins of the Bellingshausen Sea. There is very little information on this sector and the sampling showed that there are interesting sponge species here. According to a recent gap analysis carried out by Griffiths et al. (2010) the deep-sea zone of the Southern Ocean is in general a very under sampled area.

Design: The Antarctic sector corresponding to the Bellingshausen Sea is one of the most difficult areas to access with a research vessel due to the prevalence of ice most of the year (Clarke and Johnston 2003). Peter I Island (68°S) is an isolated oceanic island that lies 450 km north of Eights Coast at about 4 km water depth. The island has a maximum length of 20 km and rises to a height of 1 640 m. It is composed of different volcanic rocks although most of its surface is glaciated.

The BENTART Projects were carried out from 1994 to 2006 in four oceanographic surveys onboard the R/V Hespérides and provided valuable information on the Antarctic benthic biodiversity in the South Shetlands, Antarctic Peninsula and Bellingshausen Sea. The methodological approach used was totally innovative and consisted in sampling transects that were perpendicular to the coast at stations with a previously established bathymetric layer. The large-scale variations in the different biodiversity and abundance indices were established along latitudinal and bathymetric gradients. Quantitative multiple sampling of the three benthic compartments (endofauna, epibenthos and suprabenthos) using specific sampling gears (box corer, Agassiz trawl and suprabenthic sled) in the water column and sediment at the same stations made it possible to analyse both the biotic and abiotic data as well as gain an overall view of the benthic ecosystems and factors that regulate their distribution.

During the GEBRAP 96 survey nine trawls at 647 to 1592 m in depth were carried out on underwater volcanic structures located in the central basin of Bransfield Strait.

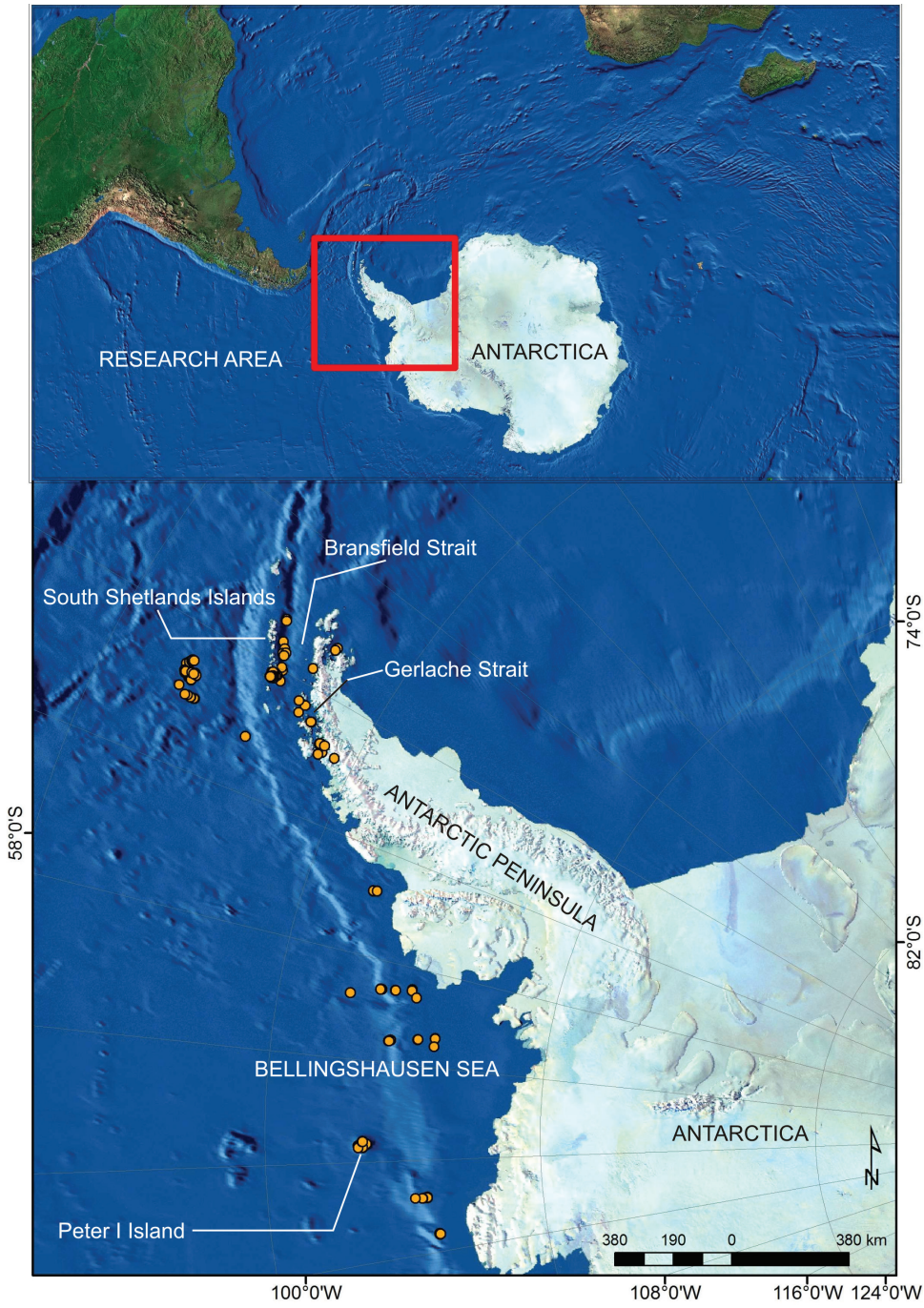

Figure 1. Bentart, Gebrap and Ciemar stations in the Bellingshausen Sea, Peter I Island and Antarctic Peninsula (South Shetland Islands, Bransfield and Gerlache Straits).

Figure 2. Summary of the procedure used to generate the dataset.

The objective was to collect lithological samples and associated benthic fauna exposed to hydrothermalism.

The macrobenthos from the Bransfield and Gerlache Straits was sampled in the CIEMAR 99/00 expedition onboard the R/V Hespérides. Invertebrate fauna was collected at 14 stations using a rock dredge with 80 cm and 30 cm horizontal and vertical openings and a 10 mm mesh size.

Porifera are one of the most important elements in the Antarctic biota due to their considerable diversity and predominance in different areas (Sarà et al. 1992). In the Antarctic benthos at depths of 100 m these sponges can attain a biomass comparable to the largest sponges from tropical areas (Beliaev and Ushakov 1957). Their large size and that of their spicules, as well as their uniform distribution, are the main aspects that characterize them. These areas are rich in silica sponges (Demospongiae and Hexactinellida) and there are very few calcareous sponges. In this project we computerized and georeferenced the database of specimens collected during the Spanish expeditions Bentart 94, Bentart 95, Bentart 03, Gebrap 96 and Ciemar 99/00.

Data published at GBIF: http://www.gbif.es:8080/ipt/resource.do?r=porifera-bentart

Taxonomic coverage

This database is devoted to the Porifera collected in the Spanish Antarctic Expeditions (Bentart, Gebrap and Ciemar) in the Antarctic Peninsula and Bellingshausen Sea onboard the R/V Hesperides. The Antarctic sponge species are characterized by an overall endemism of 43% with a higher level for the class Hexactinellida (68%) and a few endemic genera dominating shelf communities, most notably in the Weddell and Ross Seas. The Demospongiae class has the highest number of species in the Antarctic Porifera and has been recorded in all regions of the Antarctic. Calcareous sponges are the least abundant and least studied class of sponges in the Antarctic.

General taxonomic coverage: The sponges of the Antarctic and neighbouring oceanographic regions were assessed for species richness and biogeographic patterns based on over 8800 distribution records (Downey et al. 2012). Sampling intensity has varied greatly in the Antarctic. Sampling hotspots are the Antarctic Peninsula, South Georgia, north New Zealand and Tierra del Fuego. There has been little sampling carried out in the Bellingshausen and Amundsen Seas in the Southern Ocean.

Previous estimates of the number of sponge species in the Southern Ocean (SO) vary between 250 and 530. All four classes of Porifera (Hexactinellida, Demospongiae, Homoscleromorpha and Calcarea) are represented in the SO. There is a higher diversity and abundance of the first two classes (particularly the demosponges) compared to the last two. Recent studies (Downey et al. 2012) have found that there are 397 sponge species from the Southern Ocean, representing 139 genera in 70 families.

This dataset focuses on Antarctic Porifera and includes data on nine orders. The highest level of identification is Order Poecilosclerida with 53 species (577 samples). We identified five species of Lyssacinosida (123 samples), one species of Leucosolenida (2 samples), one species of Chondrosida (1 sample), three species of Spirophorida (70 samples), six species of Hadromerida (138 samples), two genera of Halichondrida (64 samples), five species of Haplosclerida (157 samples), one species of Dendroceratida (19 samples) and 63 records identified at class level.

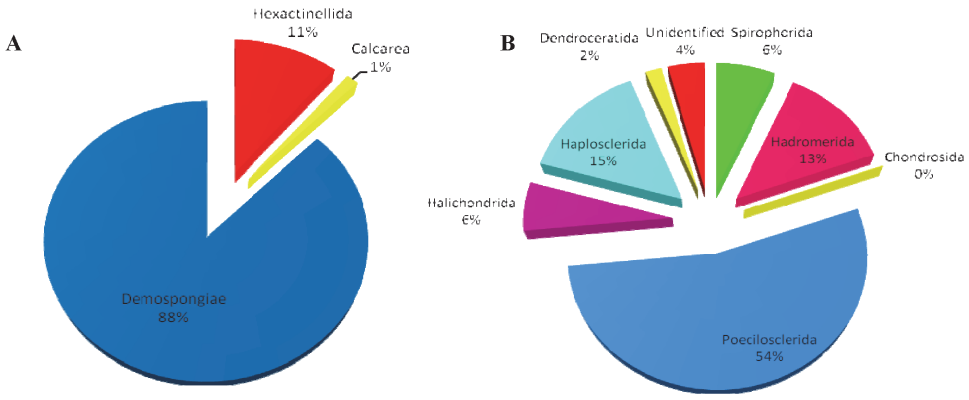

Figure 3. A Distribution range of the Porifera classes **B** Orders within the class Demospongiae.

Taxonomic ranks

Kingdom: Animalia
Phylum: Porifera
Class: Hexactinellida, Demospongiae and Calcarea
Order: Chondrosida, Dendroceratida, Hadromerida, Halichondrida, Haplosclerida, Leucosolenida, Lyssacinosida, Poecilosclerida, Spirophorida
Family: Acarnidae, Axinellidae, Chalinidae, Cladorhizidae, Clathriidae, Coelosphaeiridae, Darwinnellidae, Dendoricellidae, Desmacellidae, Grantiidae, Guitarridae, Halichondriidae, Halisarcidae, Hymedesmiidae, Iotrochotidae, Isodictyidae, Latrunculidae, Microcionidae, Mycalidae, Myxillidae, Niphatidae, Petrosiidae, Phloeodictyidae, Polymastiidae, Raspailidae, Rossellidae, Stylocordylidae, Suberitidae, Tedaniidae, Tetillidae, Timeidae
Common names: Sponges

Spatial coverage

General spatial coverage

The sampling area ranged from 70°53'S to 60°19'S latitude and from 57°01"W to 98°28"W longitude (Figure 1).

Coordinates

70°53'31"S and 60°19'08”S latitude; 57°01'10"W and 98°28'54"W longitude.

Temporal coverage:

Bentart expeditions: 1994–2003
Gebrap expedition: 1996
Ciemar expedition 1999–2000

Description of the natural collections

Parent collection identifier: Instituto Español de Oceanografia (IEO) Gijon Porifera
Collection name: IEO Gijon Porifera BENTART
Collection identifier: Pilar Ríos, Javier Cristobo. http://www.gbif.es:8080/ipt/
Specimen preservation method: Ethanol

Methods

Steps:

- The material examined onboard the R/V Hesperides was collected with different methods: rock dredge, Van Veen dredge, anchor dredge, suprabenthic sledge, fish traps, scuba diving, box corer and Agassiz trawl.
- Once on deck, the contents of the samplers were immediately sorted by taxa, washed in cold sea water and classified by a specialist in each group. Sponge samples were then placed in 80% ethanol.
- The taxonomic identification was performed in the laboratory using an optical microscope and a Scanning Electron Microscope when necessary.

Study area: The Southern Ocean with particular emphasis on the coastal shelf areas of the Bellingshausen Sea and Antarctic Peninsula as well as the Peter I, Deception and Livingston islands, without specific temporal sampling patterns.

Sampling: Porifera were collected during oceanographic cruises in the Antarctic Ocean from 1994 to 2003 as part of the Spanish expeditions Bentart 94, Bentart 95, Bentart 03, Gebrap 96 and Ciemar 99/00. The database has been upgraded with data collected in 2013. Specimens were fixed in 4% formaldehyde or 70% ethanol and then preserved in 70% ethanol. Treatment in formalin made it possible to carry out cytological studies. In the laboratory the organic matter was digested with nitric acid taken to boiling point according to the methods developed by Rützler (1978) and Cristobo et al. (1993). The spicules of some samples were examined using a Leica S440 Scanning Electron Microscope.

Quality control: Systematic reliability and consistency were checked by Pilar Rios and Javier Cristobo. Identification was based on species descriptions by different authors compiled in Systema Porifera (Hooper and Soest 2002). The doctoral thesis by Rios (2007) was used to check Antarctic species. The classification system proposed by Van Soest and Hajdu (2002) was used.

Datasets

Dataset description

Object name: Darwin Core Archive Antarctic Porifera database from the Spanish benthic expeditions
Character encoding: UTF-8
Format name: Darwin Core Archive format
Format version: 1.0
Distribution: http://www.gbif.es:8080/ipt/archive.do?r=poriferabentart
Publication date of data: 2013-05-14

Language: Spanish
Licenses of use: This Antarctic Porifera database from the Spanish benthic expeditions is made available under the Open Database License: http://opendatacommons.org/licenses/odbl/1.0/. Any rights in individual contents of the database are licensed under the Database Contents License: http://opendatacommons.org/licenses/dbcl/1.0/
Metadata language: English
Date of metadata creation: 2013-03-20
Hierarchy level: Dataset

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RESEARCH ARTICLE

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A review of the Nearctic genus *Prostoia* (Ricker) (Plecoptera, Nemouridae), with the description of a new species and a surprising range extension for *P. hallasi* Kondratieff & Kirchner

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§ *http://zoobank.org/6140264D-C2B4-4AA4-8517-DB31958648C2*
| *http://zoobank.org/0E04600A-60BF-4129-BF00-6DB953AD5577*

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Abstract

The Nearctic genus *Prostoia* (Plecoptera: Nemouridae) is reviewed. *Prostoia ozarkensis* **sp. n.** is described from the male and female adult stages mainly from the Interior Highland region encompassing portions of Arkansas, Missouri, and Oklahoma. *Prostoia ozarkensis* **sp. n.** appears most closely related to two species, one distributed broadly across the western Nearctic region, *P. besametsa* (Ricker), and one found widely throughout the central and eastern Nearctic regions, *P. completa* (Walker). A surprising range extension is noted for *P. hallasi* Kondratieff & Kirchner, a species once known only from the Great Dismal Swamp, from small upland streams in southern Illinois. Additional new state records are documented for *P. besametsa*, *P. completa*, *P. hallasi* and *P. similis* (Hagen). Taxonomic keys to *Prostoia* males and females are provided, and scanning electron micrographs of adult genitalia of all species are given.

Keywords
Plecoptera, Nemouridae, *Prostoia*, new species, North America

Introduction

Prostoia Ricker (Plecoptera: Nemouridae) was erected as a subgenus to include three species: *Nemoura* (*P.*) *besametsa* Ricker, 1952, *N.* (*P.*) *completa* Walker, 1852, and *N.* (*P.*) *similis* Hagen, 1861 (Ricker 1952). *Prostoia* was later raised to full generic rank by Illies (1966). A fourth species, *P. hallasi*, was described by Kondratieff and Kirchner (1984).

Prostoia besametsa is the sole species found in the western Nearctic region, distributed broadly from California east to New Mexico and north to Alaska (Baumann et al. 1977, Stewart and Oswood 2006, DeWalt et al. 2013). *Prostoia completa* and *P. similis* are both found widely throughout the central and eastern Nearctic regions (DeWalt et al. 2013). *Prostoia hallasi*, in contrast, has been reported only from the Great Dismal Swamp (Kondratieff and Kirchner 1984, Kondratieff et al. 1995), an Atlantic Coastal wetland located in North Carolina and Virginia (Traylor 2010).

Prostoia males are easily identified among Nemouridae by their simple, elongate, anteriorly-recurved epiproct that is comprised almost entirely by the ventral sclerite (Baumann 1975). The dorsal sclerite is reduced to a pair of lateral arms located along each side of the epiproct base, except in *P. hallasi* where they are secondarily absent (Ricker 1952, Kondratieff and Kirchner 1984). Wing coloration ranges from uniformly dark brown in *P. hallasi* to mottled with a distinctive light band near the apex in all other species.

For several years, Bill P. Stark (Mississippi College, Clinton, Mississippi) and the second author suspected that *P. completa* from the Ozark Plateau region of northern Arkansas, southern Missouri, and eastern Oklahoma represented an undescribed species. The new species is described herein, with brief anecdotes and new state records of the four previously-described species. Species keys to the male and female adult stages are provided.

Materials and methods

Prostoia specimens used in this study were obtained from, or deposited in, the following collections: B.P. Stark Collection, Mississippi College, Clinton (BPSC); Monte L. Bean Museum, Brigham Young University, Provo, Utah (BYUC); Canadian National Collection of Insects, Ottawa (CNCI); Colorado State University Collection, Fort Collins (CSUC); University of Guelph Insect Collection, Guelph (DEBU); Illinois Natural History Survey, Champaign-Urbana (INHS); Michigan State University Arthropod Research Collection, East Lansing (MSUC); Ohio Environmental Protection Agency, Groveport (OEPA); Purdue University Research Collection, West Lafayette, Indiana (PURC); R.F. Kirchner Personal Collection, Huntington, West Virginia (RFKC); Roy-

al Ontario Museum, Toronto (ROME); University of Michigan Museum of Zoology Insect Collection, Ann Arbor (UMMZ); University of Minnesota Insect Collection, St. Paul (UMSP); University of Notre Dame Insect Collection, South Bend, Indiana (UNDIC); United States National Museum Collection, Smithsonian Institution, Washington, D.C. (USNM); University of Wisconsin Entomological Research Center, Madison (UWIRC); and the S.A. Grubbs Collection, Western Kentucky University, Bowling Green (WKUC).

All specimen records for *P. hallasi* and the new species were included herein. Due to the large volume of material examined for *P. besametsa*, *P. completa*, and *P. similis*, however, these data are available only in a corresponding appendix (see Suppl. material 1 at end of paper).

Locality data, in decimal degrees, for each specimen record were obtained either directly with hand-held GPS units on site or georeferenced from museum label data (if possible). Specimens were studied with scanning electron microscopy (SEM) with a Philips XL30 ESEM FEG electron microscope at Brigham Young University.

Results and discussion

Key to the *Prostoia* adults

1 Male **2**

– Females **6**

2 Dorsal sclerite lacks lateral arms (Figs 17–18, 22–23); anterior terminus of ventral sclerite bears an ornate, secondarily divided process apically (Figs 18–21) ..... ***P. hallasi* Kondratieff & Kirchner**

– Dorsal sclerite possesses lateral arms (Figs 3, 5, 11, 13, 28–29, 34, 37); anterior terminus of ventral sclerite simple, not divided apically (Figs 2, 4, 10, 12, 26, 28, 34, 36) **3**

3 Lateral arms long and sinuate, reaching ca. ½ the length of the ventral sclerite (Figs 33–34, 37–38) ..... ***P. similis* (Hagen)**

– Lateral arms compact and markedly shorter, extending <¼ the length of the ventral sclerite (Figs 3, 5, 11, 13, 28–29) **4**

4 In dorsal view, anterior terminus of ventral sclerite narrowing gradually to a V-shaped tip, subterminal portion markedly wider than posterior portion (Figs 1–2); lateral arms highly-reduced and can be difficult to see with light microscopy, not extending beyond base of dorsal sclerite (Figs 3, 5); widespread western Nearctic species ..... ***P. besametsa* (Ricker)**

– In dorsal view, anterior terminus of ventral sclerite set apart from majority of sclerite, tip near parallel-sided, subterminal portion only slightly wider than posterior portion (Figs 9–10, 25–26); lateral arms extending beyond base of dorsal sclerite (Figs 11, 13, 15, 27, 29, 31); central and eastern Nearctic species **5**

5 In dorsal view, anterior portion of ventral sclerite parallel-sided beyond recurved base (Figs 9–10); in lateral view, posterior portion of ventral sclerite only slightly deflected ventrally (Fig. 11); tip of ventral sclerite slightly deflected upward, parallel-sided and subquadrate apically (Figs 9, 12, 14); lateral arms sickle-shaped, gradually recurved (Fig. 15) ..... ***P. completa*** **(Walker)**

– In dorsal view, anterior portion of ventral sclerite not parallel-sided, gradually expanding laterally beyond recurved base (Figs 25–27); in lateral view, posterior portion of ventral sclerite deflected ventrally (Fig. 28); tip of ventral sclerite not deflected upward (Figs 28–30); lateral arms triangular in shape, tips flared laterally (Figs 29, 31) .. ***P. ozarkensis*** **Baumann & Grubbs, sp. n.**

6 The 7th and 8th abdominal sterna not fused medially, with a well-developed subgenital plate that is convex, extending over the anteromedial margin of the 9th sternum and very slightly notched medially (Fig. 24) .... ***P. hallasi*** **Kondratieff & Kirchner**

– The 7th and 8th abdominal sterna fused medially, subgenital plate not convex and bearing a distinct medial notch (Figs 39–40) or not (Figs 8, 16, 32) **7**

7 Posterior margin of 8th sternum with a distinct medial notch, lateral lobes of subgenital plate distinctly angular, projecting ca. 1/4th over anterior margin of 9th sternum (Figs 39–40) ..... ***P. similis*** **Hagen**

– Posterior margin of 8th sternum with, at best, a shallow medial notch, lateral lobes either projecting posteriorly or not (Figs 8, 16, 32) **8**

8 Posterior margin of 8th sternum essentially straight, lateral lobes not projecting posteriorly as a subgenital plate (Figs 7–8; Baumann et al. 1977, Fig. 107); widespread western Nearctic species ..... ***P. besametsa*** **(Ricker)**

– Posterior margin of 8th sternum with a shallow median notch, lateral lobes broadly rounded, extending < 1/4th over anterior margin of 9th sternum (Figs 16, 32); central or eastern Nearctic species **9**

9 Subgenital plate as in Fig. 16; eastern and central Nearctic species, known from eastern Canada south to Alabama and Mississippi, extending westward only to Iowa and Minnesota (Fig. 41) ..... ***P. completa*** **(Walker)**

– Subgenital plate as in Fig. 32; central Nearctic species, known from Shawnee Hills region of southern Illinois west to the Ozark Plateau region encompassing southern Missouri, northern Arkansas, and eastern Oklahoma (Fig. 42) .. .. ***P. ozarkensis*** **Baumann & Grubbs, sp. n.**

Prostoia besametsa **(Ricker)**
http://species-id.net/wiki/Prostoia_besametsa
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:6099
Figs 1–8, 41

Nemoura (*Prostoia*) *besametsa* Ricker, 1952:48. Holotype ♂ (INHS), Vedder Crossing, British Columbia, Canada

Nemoura glabra (in part) Claassen, 1923:281
Nemoura glabra (in part) Needham & Claassen, 1925:202. Syn. Illies, 1966:221
Prostoia besametsa: Illies 1966:220
Prostoia besametsa: Zwick 1973:345
Prostoia besametsa: Baumann 1975:27
Prostoia besametsa: Baumann et al. 1977:38

Material examined (Suppl. material 1).

Distribution. Canada: AB, BC (DeWalt et al. 2013), NT (Stewart and Oswood 2006), YK (Stewart and Ricker 1997); USA: AK (Stewart and Oswood 2006), CA, CO, ID, MT, NM, NV, OR, SD, UT, WA, WY (DeWalt et al. 2013), NE (New state record).

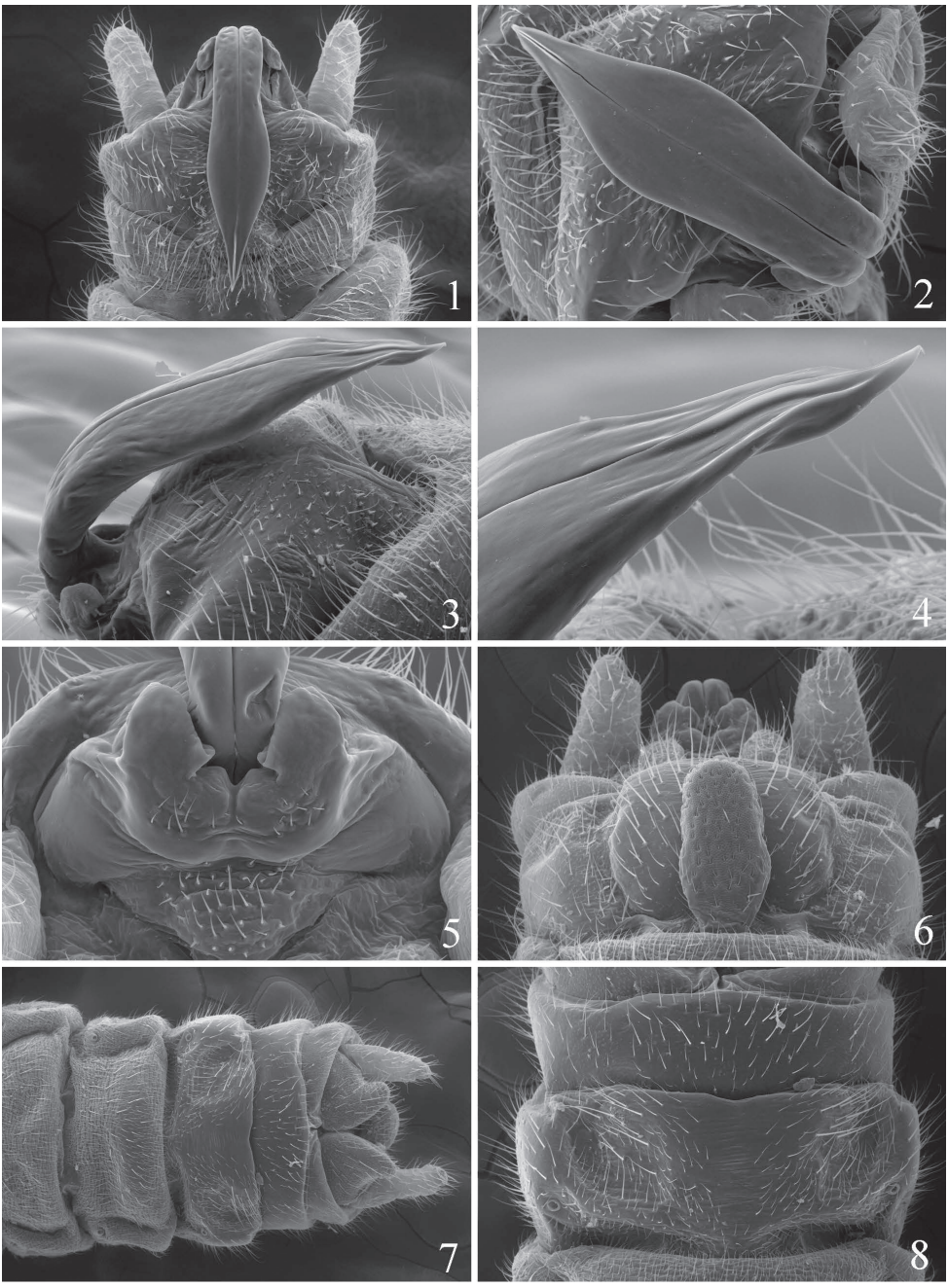
Remarks. *Prostoia besametsa*, *P. completa* and *P. ozarkensis* sp. n. appear to form a species group based on structural similarities of the male ventral sclerite and lateral arms of the dorsal sclerite, and the female subgenital plate. The Black Hills region of eastern Wyoming and western South Dakota, plus the Sand Hills region of northwestern Nebraska, mark the eastern edge of this widespread western Nearctic species in the USA (Fig. 41), and well distant from the closest distribution point of *P. completa* (Fig. 41) and *P. ozarkensis* sp. n. (Fig. 42) (Huntsman et al. 1999, DeWalt et al. 2013). *Prostoia besametsa* is typically found in greatest numbers in large streams and small rivers.

***Prostoia completa* (Walker)**
http://species-id.net/wiki/Prostoia_completa
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:6101
Figs 9–16, 41

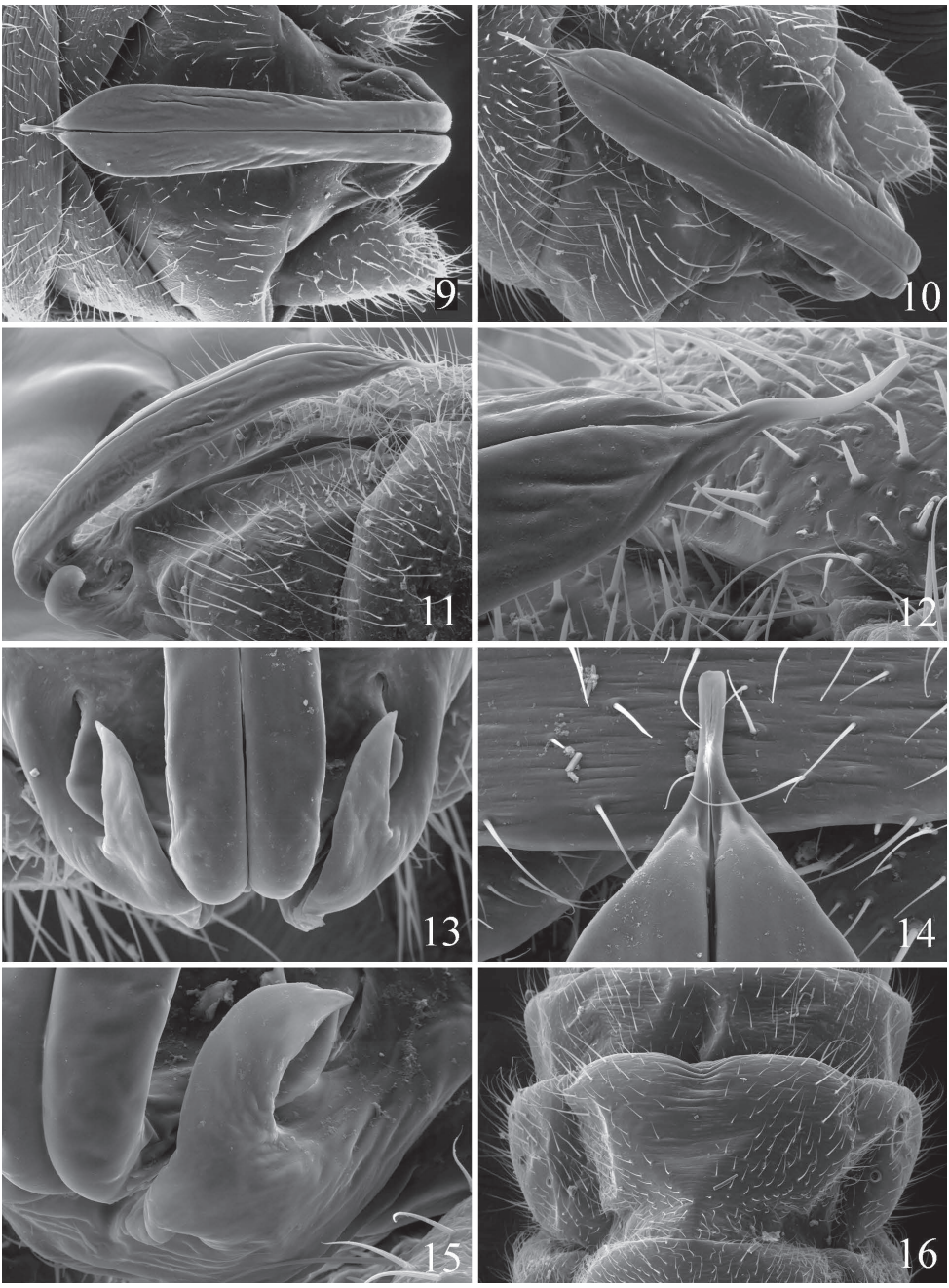
Nemoura completa Walker, 1852:191. Holotype ♂ (British Museum of Natural History, London), Nova Scotia, Canada
Nemoura glabra (in part) Claassen, 1923:281. Syn. Illies, 1966:221
Nemoura glabra: (in part) Needham & Claassen, 1925:202.
Nemoura completa: Ricker 1938
Nemoura (*Prostoia*) *completa*: Ricker 1952:49
Prostoia completa: Illies 1966:221
Prostoia completa: Zwick 1973:346
Prostoia completa: Baumann 1975:27
Prostoia completa: Poulton and Stewart 1991:29

Material examined (Suppl. material 1).

Distribution. Canada: NB, NS, ON, PE, PQ (DeWalt et al. 2013), NF (New provincial record); USA: AL, DE, IA, IN, KY, MA, ME, MI, MN, MS, NC, OH, PA, SC, TN, VA, WI, WV (DeWalt et al. 2013), MD (Grubbs 1997), NY (Myers et al. 2011), TN (New state record).



Figures 1–8. *Prostoia besametsa*, scanning electron micrographs, **1** USA, Utah, Monroe Creek, male, epiproct, dorsal view **2** USA, Montana, Gallatin River, male, epiproct, dorsal view **3** USA, South Dakota, Iron Creek, male, epiproct, lateral view **4** USA, South Dakota, Iron Creek, male, epiproct, lateral view **5** USA, Utah, Monroe Creek, male, abdominal terminalia, caudal view **6** USA, South Dakota, Iron Creek, male, abdominal terminalia, ventral view **7** USA, South Dakota, Iron Creek, female, abdominal terminalia, ventral view **8** USA, South Dakota, Iron Creek, female, abdominal terminalia, ventral view.



Figures 9–16. *Prostoia completa*, scanning electron micrographs, **9** USA, Wisconsin, Plover River, male, epiproct, dorsal view **10** Canada, Newfoundland, Walsh River, male, epiproct, dorsal view **11** Canada, Newfoundland, Walsh River, male, epiproct, lateral view **12** Canada, Newfoundland, Walsh River, male, epiproct tip, lateral view **13** USA, Virginia, Roanoke River, male, epiproct base, dorsal view **14** USA, Wisconsin, Plover River, male, epiproct tip, dorsal view **15** Canada, Newfoundland, Walsh River, male, epiproct base, lateral view **16** Canada, Newfoundland, Walsh River, female, abdominal terminalia, ventral view.

Remarks. This species is distributed from Atlantic Canada to South Carolina and westward to Minnesota and Iowa (Fig. 41). Characteristics of the male epiproct remain constant from eastern Canada to the southeastern United States, without any indication of a north-south cline. However, populations from the northern Midwest are somewhat variable. The prior records of *P. completa* from the Interior Highland region, namely the Ozark Plateau region (e.g. Poulton and Stewart 1991), now likely refer only to *P. ozarkensis* sp. n., but very few specimens were available for this study. Specimens collected sporadically from the only locality in southern Illinois (Webb 2002, DeWalt and Grubbs 2011) were reexamined and now are considered *P. ozarkensis* sp. n. This species was recently listed in Illinois as endangered due to it occurring in a single location in the state (Illinois Endangered Species Protection Board 2011). *Prostoia ozarkensis* sp. n. is very closely related to *P. completa* and separable only by experts as this time. Examination of the relatedness of these two species and congeners using genetic markers is warranted given the implications for conservation status within Illinois.

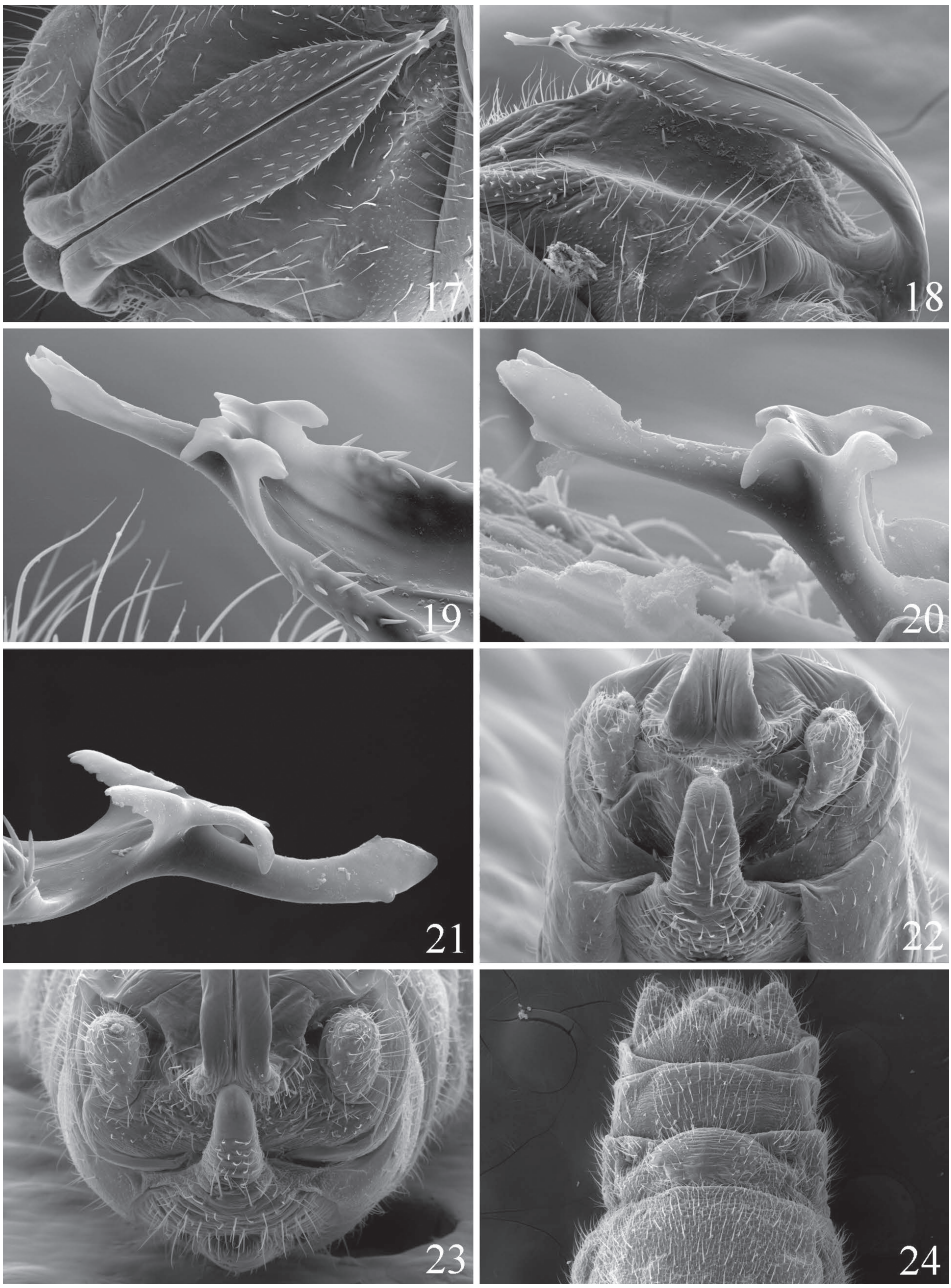
Although the ranges of *P. completa* and *P. similis* (Fig. 42) overlap extensively throughout the eastern Nearctic region, the former species is typically associated with large streams and small rivers. *Prostoia completa* is less commonly collected from upland, headwater streams, except in the northeastern Nearctic region where both species sometimes occur at the same locality.

Prostoia hallasi Kondratieff & Kirchner

http://species-id.net/wiki/Prostoia_hallasi
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:6098
Figs 17–24, 42

Prostoia hallasi Kondratieff & Kirchner, 1984:579. Holotype ♂ (USNM), Washington Ditch, City of Suffolk, Virginia

Material examined (also provided in Suppl. material 1)**. USA**, **Connecticut**, New Haven Co., Hammonasset River, Killingworth, 41.3573, -72.6126, 1 May 1988, W.G. Downs, 3♂, 25♀ (BYUC). **Georgia,** Crisp Co., Gum Creek, Hwy 257, 32.0066, -83.7374, 30 March 1993, B.A. Caldwell, 2♂, 2♀, 2 nymphs (BYUC). **Illinois**, Pope Co., tributary to Alcorn Creek, 7.1 km NW Hamletsburg, 37.1777, -88.4953, 2 March 2012, R. E. DeWalt, 2♂, 2♀ (INHS), tributary to Alcorn Creek, 15 km NE Brookport, 37.1777, -88.4891, 17 March 2013 (reared, from nymphs collected 14 March 2013), S.A. Grubbs & J.M. Yates, 2♂, 2♀, 4 nymphs (WKUC), same site, 3 April 2013, S.A. Grubbs & J.M. Yates, 2♀ (WKUC). **Massachusetts**, Unknown County, "Boston Reg.", 2 May 1936, L.J. Milne, 3♀ (USNM). **Virginia**, Essex Co., 1 mi SE Dunnsville, 37.8504, -76.8083 (malaise trap), 17–29 April 1992, D.R. Smith, 4♂, 110♀ (BYUC, USNM); same site, 26 March–8 April 1994, D.R. Smith, 4♂, 9♀ (BYUC, USNM); Falls Church City, Falls Church, 11 February 1941, J.F. Hanson, ♂



Figures 17–24. *Prostoia hallasi*, scanning electron micrographs, **17** USA, Virginia, Dunnsville, male, epiproct, dorsal view **18** USA, Virginia, Washington Ditch, male, epiproct, lateral view **19** USA, Virginia, Washington Ditch, male, epiproct tip, lateral view **20** USA, Connecticut, Hammonasset River, male, epiproct tip, lateral view **21** USA, Illinois, tributary to Alcorn Creek, male, epiproct tip, lateral view **22** USA, Illinois, tributary to Alcorn Creek, male, abdominal terminalia, ventral view **23** USA, Virginia, Washington Ditch, male, abdominal terminalia, caudal view **24** USA, Virginia, Dunnsville, female, abdominal terminalia, ventral view.

(USNM); Southhampton Co., Tarrara Creek, Hwy 666, 36.5952, -77.2274, 10 March 1991, R.W. Baumann & R.F. Kirchner, 2♂ (BYUC); Suffolk City, Washington Ditch, off Washington Ditch Road, Dismal Swamp, 36.6442, -76.5471, 2 March 1983, B.C. Kondratieff, 2♂, ♀ (paratypes; BYUC); Washington Ditch, Dismal Swamp, 36.6442, -76.5471, 10 March 1991, R.W. Baumann & R.F. Kirchner, 48♂, 54♀ (BYUC).

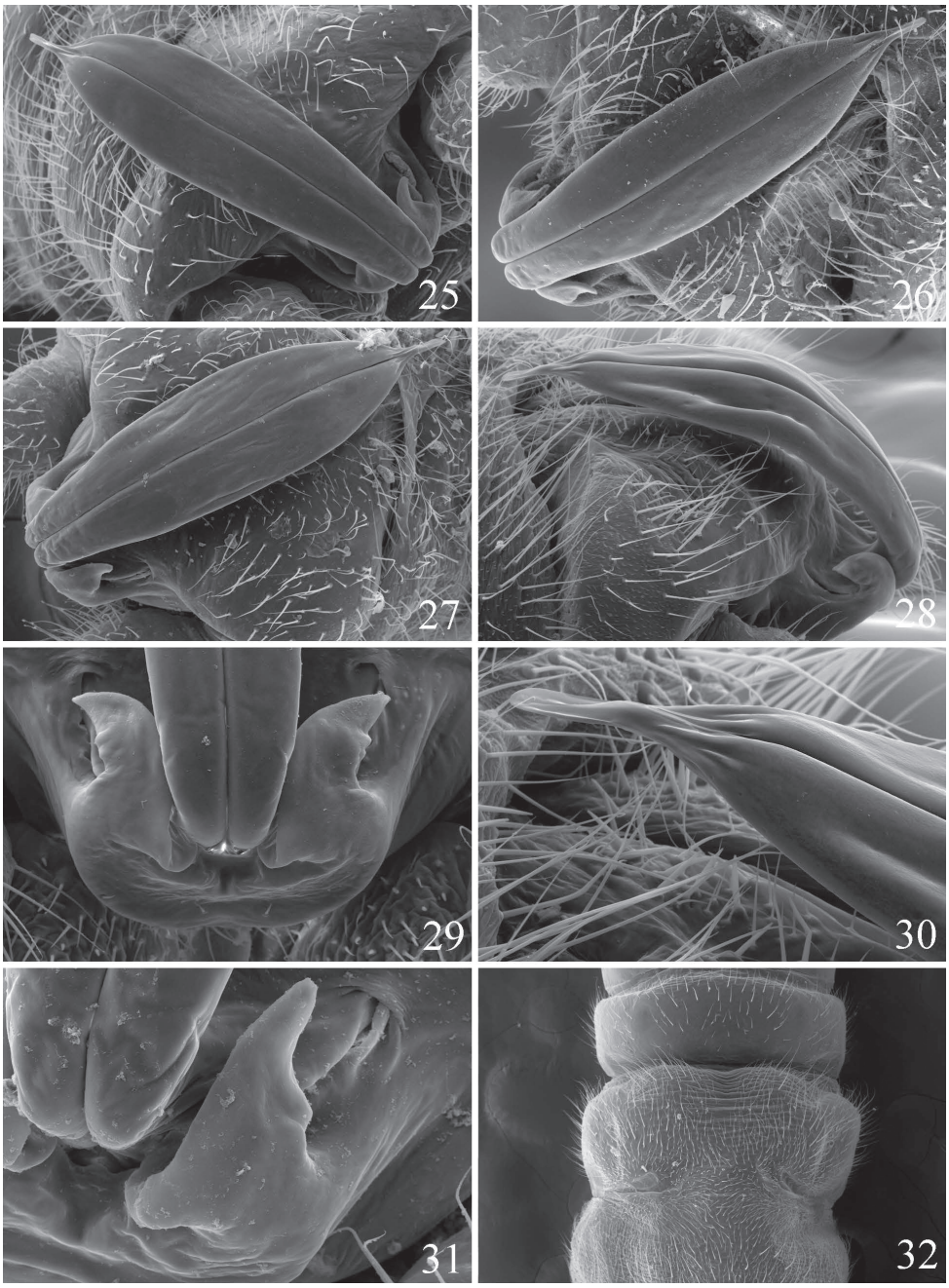
Distribution. USA: NC, VA (DeWalt et al. 2013), CT, GA, IL, MA (New state records).

Remarks. This species was once considered unique amongst Nearctic Nemouridae in that it was known only from low gradient coastal streams in the Great Dismal Swamp (Kondratieff and Kirchner 1984, Kondratieff et al. 1995). The discovery of localities north in New England and south to Georgia was not too surprising since these are range extensions along the Atlantic Coastal Plain (Fig. 42). This species should eventually be found in coastal regions within the intervening states (i.e. Delaware, Maryland, New Jersey, New York, Pennsylvania, and South Carolina).

We initially anticipated that the populations from the Shawnee Hills region of southern Illinois represented an undescribed species. Both Illinois sites were small, upland tributaries ca. 1 m wide and very distinct from the description of the type locality (Kondratieff and Kirchner 1984). Yet the SEM images of the epiproct from specimens from several locations, particularly of the complex ornamentation of the terminus of the ventral sclerite, showed unexpected across-site similarity and no evidence that the southern Illinois populations represented an undescribed species. The epiproct terminus of the populations from Essex Co., Virginia (Fig. 17), coastal Connecticut (Fig. 20), southern Illinois (Fig. 21) and the type locality in eastern Virginia (Kondratieff and Kirchner 1984, their Fig. 6) appear indistinguishable as such: the distal anterior tip is slightly bifurcate, a small ventral subterminal knob is present, and the subterminal forked structure includes paired, ventrally-directed triangular processes and paired somewhat dorsally-directed subtruncate processes. Females from southern Illinois were indistinguishable from those from the Connecticut and Essex Co., Virginia (Fig. 24) localities noted above.

Prostoia ozarkensis **Baumann & Grubbs, sp. n.**
http://zoobank.org/8DE0A193-C546-46EB-A70E-DF8FEAFEBA33
http://species-id.net/wiki/Prostoia_ozarkensis
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:463936
Figs 25–32, 42

Description. Male. Macropterous. Forewing length 7.0–8.0 mm; body length 6.0–6.5 mm. Wings mottled with light band in forewing beyond cord. General body color brown. Epiproct ventral sclerite recurved over abdomen, gradually widening anterior to base, widest in distal third, narrowing mark to an acute, parallel-sided tip, rounded apically (Figs 25–30); recurved portion of ventral sclerite deflected downward at approximately the midpoint (Fig. 28). Paraprocts broadest basally, extending beyond



Figures 25–32. *Prostoia ozarkensis* sp. n., scanning electron micrographs, **25** USA, Arkansas, Buffalo River, male, epiproct, dorsal view **26** USA, Missouri, Bryant Creek, male, epiproct, dorsal view **27** USA, Illinois, Hutchins Creek, male, epiproct, dorsal view **28** USA, Oklahoma, Baron Creek, male, epiproct tip, lateral view **29** USA, Oklahoma, Baron Creek, male, epiproct base, dorsal view **30** USA, Oklahoma, Baron Creek, male, epiproct tip, lateral view **31** USA, Illinois, Hutchins Creek, male, epiproct base, dorsal view **32** USA, Oklahoma, Baron Creek, female, abdominal terminalia, ventral view.

base of ventral sclerite, subquadrate for ca. 2/3 length, with a triangular distal portion that is slightly flared laterally (Figs 29, 31). Vesicle present. Hypoproct sclerotized, broad at base, tapering markedly to a rounded, narrow apex.

Female. Macropterous. Forewing length 8.0–9.0 mm; body length 7.0–7.5 mm. Wing and body coloration similar to male. Seventh and eighth abdominal sterna fused medially, subgenital plate of eighth sternum scarcely extending over anterior portion of ninth sternum, barely concave medially with slightly rounded lateral lobes (Fig. 32).

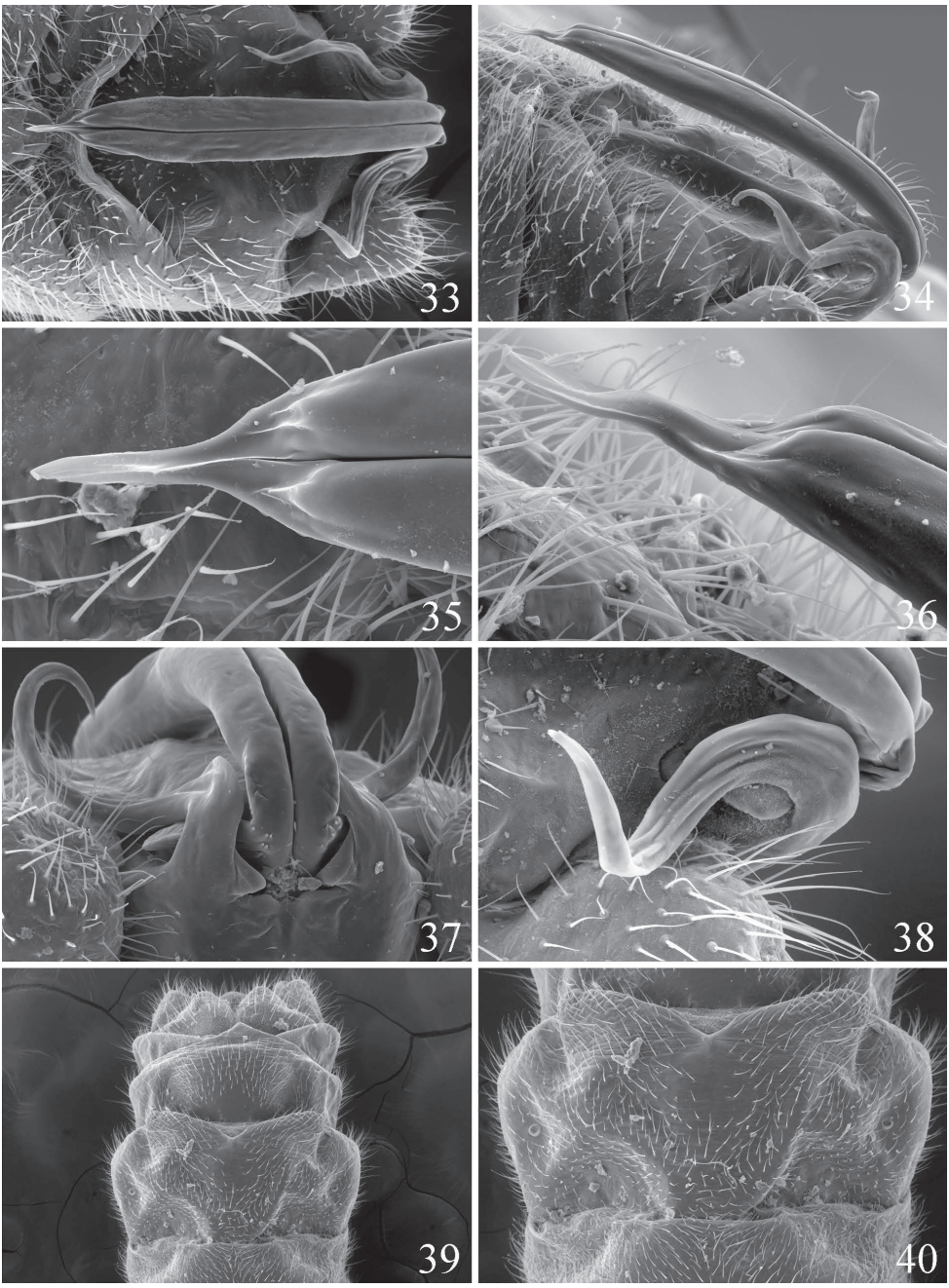
Nymph. Undescribed.

Material examined (also provided in Suppl. material 1)**.** Holotype ♂, in 75% ethyl alcohol, **USA**, **Missouri,** Webster County, Bryant Creek, Hwy 14, 3 mi SW Evans, 36.8870, -92.4733, 22 February 1972, R.W. Baumann & S.W. Szczytko, (USNM). Paratypes: **Arkansas,** Benton Co., White River, 21 February 1943, W. Larimore, ♂ (INHS); White River, Rogers, 6 March 1943, W. Larimore, ♂, 2♀ (INHS); Carroll Co., Big Clifty Creek, SW ¼ Sec 4 T19N R27W, 8 March 1963, O. Hite & L.R. Aggus, 2♀ (INHS); Osage Creek, Hwy. 60, Osage, 36.1887, -93.4152, 16 March 1963, O. Hite & L. Aggus, ♀ (INHS); Madison Co., War Eagle, Hwy 16 & Hwy 45, 36.2020, -93.8569, 10 March 1962, L.O. Warren, 9♂, 11♀ (BYUC); Kings River, Hwy 21, 4 mi N Kingston, 36.0882, -93.5417, 8 March 1963, O. Hite & M. Wall, ♀ (INHS); Marion Co., Crooked Creek, Hwy. 62, 36.2458, -92.8348, 16 March 1963, O. Hite & L. Aggus, ♀ (INHS); Georges Creek, Hwy. 62, 36.2533, -92.7487, 16 March 1963, O. Hite & L. Aggus, ♂ (INHS); Newton Co., Add Creek, Hwy 43, Ponca, 36.0210, -93.3600, 25 March 1972, R.W. Baumann & S.W. Szczytko, ♂, 4♀ (BYUC); Buffalo River, Hwy 74, near Ponca, 36.0221, -93.3547, 25 March 1972, R.W. Baumann, ♀ (BYUC); same site, 8 February 1976, McCraw & Kittle, 3♂, ♀ (BYUC); Buffalo River, Boxley, 35.9610, -93.4040, 16 March 2002, B.C. Kondratieff & R. Zuellig, 2♂ (CSUC); Searcy Co., Big Creek, St. Rd. 14, 35.9789, -92.4815, 17 March 1963, O. Hite & L. Aggus, 4♀ (INHS); Stone Co., Wallace Creek, State Rd. 14, 35.7764, -91.8872, 17 March 1963, O. Hite & L. Aggus, ♀ (INHS); Sylamore Creek, St. Rd. 9, 35.9419, -92.1201, 17 March 1963, O. Hite & L. Aggus, ♂ (INHS); Rocky Bayou, State Rd. 14, 35.8598, -92.0469, 17 March 1963, O. Hite & L. Aggus, 2♂, 4♀ (INHS); Van Buren Co., Peyton Creek, Hwy. 65, 35.7881, -92.5397, 17 March 1963, O. Hite & L. Aggus, ♀ (INHS); Washington Co., War Eagle Creek, SW ¼ Sec 19 T18N R28W, 28 February 1963, O. Hite & L.R. Aggus, ♀ (INHS); same but 14 March 1963, O. Hite & L.R. Aggus, ♂ (INHS); no locality data, 20 March 1962, O. Hite & M. Hite, ♂, 2♀ (INHS). **Illinois,** Union Co., Hutchins Creek, Wolf Lake, 37.5107, -89.3773, 13 March 1946, H.H. Ross & B.D. Burks, ♂, ♀ (INHS); Hutchins Creek, 5.4 km E Wolf Lake, 93-152, T11S, R2W, S31, 37.5107, -89.3776, 19 April 1993, M.A. Harris & D.W. Webb, ♂, ♀ (INHS). **Missouri,** Bollinger Co., Whitewater River, Alliance, 37.5791, -90.0013, 6 March 1958, Ross & Stannard, ♂ (INHS); Christian Co., Bull Creek, Hwy W, 3 March 1972, R.W. Baumann & B.K. Newman, 3♂, 5♀ (BYUC); same site, 20 March 1972, B.K. Newman, ♀ (BYUC); Crawford Co., Meramec River, N Steeleville at MO 19, 37.9889, -91.3761, 4 February 2012, R.E. DeWalt & S.K. Ferguson, 2♂, ♀, 5 nymphs (INHS); Meramec River,

Steeleville, 37.9849, -91.3724, 6 March 1958, Ross & Stannard, ♂, 3♀ (INHS); Huzzah Creek, Dilliard, Mark Twain [Clark] National Forest, 37.7406, -91.2029, 6 March 1958, Ross & Stannard, ♂, ♀ (INHS); Dade Co., Turnback Creek, Hwy O, E Greenfield, 37.4023, -93.8020, 19 February 1972, D.A. Boehne, 2♂, 4♀ (BYUC); same site, 18 March 1972, D.A. Boehne, ♂, ♀ (BYUC); Douglas Co., Bryant Creek, Hwy 14, 3 mi SW Evans, 36.8870, -92.4733, 22 February 1972, R.W. Baumann & S.W. Szczytko, 12♂, 25♀ (BYUC); Bryant Creek, Hwy 14, near Gentryville, 36.8868, -92.4734, 14 March 1972, R.W. Baumann & C.D. Inman, ♂, 9♀ (BYUC); Bryant Creek, Gentryville, 18 February 1962, Ross & Stannard, ♂, 4♀ (INHS); North Fork White River, Hwy 14, Twin Bridges, 36.8109, -92.1492, 22 February 1972, R.W. Baumann, ♂, 2♀ (BYUC); Franklin Co., Indian Creek, 1.5 mi S Piney park at Hwy K, 38.2692, -90.9447, 4 February 2012, R.E. DeWalt & S.K. Ferguson, 11♂, 5♀, 8 nymphs (INHS); Greene Co., Little Pomme de Terre River, Hwy 65, near Fair Grove, 37.4161, -93.1452 , 15 February 1972, R.W. Baumann, 2♂ (BYUC); same site, 24 March 1972, R.W. Baumann, ♀ (BYUC); Lawrence Co., White Oak Creek, near Red Oak, 37.2291, -94.0276, 19 March 1972, R.W. Baumann, ♀ (BYUC); Shannon Co., Current River, Hwy B, Cedar Grove, 37.4189, -91.6029, 17 March 2002, B.C. Kondratieff & R. Zuellig, ♂ (CSUC); Jacks Fork River, Hwy S, Creek, 17 March 2002, B.C. Kondratieff & R. Zuellig, 5♂, 6♀ (CSUC); Manan Creek, Hwy 106, W Eminence, 37.1461, -91.3792, 16 March 2002, B.C. Kondratieff & R. Zuellig, ♂ (CSUC); Big Shawnee Creek, 2 mi E Eminence at MO 106, 37.1528, -91.3131, 5 February 2012, R.E. DeWalt & S.K. Ferguson, ♂ (INHS), Shawnee Creek, Hwy 106, N Winona, 37.1528, -91.3132, 17 March 2002, B.C. Kondratieff & R. Zuellig, 3♂, 4♀ (CSUC); Taney Co., Bull Creek, Hwy 76, 36.7311, -93.1933, 28 February 1972, B.K. Newman, ♂, 3♀ (BYUC); same site, 8 March 1972, B. K. Newman, 4♂, 3♀ (BYUC); Texas Co., Big Piney River, Hwy RA, N Simmons, 17 March 2002, B.C. Kondratieff & R. Zuellig, ♀ (CSUC); Hog Creek, S Houston, 37.2400, -91.9527, 17 March 2002, B.C. Kondratieff & R. Zuellig, 2♀ (CSUC); Jacks Fork River, 5 mi S Pine Crest, 37.0563, -91.6679, 17 February 1962, Ross & Stannard, ♂ (INHS); Wright Co., Gasconade River, Hwy E, 9 mi. NE Hartville, 37.3135, -92.3988, 13 March 1987, B.C. Poulton, 2♀ (BYUC). **Oklahoma,** Adair Co., Ballard Creek, 36.0924, -94.5881, 20 February 1972, B.P. Stark, ♂, 4♀ (BYUC); unnamed stream, Hwy 59, Baron, 35.9195, -94.6199, 20 February 1972, B.P. Stark, 2♂, 2♀ (BYUC); Delaware Co., Flint Creek, 36.1942, -94.7069, 19 February 1984, B.C. Poulton, 2♂, 2♀ (BYUC).

Etymology. The specific epithet recognizes that this species is broadly widespread across the Ozark Plateau region of southern Missouri, northern Arkansas, and northeastern Oklahoma, with one additional isolated locality in southwestern Illinois. The common name Ozark Forestfly is proposed for this species (Stark et al. 2012).

Diagnosis. *Prostoia besametsa*, *P. completa*, and *P. ozarkensis* sp. n. appear to form a closely-related species group based primarily on structural similarities of the short, compact lateral arms of the male dorsal sclerite and the female 8th sternum that bears a faint medial notch with poorly-developed lateral lobes. The combination of the narrow, v-



Figures 33–40. *Prostoia similis,* scanning electron micrographs, **33** USA, Virginia, Big Run, male, epiproct, dorsal view **34** USA, Virginia, McClure River, male, epiproct, lateral view **35** USA, Virginia, McClure River, male, epiproct tip, dorsal view **36** USA, Virginia, McClure River, male, epiproct tip, lateral view **37** USA, Virginia, McClure River, male, epiproct base, caudal view **38** USA, Virginia, Big Run, male, epiproct base, dorsal view **39** USA, McClure River, Virginia, female, abdominal terminalia, ventral view **40** USA, Virginia, McClure River, female, abdominal terminalia, ventral view.

shaped epiproct tip and the western Nearctic distribution of *P. besametsa* easily separates this species from *P. completa* and *P. ozarkensis* sp. n. The epiproct of *P. completa* and *P. ozarkensis* sp. n. narrow markedly to an acute, parallel-sided tip. In addition, the lateral arms of *P. besametsa* do not extend past the epiproct base whereas in *P. completa* and *P. ozarkensis* sp. n. the lateral arms are noticeably longer. *Prostoia ozarkensis* sp. n. closely resembles *P. completa* in both the male and female adult stages. Whereas females of the two species appear indistinguishable, males can be separated by close examination of details of the lateral arms and the overall shape of the ventral sclerite. The lateral arms of *P. ozarkensis* sp. n. are short, pointed apically, and bear a stout nub on the outer surface (Fig. 29). While in *P. completa* the lateral arm is longer, scythe-shaped, and has a smooth outer margin (Fig. 15). The ventral sclerite of *P. ozarkensis* sp. n. is recurved in lateral aspect, especially along the ventral margin (Fig. 28) and expanded dorsally toward the apex (Fig. 25). Conversely, in *P. completa* the ventral sclerite is nearly straight in lateral aspect (Fig. 11) and narrow and nearly parallel-sided dorsally (Figs 9, 10).

Prostoia ozarkensis sp. n. overlaps in range only with *P. similis* (Fig. 42), but the combination of the long, sinuate lateral arms and the well-developed lateral lobes of the female 8th sternum easily distinguish the latter species from each of the four other *Prostoia* species. With the surprising discovery of *P. hallasi* from southern Illinois, the distribution of this species is likely far from understood and there is no reason to preclude its presence west of the Mississippi River into the Interior Highland region. The ornate epiproct tip and absence of lateral arms of *P. hallasi* are distinctive features that make it easy to identify males of this species. Additionally, *P. hallasi* is the only *Prostoia* species with a convex subgenital plate.

Remarks. *Prostoia ozarkensis* sp. n. specimens from the Ozark Plateau, including the Boston Mountains, consistently exhibit distinctive male characters that set it apart from widespread *P. completa*. Specimens from states to the east, namely Indiana and Kentucky, are more difficult to separate consistently and even show variability in the same population. The *P. completa* records presented in Poulton and Stewart (1991) likely now pertain to *P. ozarkensis* sp. n., but very few of their specimens were available for study. The same also applies for *P. completa* reported in Stark and Stewart (1973), Ernst et al. (1984), Ernst and Stewart (1985a, 1985b, 1986), Jop and Stewart (1987), Phillips and Kilambi (1994), and Harp and Robison (2006).

***Prostoia similis* (Hagen)**
http://species-id.net/wiki/Prostoia_similis
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:6094
Figs 33–40, 42

Taeniopteryx similis Hagen, 1861:34. Holotype ♂ (USNM), Washington D.C., USA.
Nemoura similis: Banks 1907:14.
Nemoura divergens: Claassen 1923:282. Syn. Illies, 1966:221.
Nemoura divergens: Needham and Claassen 1925:203.

Nemoura similis: Needham and Claassen 1925:214.
Nemoura (*Prostoia*) *similis*: Ricker 1952:49.
Prostoia similis: Illies 1966:221.
Prostoia similis: Zwick 1973:346.
Prostoia similis: Baumann 1975: 27.
Prostoia similis: Poulton and Stewart 1991:30.

Material examined (Suppl. material 1).

Distribution. Canada: ON (New provincial record), PQ (DeWalt et al. 2013); USA: CT, DE, IL, IN, KY, MA, MD, ME, MI, MN, MO, NY, OH, PA, SC, VA, WI, WV (DeWalt et al. 2013), TN (New state record).

Remarks. *Prostoia similis* is readily distinguished from all other *Prostoia* species by the dorsal sclerite of the epiproct bearing long and sinuate lateral arms. As stated earlier, the ranges of *P. completa* and *P. similis* overlap extensively. Examination of large collections of *P. similis* and *P. completa* from the Great Lakes region has revealed that the former species appears to be markedly less common with increasing latitude (Grubbs et al. 2012). In comparison to *P. completa*, there are far fewer historical (pre-1960) and contemporaneous collections of *P. similis* from Michigan, Minnesota, Wisconson, and Ontario.

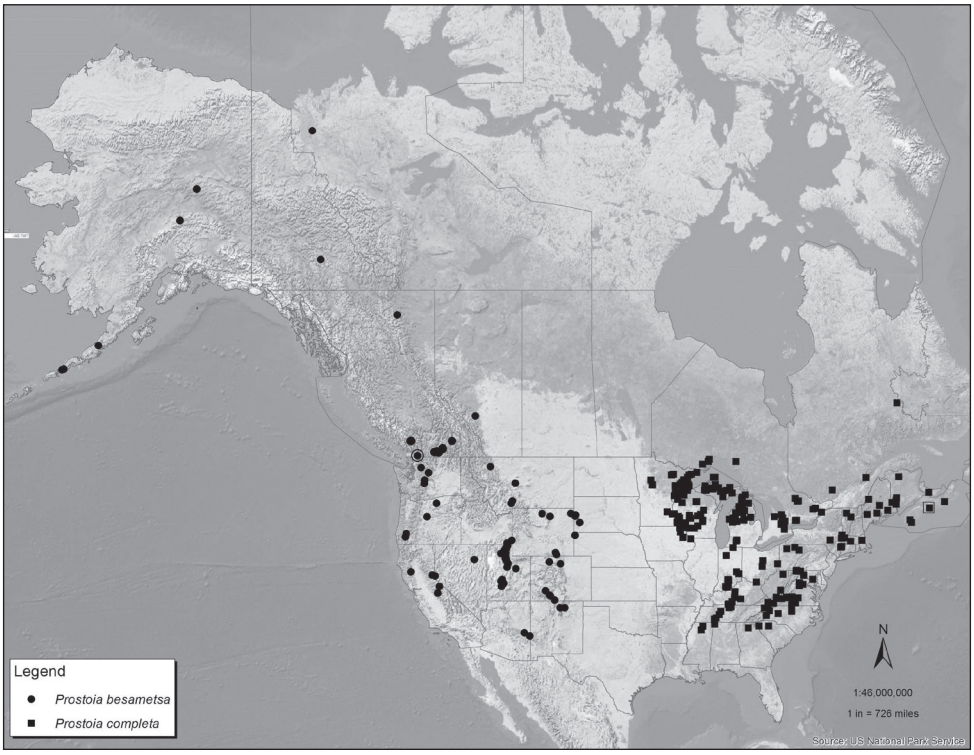


Figure 41. Distribution map for *P. besametsa* (circles) and *P. completa* (squares). The open symbols enclosing the solid symbols refer to the type localities for the two species.

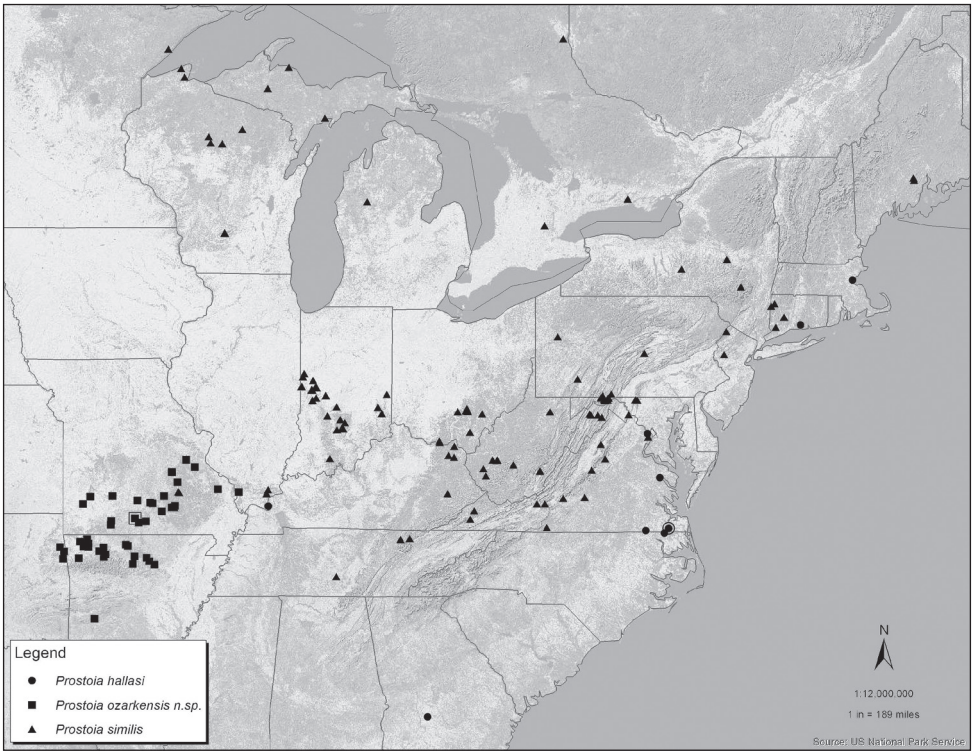


Figure 42. Distribution map for *P. hallasi* (circles), *P. ozarkensis* sp. n. (squares), and *P. similis* (triangles). The open symbols enclosing the solid symbols refer to the type localities for the three species.

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Supplementary material 1

Raw locality data for all *Prostoia* material examined in this study.

Authors: Scott A. Grubbs, Richard W. Baumann, R. Edward DeWalt, Tari Tweddale

Data type: MS Excel spreadsheet (xls) of species locality data.

Explanation note: Supplementary material 1 is an MS Excel spreadsheet with all specimen locality data used in this article.

Link: doi: 10.3897/zookeys.401.7299.app1

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RESEARCH ARTICLE

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A remarkable new species group of green seed beetles from genus *Amblycerus* Thunberg (Coleoptera, Chrysomelidae, Bruchinae), with description of a new Brazilian species

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Abstract

Representatives of the subfamily Bruchinae (Coleoptera: Chrysomelidae) are usually small and inconspicuous, with only a few species drawing the attention. Here we deal with several unusually colored species of *Amblycerus* Thunberg, 1815, one of the two most diverse bruchine genera in the Western hemisphere. We define the *virens* group that consists of five species whose bodies are covered with a green vestiture, including one new for science, *Amblycerus medialis* Ribeiro-Costa, Vieira & Manfio, **sp. n.** (Type locality: Brazil: Pará, Rondônia). This study also provides redescriptions, diagnoses, comparative notes, illustrations, geographic distribution records and a key to the species in this group.

Keywords

Seed beetle, new species, taxonomy, key, Western hemisphere

Introduction

Bruchinae Latreille, commonly known as seed beetles, is one of the 13 subfamilies of Chrysomelidae (Bouchard et al. 2011). This subfamily encompasses more than 1700 species (Ribeiro-Costa and Almeida 2012) that are distributed worldwide. In the Western hemisphere, two genera, *Amblycerus* Thunberg, 1815 (Amblycerini: Amblycerina) and *Acanthoscelides* Schilsky, 1905 (Bruchini: Acanthoscelidina), stand out as the most hyperdiverse genera (Kingsolver 1990, Ribeiro-Costa 1999), the first with 340 species (Kingsolver 1990) and the second with more than 100 species (Romero et al. 1996, Ribeiro-Costa 2000). For *Acanthoscelides*, several molecular analyses indicate that the genus is likely paraphyletic (Kergoat and Silvain 2004, Kergoat et al. 2005, 2008), which is not surprising considering the lack of clear diagnostic characters for the genus (Borowiec 1987, Kergoat and Silvain 2004). On the contrary, a morphological cladistic analysis of *Amblycerus* sampled in the United States and Mexico (Romero et al. 2002) suggests that the genus *Amblycerus* is possibly monophyletic.

Members of *Amblycerus* are well defined and easily recognized by their subovate body, shallowly emarginate eyes, hind tibia without prominent lateral carinae, and the presence of two apical spurs on hind tibia (Romero et al. 1996, Kingsolver 2004). Though most species for which host plants are known usually develop on Fabaceae (Romero et al. 1996, 2002), several *Amblycerus* species are quite remarkable because they are associated with other plant families (Romero et al. 1996, 2002). In total, at least 13 distinct plant families have been thus recorded for the genus *Amblycerus*, a pattern that contrasts with most bruchine genera that are only associated with one or a few host plant families (Borowiec 1987). Another interesting feature of *Amblycerus* is the unusual coloration pattern of a few species. In general seed-beetles have a black, yellow or reddish non-metallic body (Borowiec 1987). Their vestiture is more or less dense, and is usually not made of conspicuous colors. Among *Amblycerus*, several species clearly depart from this pattern as they exhibit a conspicuous green vestiture. The first species with such an unusual coloration pattern, *Amblycerus virens* (Jekel, 1855), was described in 1855 from French Guiana. Following a revisional work initiated almost 20 years ago as a part of a thesis on Brazilian *Amblycerus* species (Ribeiro-Costa 1995), three other species were later described in 1998: *A. virescens* Ribeiro-Costa, 1998 *A. viridans* Ribeiro-Costa, 1998 and *A. viridis* Ribeiro-Costa, 1998. At that time, phenetic analyses were used to place these four species in a distinct species group (Ribeiro-Costa 1995), but a clear formalization of the corresponding species group (*virens* group) is lacking to date. As these species with a green vestiture do not occur in the United States and Mexico they were also not included in the morphological cladistic analysis of Romero et al. (2002).

To advance in the taxonomy and systematics of the *virens* group we propose a revision of the entire species group, including a redescription of *A. virens* and a description of a new *Amblycerus* species that also harbors this unusual green vestiture. We also provide an identification key, geographic distribution data and a diagnosis for the group

based on comparisons of morphological characters used at group level in previous taxonomic and cladistic studies (Romero et al. 1996, 2002). All these species possibly form a natural group, but comprehensive phylogenetic studies (with a dense sampling of *Amblycerus* species) are definitely required to precise this hypothesis.

Material and methods

The material examined was loaned from museums/collections listed below (acronyms of museums/collections and curators' names are also provided).

CNCI Canadian National Collection of Insects, Ottawa, Canada, (A. E. Davies);
CMNH Carnegie Museum of Natural History, Pittsburgh, United States, (R. Davidson);
DZUP Coleção de Entomologia Pe. J.S. Moure, Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Paraná, Brazil, (C. S. Ribeiro-Costa);
FSCA Florida State Collection of Arthropods, Gainesville, Florida, United States, (M. C. Thomas);
FIOC Fundação Instituto Oswaldo Cruz, Rio de Janeiro, Rio de Janeiro, Brazil, (J. Costa);
MZSP Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil, (S. Casari);
MPEG Museu Paraense Emílio Goeldi, Belém, Pará, Brazil, (O. T. Silveira);
BMNH The Natural History Museum, London, United Kingdom, (S. Shute);
USNM United States National Museum of Natural History, Washington D.C., United States, (A. Konstantinov and E. Roberts).

Most characters were observed from dry pinned insects. Male genitalia were studied following Manfio et al. (2013), except for *A. virens* for which we followed Ribeiro-Costa (1998). Colored images of the external morphology were captured with a LEICA DFC 500 digital camera attached to a LEICA MZ16 stereomicroscope, and subsequently processed using Auto-Montage Pro (Syncroscopy) image processing software of the "TAXon line- Rede Paranaense de Coleções Biológicas" at the Departamento de Zoologia, Universidade Federal do Paraná (UFPR). The terminology adopted was that of Ribeiro-Costa and Silva (2003) except for some thoracic and abdominal sclerites for which we followed Lawrence et al. (2010). Measurements were obtained using AXIOVISION version 4.8.2.0 over images captured with a SONY CYBER-SHOT DSC W350 digital camera coupled in the stereoscopic microscope CARL ZEISS DISCOVERY version 8. Measurements of body parts (body length and width, ocular index and *sinus*, postocular lobe, antennomeres length and width) were carried out on one randomly chosen specimen of each species following traits highlighted in Ribeiro-Costa (1998: 631, Figs 1, 2, 3, 5 and 8). The following abbreviations were used: BL, body length (from anterior margin of pronotum to elytra apex) and BW, body width (the largest width on the subapical region of the elytra).

Results and discussion

The *virens* species group consists of five species: *Amblycerus virens* (Jekel, 1855), *A. virescens* Ribeiro-Costa, 1998, *A. viridans* Ribeiro-Costa, 1998, *A. viridis* Ribeiro-Costa, 1998 and *A. medialis* Ribeiro-Costa, Vieira & Manfio, sp. n. It can be distinguished from other *Amblycerus* species groups by combinations of characters that are listed below in the diagnosis.

Group *virens*

Figs 1–12

Diagnosis. Most of dorsum covered with a green vestiture (Figs 1, 7); pygidium with yellowish setae homogeneously distributed (Figs 4, 10). Head covered with fine and dense punctures, without frontal carina (Figs 3, 9); frontoclypeal suture indistinct (Fig. 3). Disc of pronotum semicircular (Figs 1, 7), with background covered with fine and dense punctures; lateral carina almost reaching the anterior margin of pronotum (Fig. 2); cervical sulcus absent; prosternal process not expanded beyond anterior coxae, slightly constricted between coxae. Metepisternum without transverse, fusiform, curved and striate file; metepisternal sulcus forming right angle. Metaventrite with moderately coarse and sparse punctures; median sulcus one-half as long as metaventrite. Pygidium with apical margin rounded (Figs 4, 10). Internal sac of male genitalia at the median region with a pair of blade sclerites with serrate margin and a wishbone-shaped unpaired sclerite (Figs 5, 11).

Comparative notes. Within the *virens* group, *A. virens*, *A. virescens*, *A. viridans* and *A. viridis*, share more morphological similarities to each other than with *A. medialis* Ribeiro-Costa, Vieira & Manfio, sp. n. The most obvious difference between them is the fact that for *A. virens*, *A. virescens*, *A. viridans* and *A. viridis*, the pubescence on pronotum and elytra is not variegated and does not present stripes.

In comparison with other *Amblycerus* species, it is worthy to note that *A. medialis* presents two long, serrate blades in the internal sac of male genitalia. Interestingly, these serrate blades (character 24(1), pg. 7, Romero et al. (2002)) are also found in two species (*A. barcenae* and *A. pictus*) of the *marmoratus* clade (Romero et al. 2002). The broader blades of *A. viridis*, *A. virescens* and *A. viridans* are more similar with those of many other Brazilian species studied by Ribeiro-Costa (1995). *Amblycerus viridis*, *A. viridans* and *A. virens* also share the presence of two plates with small tubercles on the dorsal surface of the internal sac of male genitalia (character 25(1), pg. 7, Romero et al. (2002)) with the clade *anosignatus* (composed of *A. anosignatus*, *A. chiapas* and *A. guerrerensis*). The issue of determining whether these morphological similarities are homoplastic or not is complex, and will clearly benefit from results of future phylogenetic analyses of molecular datasets.

Sexual dimorphism. Sexual dimorphism was not observed even in the shape of the apex of the last abdominal ventrite.

Geographical distribution. Neotropical region, although the species from this group are more commonly distributed between the North of French Guiana to Midwest Brazil.

Host plants. This species group does not have known host plants records.

Key to males of *virens* group

1 Eyes prominent laterally (Ribeiro-Costa 1998: 636, Figs 3, 9, 16), metaventrite protuberant between mid coxae in lateral view (Ribeiro-Costa 1998: 636, Figs 2, 17) **2**

1' Eyes flat laterally (Ribeiro-Costa 1998:631, Fig. 1) metaventrite flat between mid coxae in lateral view (Ribeiro-Costa 1998: 631, Fig. 4)..... **3**

2 (1) Pronotum and elytra with mid strip of vestiture (Fig. 7), antennae serrate from 4 to 10 antennomere (Fig. 8), ocular index: 2,04–2,22 .... ***Amblycerus medialis* Ribeiro-Costa, Vieira & Manfio, sp. n.**

2' Pronotum with uniform pattern of vestiture, lacking stripes (Fig. 1), antennae moderately serrate from 5 to 10 antennomere (Ribeiro-Costa 1998: 631, Fig. 3), ocular index: 2.41–3.43..... **4**

3 (1') Median lobe of male genitalia with wishbone sclerite as long as the blade sclerites (Ribeiro-Costa 1998: 632, Fig. 9)..... ..... ***Amblycerus virescens* Ribeiro-Costa, 1998**

3' Median lobe of male genitalia with wishbone sclerite more than half of the length of the blade sclerites (Ribeiro-Costa 1998:634)..... ..... ***Amblycerus viridans* Ribeiro-Costa, 1998**

4 (2') Median lobe of male genitalia with blade sclerites longer than wishbone sclerite, denticulate from the apex to half its length (Ribeiro-Costa 1998: 636, Fig. 19)..... ***Amblycerus viridis* Ribeiro-Costa, 1998**

4' Median lobe of male genitalia with blade sclerites about one half of wishbone sclerite length, with denticles restricted to subapical region (Fig. 5) .... ***Amblycerus virens* (Jekel, 1855)**

***Amblycerus virens* (Jekel, 1855)**
http://species-id.net/wiki/Amblycerus_virens
Figs 1–6

Spermophagus virens Jekel, 1855: 33 (holotype, type locality: French Guiana; description, distribution); Gemminger and Harold 1873: 3219 (catalog, distribution); Pic 1913:63. (catalog, distribution).

Amblycerus virens: Blackwelder 1946: 763 (catalog, new combination); Udayagiri and Wadhi 1989:16 (catalog); Ribeiro-Costa 1998: 633 (citation).

Redescription. BL: 5.6 mm; BW: 3.84 mm

Integument (Figs 1–4). Body mostly black, mouth parts and antennomeres 1 and 2 brown to yellowish, apical spurs of hind tibiae reddish brown, pygidium and abdomen rufous with golden shine.

Vestiture (Figs 1–4). Pronotum, elytra and thorax covered with greenish setae, abdomen and pygidium with yellowish setae, both not variegated.

Head (Fig. 3). Covered with fine and dense punctures. Frons without frontal carina. Eye finely faceted, moderately prominent laterally. Ocular index: 3.11; ocular *sinus*: 0.63; postocular lobe 0.33 the eye length. Antenna not reaching anterior margin of hind coxa; moderately serrate from antennomeres 5-10 (Ribeiro-Costa 1998: 631, Fig. 3); from 5 to11 antennomeres 1.33 wider than long; last antennomere with truncate apex. Frontoclypeal suture indistinct. Clypeus covered with fine and dense punctures except in narrow band on apical portion. Labrum with few fine punctures on basal margin.

Prothorax. Pronotum semicircular; covered with fine and dense punctures, moderately coarse punctures intermixed on lateral areas (Fig. 1). Lateral carina almost reaching the anterior margin of pronotum (Fig. 2). Cervical sulcus absent. Prosternal process not expanded beyond anterior coxae; flat and slightly constricted between coxae.

Mesothorax and metathorax. Scutellum as long as wide; round or unidentate at apex (Fig. 1). Elytron with striae 1 and 10 moderately impressed; 2, 3, 8 and 9 weakly impressed until the third apical region of elytron then only isolated punctures representing striae; 4–7 striae formed only by isolated punctures; 4 and 5 anastomosed before the fusion of 6+7. Interstriae with moderately coarse and sparse punctures. Metaventrite moderately protuberant (Fig. 2) with moderately coarse and sparse punctures; median sulcus one-half as long as metaventrite. Metepisternum with moderately coarse and sparse punctures; metepisternal sulcus forming straight angle, with transverse axis straight and not reaching lateral margin of metepisternum. Mid coxae lower than anterior coxae, in lateral view (Fig. 2). Hind femur about 2.5 times longer than wide. Hind coxae with moderately coarse and sparse punctures. Hind tibia lateral spur about 1.5 times the length of median spur; 1-tarsomere about 1.5 the length of the lateral spur and 2.5 times the median spur.

Abdomen (Fig. 4). Ventrites with moderately coarse and dense punctures; last ventrite as long as 4-ventrite. Pygidium one-third covered by the elytra; apical margin rounded, with moderately coarse and dense punctures.

Male genitalia. Median lobe (Fig. 5) about 4.15 times its widest at apical region; ventral valve with lateral margins straight; dorsal valve with lateral margins concave and acuminate apex. Internal sac (Fig. 5) in the apical region without anterior sclerites; a pair of tuberculate median sclerites; a pair of ovoid and denticulate posterior sclerites. Median region with a pair of sinuous blade sclerites, sinuous at base and denticulate at apex; a long wishbone sclerite, about two times longer than the blade sclerites, curved and denticulate at apex and with stems moderately separated. Basal region of sac without sclerites; apical and median regions with several spines. Tegmen (Fig. 6) slightly emarginated between lateral lobes expanded.

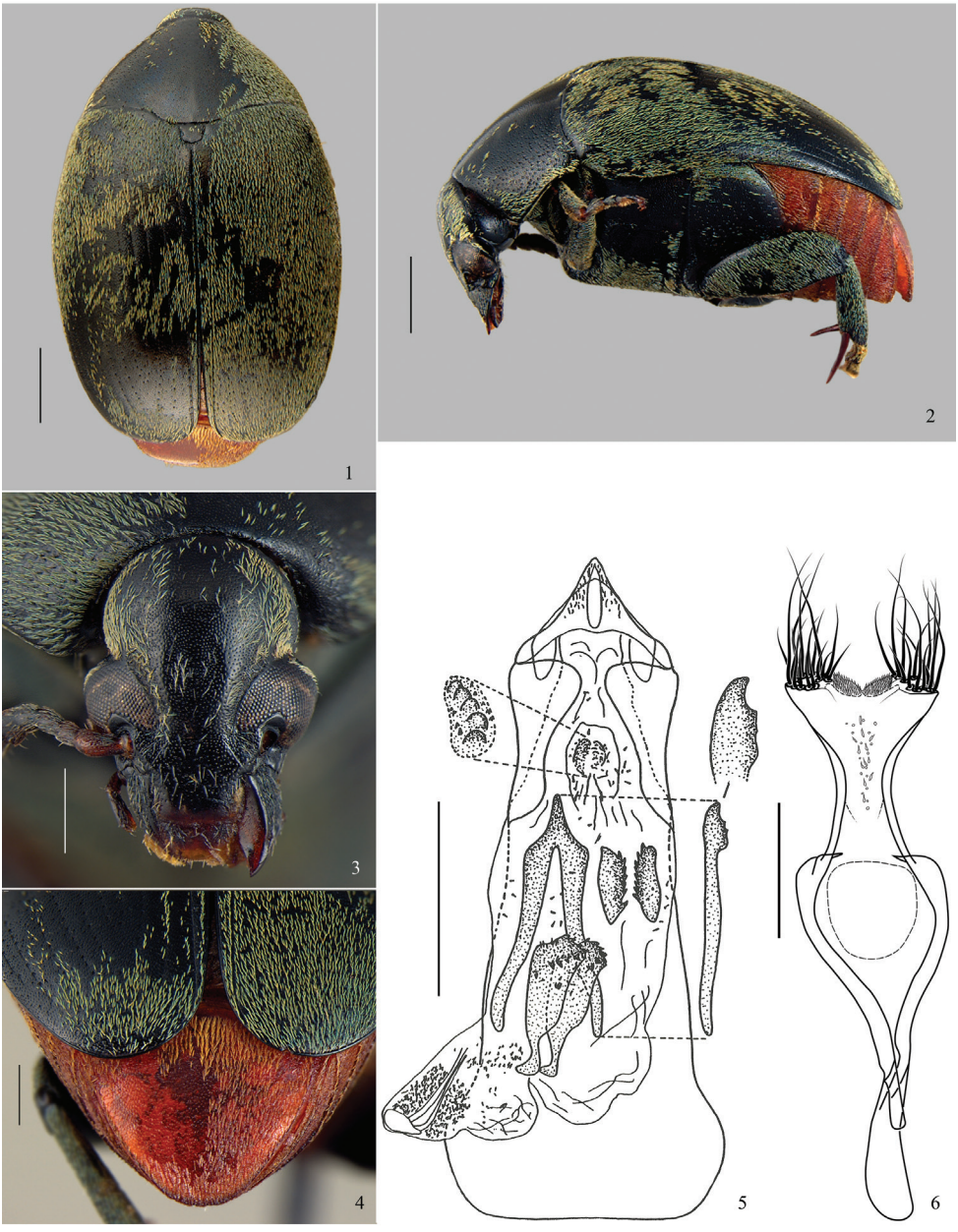

Figure 1–6. *Amblycerus virens* (Jekel, 1855), specimen male: **1** dorsal **2** lateral **3** head **4** pygidium **5** median lobe of male genitalia **6** tegmen of male genitalia. Scale bars = 1.0 mm (Figs **1–2**); scale bars = 0.5 mm (Figs **3–4, 6**); scale bar = 0.2 mm (Fig. **5**).

Type material. Syntype studied by the first author and deposited in BMNH, sex undetermined, labels: 'Type H. T.' [round, white with red margin]; 'Cayenna' [white]; 'ex. Mus. W. W. S.' [white]; 'Type' [white]; '53272' [white]; 'Fry Coll. 1905. 100'

[white]; '*Spermophagus virens* Dj. n. sp. Cayen'; 'SYNTYPE/Spermophagus/virens Jekel, 1855/Ribeiro-Costa, C. S.'

Notes. Jekel (1855) described the material quoted by Dejean (1837) but in his description, he did not specify how many specimens were studied. Therefore the exemplar received from BMNH, from the locality quoted in the original description, is a type specimen and regarded as a syntype.

Additional material. BRAZIL: Amazonas: 1 male specimen, São Gabriel, Rio Negro, 9.X.1927, J.F. Zikán, (FIOC). Pará: 1 male specimen, Santarém, VII.1919, S. M. Klages(CARN). **FRENCH GUIANA**: Bélvédère de Saül: 1 male specimen, Mont Itoupé, 30.III.2010, P. H. D. leg. (DZUP).

Distribution. Brazil (Amazonas and Pará), Fench Guiana.

Comparative notes. *Amblycerus virens* differs from the other species of the group by the length of the lateral spur of hind tibia (2.4 times the length of median; Fig. 2) (for other species the length of the lateral spur of hind tibia is less than 1.85 times the length of median); the internal sac of male genitalia has small blade sclerites (Fig. 5) (other species in the group have long blade sclerites).

This species shares with *A. viridis* and *A. medialis* the prominent eyes (Figs 3, 9), postocular lobe narrower and metaventrite protuberant in lateral view (Figs 2) but the male genitalia do not show closer similarities among these species. *Amblycerus virens* and *A. virescens* share a long wishbone sclerite comparing to the blades in the internal sac of male genitalia (Fig. 5; Ribeiro-Costa 1998: 632. Fig. 9).

Amblycerus virescens Ribeiro-Costa, 1998

http://species-id.net/wiki/Amblycerus_virescens

Amblycerus virescens Ribeiro-Costa, 1998: 630 (original description, holotype, type locality: Brazil, Amazonas). Ribeiro-Costa 1998: 631–632, Figs 1–10. Detailed description and information of type material are in Ribeiro-Costa (1998).

Distribution. Brazil (Amazonas, Amapá and Goiás).

Comparative notes. This species can be distinguished from all other of *virens* group by the internal sac of male genitalia that has a pair of subtriangular sclerites with denticulate margins (Ribeiro-Costa 1998: 632. Fig. 9) (*A. virens*, *A. viridis* and *A. viridans*, have a pair of sclerites with small rounded protuberances) (Fig. 5; Ribeiro-Costa 1998: 634, 636. Figs 14, 19); *A. medialis* Ribeiro-Costa, Vieira & Manfio, sp. n. absent (Fig. 11)).

Amblycerus virescens and *A. viridans* have no salient eyes (Ribeiro-Costa 1998: 631. Fig. 1), postocular lobe long, and metaventrite not protuberant (Ribeiro-Costa 1998: 631. Fig. 4). However, comparisons of male genitalia indicate that *A. virescens* is similar to *A. virens* because they both have a wishbone sclerite that is longer than the blades (Fig. 5; Ribeiro-Costa 1998: 632. Fig. 9).

***Amblycerus viridans* Ribeiro-Costa, 1998**
http://species-id.net/wiki/Amblycerus_viridans

Amblycerus viridans Ribeiro-Costa, 1998: 633 (original description, holotype, type locality: Brazil, Mato Grosso). Ribeiro-Costa 1998: 634, Figs 11–15. Detailed description and information of type material are in Ribeiro-Costa (1998).

Distribution. Brazil (Mato Grosso).

Comparative notes. *Amblycerus viridans* differs from all other species in the group by the structure of the internal sac of male genitalia, which includes a pair of sclerites formed by dense denticles (Ribeiro-Costa 1998: 634, Fig. 14: EPL) (character absent in *A. virescens*, *A. viridis*, *A. virens* and *A. medialis*). This species is similar to *A. viridis* because they both have a wishbone sclerite that is shorter than the blades; in addition both species also share the presence of a pair of slender denticulate sclerites on median region (Ribeiro-Costa 1998: 634, Fig. 14: EPC). Additional information on external morphological similarities is also presented in the section dedicated to *A. virescens*.

***Amblycerus viridis* Ribeiro-Costa, 1998**
http://species-id.net/wiki/Amblycerus_viridis

Amblycerus viridis Ribeiro-Costa, 1998:635 (original description, holotype, type locality: Brazil, Mato Grosso). Ribeiro-Costa 1998: 636, Figs 16–19. Detailed description and information of type material are in Ribeiro-Costa (1998).

Distribution. Brazil (Mato Grosso).

Comparative notes. *Amblycerus viridis* differs from the other species in the group by its shorter hind femur, which is 2.32 times longer than its width (in others species the ratio is superior to 2.5 times). Additional information on external and internal similarities is also presented in the sections dedicated to *A. virens* and *A. viridans*.

***Amblycerus medialis* Ribeiro-Costa, Vieira & Manfio, sp. n.**
http://zoobank.org/D819155A-D242-4BE0-813B-B5B258DD4554
http://species-id.net/wiki/Amblycerus_medialis
Figs 7–12

Description. BL: 6.3 mm; BW: 3.78 mm

Integument color (Figs 7–10). Body black except mouth parts brownish; apical spurs of hind tibiae brownish to black.

Vestiture (Figs 7–10). Pronotum with a predominantly green vestiture but also with yellowish setae on the anterior margin, lateral areas and median line; elytra with a

predominantly green vestiture but also with yellowish setae on 1 interstria; thorax and abdomen covered with pale yellowish setae.

Head (Fig. 9) covered with fine and dense punctures. Frons without frontal carina. Eyes moderately faceted, strongly prominent laterally. Ocular index: 2.23; ocular *sinus*: 0.78; postocular lobe 0.34 the eye length. Antennae not reaching anterior margin of hind coxa (Fig. 8); serrated from 4 to 10 antennomeres; from 3 to 11 antennomeres 1.94 longer than wider; 11 antennomere with truncate apex (Fig. 8). Frontoclypeal suture indistinct. Clypeus covered with fine and dense punctures except on a narrow band on apical portion. Labrum with few fine punctures on basal margin.

Prothorax (Fig. 7). Pronotum semicircular; covered with fine and dense punctures, moderately coarse punctures intermixed all over pronotum. Lateral carina complete, almost reaching the anterior margin of pronotum. Cervical sulcus absent. Prosternal process longer than anterior coxae, gently arched between coxae and slightly constricted between coxae.

Mesothorax and Metathorax. Scutellum longer than wide with tridentate apex. Elytron with striae moderately impressed, not fused apically. Interstriae with moderately coarse and dense punctures (Fig. 7). Metaventrite slightly protuberant with moderately coarse and sparse punctures; median sulcus one-half as long as metaventrite. Metepisternum without punctures; metepisternal sulcus forming straight angle, with transverse axis straight and reaching lateral margin of metepisternum. Mid coxae lower than anterior coxae, in lateral view (Fig. 8). Surface of hind coxae without punctures. Hind femur 3 times longer than wide. Hind tibia lateral spur about 1.5 times the length of median spur, and 1-tarsomere about 1.5 the length of lateral spur and 2.5 times the median spur.

Abdomen (Fig. 10). Ventrites finely punctulate, the last about 2 times wider than the 4-ventrite; pygidium one-half covered by the elytra, with apical margin rounded, with fine punctures.

Male genitalia (Figs 11–12). Median lobe (Fig. 11) about 5.43 times its widest at apical region; ventral valve with lateral margins concave, dorsal valve with lateral margins straight. Internal sac (Fig. 11) in the apical region without sclerites. Median region with a pair of straight blade sclerites, one side denticulate; wishbone sclerite as long as blade sclerites, curved at apex and stems moderately separated. Basal region with a sclerite with long stems gradually approximated. Apical and median regions with several spines and denticles. Tegmen (Fig. 12) deeply emarginated, about 0.35 times the length of the expanded lateral lobes.

Type material. Holotype deposited in FSCA, male, with labels: 'BRAZIL: Rondônia 62/ km SW Ariquemes, nr/ Fzda. Rancho Grande/ 8-20-XI-1994 JE Eger/ MV & Black Lights'[white, printed in black]; 'FSCA' [green, printed in black]; 'HOLOTYPE/ Amblycerus medialis/ Ribeiro-Costa, Vieira & Manfio, / [white with red margin, printed in black] (FSCA). 1 paratype deposited in CNCI, female, with labels: 'BRAZIL, Pará ♀/ Faz. Taperinha/ XI-19-22-1969/ JM & BA Campbell' [white, printed in black]; 'CNC' [white with green line in the middle, printed in black];

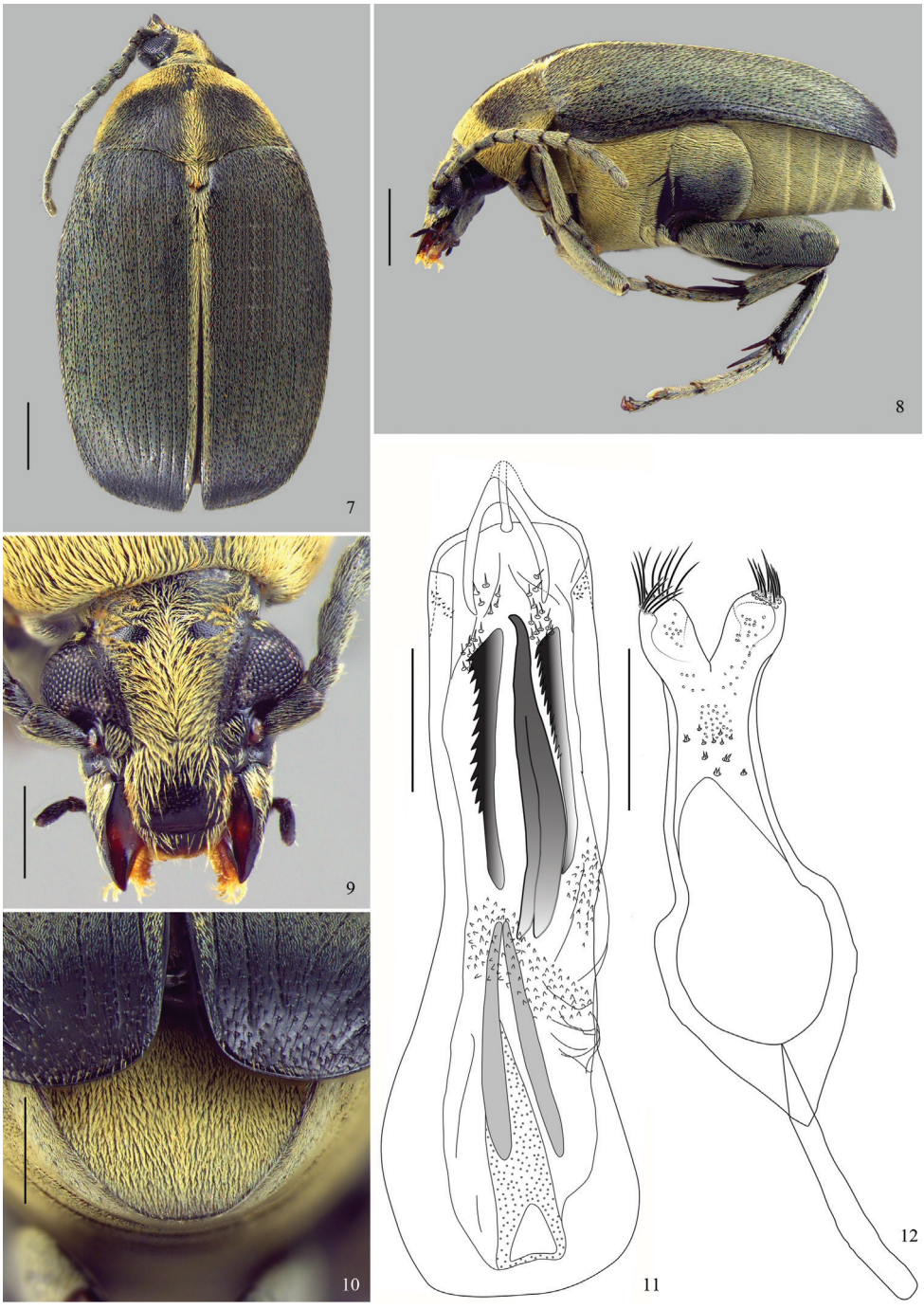

Figure 7–12. *Amblycerus medialis* Ribeiro-Costa, Vieira & Manfio, sp. n., holotype male: **7** dorsal **8** lateral **9** head **10** pygidium **11** median lobe of male genitalia **12** tegmen of male genitalia. Scale bars = 1.0 mm (Figs 7–**8**); scale bars = 0.5 mm (Figs **9–12**).

'PARATYPE/ Amblycerus medialis/ Ribeiro-Costa, Vieira & Manfio/ [white with yellow margin, printed in black] (CNCI).

Distribution. Brazil (Pará and Rondônia).

Comparative notes. *Amblycerus medialis* can be easily separated from others species in the group by the presence of yellow pubescent stripes on the pronotum and elytra (Fig. 7) (others species are exclusively with a green vestiture); antennomeres about 2 times as long as wide (Figs 7–8) (others wider than long).

Additional information on external and internal similarities is also presented in the sections dedicated to *A. virens* and *A. viridans*.

Etymology. The specific name refers to the median line on dorsum.

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RESEARCH ARTICLE

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Revision of the carnivorous snail genus *Discartemon* Pfeiffer, 1856, with description of twelve new species (Pulmonata, Streptaxidae)

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| *http://zoobank.org/05D46259-DA45-45A4-9127-5AF361D566A7*
¶ *http://zoobank.org/AC935098-D901-4F35-A414-4B0D4FE44E79*

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Abstract

Twelve new species of the streptaxid snail genus *Discartemon* Pfeiffer, 1856 are described from southern Thailand and western Malaysia, *D. afthonodontia* **sp. n.**, *D. circulus* **sp. n.**, *D. deprima* **sp. n.**, *D. discadentus* **sp. n.**, *D. discamaximus* **sp. n.**, *D. expandus* **sp. n.**, *D. flavacandida* **sp. n.**, *D. kotanensis* **sp. n.**, and *D. megalostraka* **sp. n.** from southern Thailand, as well as *D. conicus* **sp. n.**, *D. epipedis* **sp. n.** and *D. triancus* **sp. n.** from western Malaysia. All 15 previously described species are revised and commented upon based on examined material. *Streptaxis paradiscus* Möllendorff, 1900 is considered a junior subjective synonym of the type species *D. discus* (Pfeiffer, 1853). Details of the genital anatomy of twelve species, and the radula and pallial system, are provided for the first time. An identification key is provided.

Keywords
Systematics, genitalia, predator, anatomy, Southeast Asia

Introduction

The Streptaxoidea is divided into two sister families, Streptaxidae Gray, 1860 and Diapheridae Panha & Naggs, 2010 (Sutcharit et al. 2010). The superfamily is thought to have originated on the Laurasian continent during the Mesozoic era (Rowson et al. 2010). The Streptaxidae are carnivorous land snails occurring in tropical and subtropical areas from South America to Africa and Asia (Bruggen 1967, Schileyko 2000, Sutcharit et al. 2010). Most appear to be active predators feeding on other snails or other soil invertebrates, and may also be cannibalistic (Gray 1860, Blanford and Godwin-Austen 1908, Benthem Jutting 1954, Berry 1963). Streptaxids are particularly diverse in Africa, with hundreds of described species (Bruggen 1967, Winter and Gittenberger 1998, Rowson et al. 2010, Rowson and Tattersfield 2013). They are also diverse in Southeast Asia, comprising more than 130 nominal species in 15 genera (Blanford and Godwin-Austen 1908, Benthem Jutting 1954, Zilch 1960, Richardson 1988, Schileyko 2000, Siriboon et al. 2013, Siriboon et al. in press).

The shell has traditionally been emphasized in streptaxid taxonomy (Tryon 1885, Kobelt 1905, 1906, Benthem Jutting 1954). As in many stylommatophorans, the reproductive organs have also proven to be useful in discriminating taxa at the generic and specific levels (Stoliczka 1871, Berry 1963, 1965, Schileyko 2000, Siriboon et al. 2013, in press). To date, six generally accepted Southeast Asian genera, *Discartemon* Pfeiffer, 1856, *Oophana* Ancey, 1884, *Perrottetia* Kobelt, 1905, *Haploptychius* Möllendorff, 1906 and *Indoartemon* Forcart, 1946, have been critically dissected, investigated and illustrated, providing additional anatomical diagnostic and systematic characters (Stoliczka 1871, Berry 1963, 1965, Schileyko 2000, Siriboon et al. 2013, in press).

The genus *Discartemon* can be distinguished from other Southeast Asian streptaxid genera by having a flattened to subglobose-heliciform shell with the last whorl not being axially distorted from the columellar axis (Kobelt 1906, Benthem Jutting 1954, Zilch 1960, Richardson 1988, Schileyko 2000). *Discartemon* species are all larger than those of *Platycochlium* Laidlaw, 1950, a genus from Borneo whose anatomy is not known, and do not share the riblets on slopes of umbilicus, spaced transverse ridges, and continuous peristome. Knowledge of the genital anatomy of *Discartemon* is currently limited to *D. stenostomus* Benthem Jutting, 1954 as studied by Berry (1965). The genitalia show a short penis with a blunt appendix and a penial sheath along its whole length. The internal penial wall has cornified ridges but no penial hooks apart from a single large "stylet" in the apex of the penis.

The genus currently includes 15 nominal species and ranges from the Isthmus of Kra to peninsular Malaysia, with a few species recorded from Sumatra, Sulawesi and Indochina (Benthem Jutting 1954, 1959, Bruggen 1967, 1972, Richardson 1988). Most species have narrow distributions. Ten are recorded in peninsular Malaysia (Benthem Jutting

1954, 1959, Maassen 2001). Four species, *Discartemon roebeleni* (Möllendorff, 1894), *D. sykesi* (Collinge, 1902), *D. nummus* (Laidlaw, 1929) and *D. khaosokensis* Panha & Burch, 1998 have previously been recorded from Thailand (Panha 1996, Hemmen and Hemmen 2001). Two species occur in Cambodia and Vietnam, two further ones were recorded from Sumatra and one species was described from Sulawesi (Morlet 1889, Kobelt 1906, Laidlaw 1933, Benthem Jutting 1959, Marwoto 2008, Schileyko 2011). The Sulawesi species of *Discartemon* represents one of only two streptaxid genera recorded from Sulawesi, the other being *Haploptychius*, of which three species are recorded (Bruggen 1972).

This present study aims firstly to provide shell and anatomical descriptions for characterization and identification within the genus *Discartemon*, including new species The second aim is to revise the previously described species. The third aim is to record and discuss the geographic distribution of the genus.

Material and methods

Streptaxids were intensively surveyed throughout southern Thailand and western Malaysia and Vietnam from 1995–2012. Identifications were provisionally made based on Kobelt (1906) and Benthem Jutting (1954, 1959) and comparison with type specimens from many museums. Living snails were photographed before being stored at -20 °C prior to being preserved in 70% and 95% ethanol for anatomical and molecular studies. Shell height (H), shell width (W), whorl counts and H/W ratio were measured and calculated. Shells were digitally imaged using Cell'D Imaging Software. Description of apertural dentition follows Pilsbry (1916) and Siriboon et al. (2013). The genitalia of 5–10 specimens of each species were dissected under a stereo-microscope. Anatomical sketches were drawn using a camera lucida. The buccal masses were removed, and the radulae were soaked in 10% sodium hydroxide, cleaned in distilled water, examined and photographed under SEM (JEOL, JSM-5410 LV). Atrial and penial and vaginal hooks were critical point dried by using absolute ethanol prior to investigation under SEM (PHILIPS, XL30). In the descriptions, 'proximal' relates to the genital orifice, and 'distal' to the region furthest away from the genital orifice. Apart from the term 'penial appendix' terms are as defined by Stoliczka (1871), Berry (1963), Verdcourt (2000), Sutcharit et al. (2010) and Siriboon et al. (2013)

Anatomical abbreviations: a, anus; ag, albumen gland; at, atrium; fo, free oviduct; gd, gametolytic duct; gs, gametolytic sac; h, heart (auricles and ventricle); hd, hermaphroditic duct; k, kidney; ov, oviduct; p, penis; pa, penial appendix; pn, pneumostome; pp, penial papilla; pr, penial retractor muscle; ps, penial sheath; psr, penial sheath retractor muscle; puv, pulmonary vein; rt, rectum; sv, seminal vesicle; ta, talon; ur, ureter; v, vagina; vd, vas deferens.

Institutional abbreviations: Examined material was deposited in the following institutions:

CUMZ Chulalongkorn University Museum of Zoology, Bangkok;

MNHN Muséum National d'Histoire Naturelle, Paris;
NHMUK The Natural History Museum, London;
NHMW Naturhistorishes Museum Wien, Vienna;
NMW National Museum of Wales, Cardiff;
RMNH National Museum of Natural History Naturalis, Leiden;
RBINS Royal Belgian Institute of Natural Sciences, Brussels;
SMF Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main;
ZMA Zoological Museum Amsterdam, Amsterdam;
ZMB Museum für Naturkunde, Berlin.

All descriptions of the new species are here attributed to the first and the fourth author, Siriboon and Panha, respectively.

Systematics

Family Streptaxidae Gray, 1860

Genus *Discartemon* Pfeiffer, 1856

http://species-id.net/wiki/Discartemon

Discartemon Pfeiffer, 1856: 173. Ancey 1884: 399. Tryon 1885: 58. Gude 1903: 226. Benthem Jutting: 1954: 71–94. Zilch 1960: 560. Richardson 1988: 182–185: Schileyko 2000: 784. Hemmen and Hemmen 2001: 42.
Odontartemon (*Discartemon*) – Kobelt 1905–1906: 91, 96.

Type species. *Streptaxis discus* Pfeiffer, 1853, by subsequent designation by Ancey (1884: 399).

Description. Shell. Shell flattened to globose-heliciform, white, semi-transparent to translucent. Whorls 4–7; spire flattened to conical. Shell surface glossy, nearly smooth or with transverse ridges; varices often present. Embryonic shell, about 2½ whorls, with a smooth surface; following whorls regularly coiled or at most only slightly axially deflected. Last whorl rounded to angular, often with peripheral keel, whorls regularly to rapidly expanded. Umbilicus open to very widely open. Aperture semi-ovate to triangular. Peristome discontinuous, thin to thick, expanded and reflected. Longitudinal furrows outside aperture may be present. Apertural dentition always with one parietal lamella; other lamellae may be present including: upper palatal, palatal, basal, columellar and supracolumellar lamellae.

Radula. Teeth unicuspid, elongate lanceolate, and arranged in anteriorly V-shaped rows. Central tooth tiny with pointed cusp. Lateral and marginal teeth undifferentiated. Latero-marginal teeth gradually reduce in size, with outermost teeth smaller and shorter than inner teeth.

Genital organs. Penis short to long, sometimes with a penial appendix. Penial sheath short (less than half of penis length) to long (equivalent to penis length). Internal wall of introverted penis with transparent to brown penial hooks. Vas deferens passes through a short section of penial sheath before connecting distally to penis. Vagina and free oviduct short to long. Seminal vesicle present, convoluted, short to long.

External features. Live specimens exhibit a semi-transparent dark yellow to pale yellow body, covered with reticulated skin, and sometimes with brownish spots. Upper tentacles long with black eye-spot on the tip, yellow to orange; lower tentacles short. Brownish digestive gland and black kidney may be visible through transparent shell. Foot narrow, undivided and with short tail.

Remarks. The genitalia of *Discartemon* are distinguished from those of other Southeast Asian streptaxid genera in sometimes having a penial appendix, in lacking vaginal hooks, and also as follows: *Indoartemon* has the vas deferens attached to the distal end of the penial sheath by a narrow band of connective tissue; in *Perrottetia* the gametolytic duct and sac may not extend as far as the albumin gland; and *Haploptychius* and *Oophana* have a long penial sheath and very short seminal vesicle respectively (Stoliczka 1871, Berry 1963, 1965, Schileyko 2000, Siriboon et al. 2013, Siriboon et al. in press).

An identification key to species follows. In addition we propose an informal subdivision of *Discartemon* into three groups of species, based mainly on shell shapes as shown in Figure 1, that may be useful as an alternative aid to identification. The figures of shells are presented in the same order.

Further remarks on the systematics and biogeography of the genus are made in the Discussion.

Group I: *Discartemon discus*-group. Have a generally flattened shell with a concave to flattened spire, and a very wide umbilicus. The H/W ratio ranges between 0.3–0.5 (average 0.40). This group comprises 10 species: *D. discus* (Pfeiffer, 1853), *D. planus* (Fulton, 1899), *D. sykesi* (Collinge, 1902), *D. nummus* (Laidlaw, 1929), *D. khaosokensis* Panha & Burch, 1998, *D. circulus* sp. n., *D. discadentus* sp. n., *D. discamaximus* sp. n., *D. deprima* sp. n., and *D. expandus* sp. n.

Group II: *Discartemon plussensis*-group. Have a depressed-heliciform shell with a flattened to only slightly convex spire, and a widely open umbilicus. The H/W ratio ranges between 0.4–0.6 (average 0.50). This group comprises 7 species: *D. plussensis* (Morgan, 1885), *D. hypocrites* Benthem Jutting, 1954, *D. leptoglyphus* Benthem Jutting, 1954, *D. platymorphus* Benthem Jutting, 1954, *D. afthonodontia* sp. n., *D. epipedis* sp. n., and *D. flavacandida* sp. n.

Group III: *Discartemon roebeleni*-group. Have a globose-heliciform shell with a conical to elevated conical spire, and a widely open umbilicus. The H/W ratio ranges between 0.5–0.8 (average 0.63). This group comprises 10 species: *D. lemyrei* (Morlet, 1883), *D. roebeleni* (Möllendorff, 1894), *D. collingei* (Sykes, 1902), *D. stenostomus* Benthem Jutting, 1954, *D. sangkarensis* Benthem Jutting, 1959, *D. vandermeermohri* Benthem Jutting, 1959, *D. conicus* sp. n., *D. kotanensis* sp. n., *D. megalostraka* sp. n., and *D. triancus* sp. n.

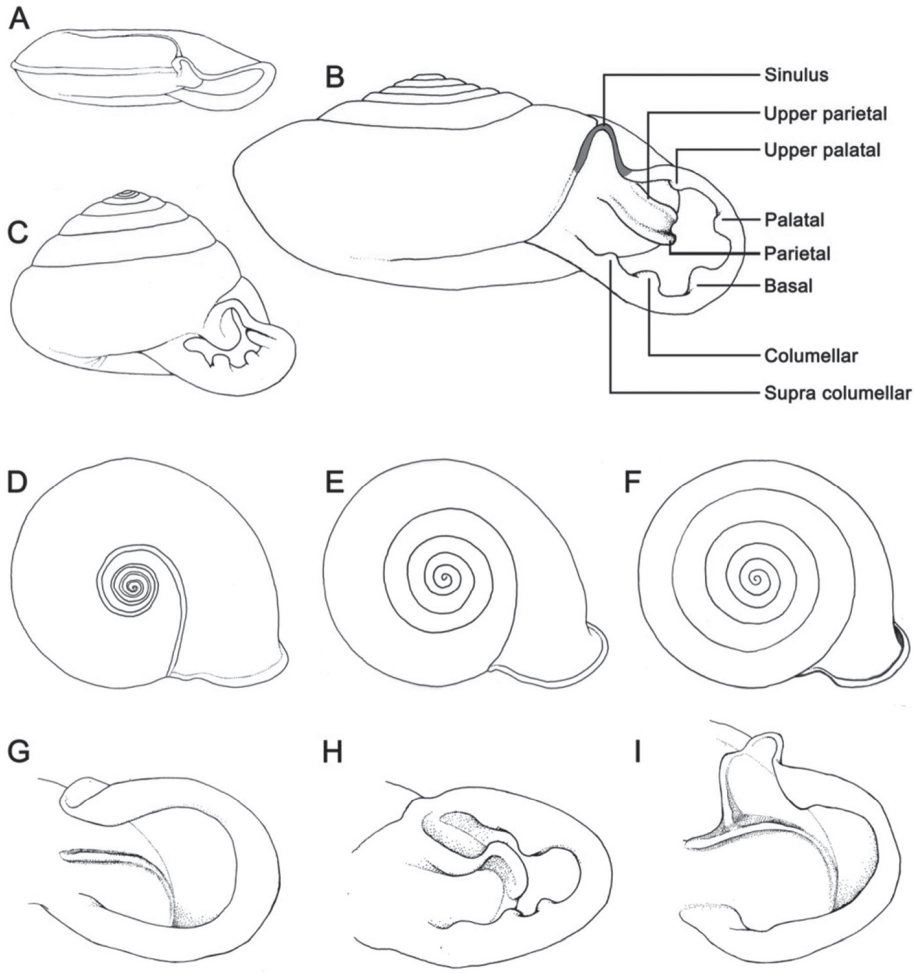

Figure 1. Schematic of shell shapes, last whorl expansion and parietal lamella shape. Terminology of *Discartemon* apertural dentition in figure **B**. **A–C** Shell form and spire **A** flattened shell with concave spire **B** depressed-heliciform shell with only slightly convex spire, and **C** globose-heliciform with conical spire **D–F** Last whorl expansion **D** rapidly expanded **E** intermediately expanded, and **F** regularly expanded **G–I** Parietal lamella form **G** single lamella with straight shape (typical) **H** single lamella with curved shape (sinuous), and **I** modified with "Y" shaped lamella.

Key to species of *Discartemon* Pfeiffer, 1856

Numbers for each species refer to the order in which species treatments appear in this paper.

1a Shell flattened (Fig. 1A); spire concave, flattened or only slightly elevated .. **2**
1b Shell depressed (Fig. 1B)- or globose-heliciform (Fig. 1C); spire flattened, convex or conical **11**
2a Shell width usually greater than 10 mm **3**

2b Shell width usually less than 10 mm **6**

3a Spire concave; last whorl angular with strong peripheral keel .... **5. *D. khaosokensis***

3b Spire flattened or only slightly elevated; last whorl angular **4**

4a Apertural dentition with four or five lamellae: parietal, palatal, basal, columellar and small supracolumellar lamellae (the last sometimes absent)..... ..... **6. *D. discadentus* sp. n.**

4b Apertural dentition with only a parietal lamella (Fig. 1G)..... **5**

5a Last whorl regularly expanded (Fig. 1F); shell surface smooth; spire flattened..... **1. *D. discus* (= *D. paradiscus*)**

5b Last whorl rapidly expanded (Fig. 1D); transverse ridges present only near suture; spire flattened to concave ..... **7. *D. discamaximus* sp. n.**

6a Spire concave..... **7**

6b Spire flattened..... **8**

7a Last whorl rounded, rapidly expanded; aperture triangular. Apertural dentition with parietal, palatal and columellar lamellae..... **2. *D. planus***

7b Last whorl angular with strong peripheral keel, intermediately expanded (Fig. 1E); aperture semi-ovate. Apertural dentition with only a parietal lamella .... **9. *D. deprima* sp. n.**

8a Apertural dentition with five lamellae: parietal, palatal, basal, columellar and supracolumella lamellae ..... **8. *D. circulus* sp. n.**

8b Apertural dentition with one or two lamellae: parietal and columellar lamellae..... **9**

9a Shell width usually less than 7 mm; last whorl angular with peripheral keel; Y-shaped parietal lamella (Fig. 1I)..... **4. *D. nummus***

9b Shell width greater than 7 mm; last whorl angular or rounded; straight parietal lamella..... **10**

10a Shell surface smooth; peristome thickened and expanded ..... **3. *D. sykesi***

10b Shell surface with transverse ridges disappearing below periphery; peristome thin and widely expanded..... **10. *D. expandus* sp. n.**

11a Shell depressed-heliciform; spire flattened to convex (Fig. 1B)..... **12**

11b Shell globose-heliciform; spire conical to elevated conical (Fig. 1C)..... **18**

12a Shell surface usually smooth or with few transverse ridges near aperture. Last whorl shouldered or angular and with strong peripheral keel **13**

12b Shell surface with fine transverse ridges. Last whorl angular or rounded.... **15**

13a Longitudinal furrow absent. Apertural dentition with four lamellae: parietal, palatal, basal and columellar lamellae..... **16. *D. epipedis* sp. n.**

13b Two longitudinal furrows present. Apertural dentition with five to seven lamellae **14**

14a Shell width usually greater than 10 mm; spire only slightly convex; varices absent. Last whorl slightly axially deflected. Apertural dentition with seven lamellae: parietal, upper parietal, upper palatal, palatal, basal, columellar and supracolumellar lamellae. The two latter lamellae usually small. Penis long, about same length as free oviduct; penial appendix present ..... **17. *D. flavacandida* sp. n.**

14b Shell width usually less than 10 mm; spire conical; varices present. Last whorl regularly coiled. Apertural dentition usually with five lamellae: parietal, palatal, basal, columellar and supracolumellar lamellae. An additional upper parietal and upper palatal lamellae are sometimes present. Penis short, about ¼ length of free oviduct; penial appendix absent....**15. *D. afthonodontia* sp. n.**

15a Apertural dentition with four lamellae: sinuous parietal (Fig. 1H), palatal, columellar and supracolumellar lamellae.....**12. *D. hypocrites***

15b Apertural dentition with only one lamella or two lamellae: parietal and palatal lamellae **16**

16a Transverse ridges present over entire shell; last whorl angular and less inflated .....**13. *D. leptoglyphus***

16b Transverse ridges disappear below periphery; last whorl rounded and more inflated **17**

17a Shell width usually less than 7 mm; spire flattened; sinulus present ....**11. *D. plussensis***

17b Shell medium (7 ≤ shell width ≤ 10 mm); spire low convex; sinulus absent ....**14. *D. platymorphus***

18a Apertural dentition with only parietal lamella.....**19**

18b Apertural dentition with four lamellae.....**22**

19a Umbilicus usually narrow; sinulus absent.....**18. *D. lemyrei***

19b Umbilicus widely open; sinulus present **20**

20a Shell surface with fine transverse ridges; spire conical; last whorl rounded; aperture triangular **21**

20b Shell surface smooth; spire elevated conical; last whorl angular; aperture subcircular .....**27. *D. conicus* sp. n.**

21a Apertural dentition with only parietal lamella; sinulus present ....**22. *D. sangkarensis***

21b Apertural dentition with two lamellae: parietal and columellar lamellae; sinulus absent.....**23. *D. vandermeermohri***

22a Spire only slightly convex; last whorl shouldered or angular.....**23**

22b Spire conical to elevated conical; last whorl rounded.....**24**

23a Parietal lamella sinuous; supracolumellar lamella present**21. *D. stenostomus***

23b Parietal lamella straight; basal lamella present .....**26. *D. triancus* sp. n.**

24a Shell width usually greater than 10 mm. Free oviduct very long ....**25. *D. megalostraka* sp. n.**

24b Shell width usually less than 10 mm. Free oviduct very short.....**25**

25a Last whorl shouldered and slightly axially deflected .....**20. *D. collingei***

25b Last whorl rounded and regularly coiled **26**

26a Spire elevated conical. Penis about four times longer than free oviduct and seminal vesicle short.....**24. *D. kotanensis* sp. n.**

26b Spire conical. Penis about same length as vagina and free oviduct and seminal vesicle very long.....**19. *D. roebeleni***

Group I: *Discartemon discus*-group: Species with flattened shell

1. *Discartemon discus* (Pfeiffer, 1853) ["1851"]

http://species-id.net/wiki/Discartemon_discus
Figs 4A–C, 11A–C, 22A, 23, Table 1

Streptaxis discus Pfeiffer, 1851: 252. Type locality: Unknown. Pfeiffer 1853: 289. Pfeiffer 1854: 394, 395, pl. 145, figs 15–17. Ancey 1884: 399. Tryon 1885: 66, pl. 16, figs 77–79. Gude 1903: 226.

Discartemon discus – Bourguignat 1899: 46. Richardson 1988: 182. Schileyko 2000: 784, fig. 1022.

Streptaxis (*Discartemon*) *paradiscus* Möllendorff, 1900: 117. Type locality: Phucson bei Touranne, Annam. Gude 1903: 227. Ancey 1904: 289, 290.

Odontartemon (*Discartemon*) *discus* – Kobelt 1906: 97, pl. 55, figs 5–7.

Odontartemon (*Discartemon*) *paradiscus* – Kobelt 1906: 97, 98, pl. 55, figs 8, 9.

Discartemon paradiscus – Benthem Jutting 1954: 79. Zilch 1960: fig. 1961. Zilch 1961: 82, pl. 5, fig. 3. Schileyko 2011: 22, 23.

Material examined. This species was described from specimens from the H. Cuming collection. The number of specimens was not indicated, but only one set of measurements was given in the original description. Only one specimen from the H. Cuming collection at NHMUK has Pfeiffer's handwriting on the species name label. It is identical to the illustration and measurements in Pfeiffer (1854: 394, 395, pl. 145, figs 15–17) and is designated here as the lectotype to stabilize the name: NHMUK 20130684 (Fig. 4A).

Lectotype of *Streptaxis paradiscus* Möllendorff, 1900 SMF 108534 (Fig. 4B) and paralectotypes SMF 108535 (5 shells). Marble Mountain, Da Nang, Vietnam (16°0'13.4"N, 108°15'49.1"E): CUMZ 6001 (39 shells; Fig. 4C), 6257 (6 specimens in ethanol; Figs 11A, B, 22A). Annam: MNHN Jousseaume Coll. (1 shells), MNHN Denis Coll. (2 shells), MNHN Letellier Coll. (3 shells), NHMW 40858 (2 shells), NHMUK 1901.12.23.13–14 (2 shells), NHMUK Trechmann coll. Acc. 2176 (2 shells), NHMUK Connolly Coll. Acc. 2154 (1 shell), RMNH Fruhstorfer Coll. 45a (1 shell), RMNH Saverbgen Coll. (2 shells). Tourane [=Da Nang], Central Annam: NHMUK McAndrew coll. Acc. 1563 (2 shells). Touraine, Annam: NHMW Rusnov Coll. R 283 (2 shells), NMW 1955.158.25251 (1 shell), RMNH Verdcourt Coll. (2 shells), ZMB 6619 (3 shells), ZMB 52300 (3 shells). Phuc-Son, Annam: NHMW 31140 (1 shell).

Description. Shell. Shell flattened, white and translucent; whorls 6–6½; spire flattened with distinct suture. Shell surface glossy, smooth with growth lines and varices present. Embryonic shell large, about 2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl angular, regularly expanded; umbilicus very wide, shallow and showing all preceding whorls. Aperture semi-ovate; peristome discontinuous, thickened, expanded and reflected; apertural dentition with only one parietal lamella (Fig. 4A–C).

Table 1. Shell measurements of *Discartemon* spp (*D. discus*-group). Specimen collections and catalogue numbers indicated in parentheses.

Species and locality and CUMZ nos	No. of specimens	Ranges, mean ± S.D. in mm of:			Number of whorls
		Shell height	Shell width	H/W ratio	
Discartemon discus (Pfeiffer, 1853)					
Da Nang, Vietnam: (6001, 6257)	45	4.2–6.7 5.0±0.43	11.78–14.26 12.9±0.59	0.3–0.5 0.4±0.03	6–6½
Discartemon nummus (Laidlaw, 1929)					
Khao Ok Thalu, Phatthalung: (3594)	24	2.4–3.3 2.8±0.21	6.1–7.2 6.5±0.27	0.4–0.5 0.4±0.03	5½
Discartemon khaosokensis Panha & Burch, 1998					
Khao Sok N. P., Suratthani: (6242, 6243)	5	3.4–4.0 3.6±0.26	11.2–12.4 11.8±0.47	0.3–0.3 0.3±0.02	5½–5¾
Discartemon discadentus sp. n.					
Wat Tam Yai, Suratthani: (6209, 6244, 6258)	16	3.9–5.8 5.0±0.49	10.1–15.4 11.9±0.32	0.4–0.5 0.4±0.04	6
Wat Tam Wararam, Suratthani: (3571)	15	5.5–7.0 6.3±0.33	12.4–13.6 13.1±0.32	0.4–0.5 0.4±0.02	6
Discartemon discamaximus sp. n.					
Tam Namphud, Phangnga: (6005, 6245)	5	4.7–5.0 4.9±0.10	12.4–13.6 14.3±0.49	0.3–0.4 0.3±0.02	7
Tam Kobe, Phangnga: (3669, 6197)	17	4.4–5.6 4.9±0.38	10.8–13.7 12.3±0.76	0.4–0.4 0.4±0.02	7
Discartemon circulus sp. n.					
Tam Phannara, Nakhon Si Thammarat: (3665, 6246, 6262)	23	3.0–4.5 3.7±0.32	7.7–9.5 8.6±0.45	0.4–0.5 0.4±0.03	5½–6
Discartemon deprima sp. n.					
Khao Hup Ta Hae, Prathiew, Chumphon: (3573, 6247)	7	2.5–3.4 2.9±0.30	8.2–10.3 9.1±0.72	0.3–0.3 0.3±0.02	5–5½
Ban Tam Thong, Prathiew, Chumphon: (6259)	5	3.1–3.8 3.5±0.27	9.5–11.2 10.1±0.68	0.3–0.3 0.3±0.01	5–5½
Discartemon expandus sp. n.					
Klong Hoy, Suratthani: (3664, 6248)	16	3.6–4.3 4.0±0.30	8.2–10.9 9.9±0.84	0.4–0.5 0.4±0.03	5½–6

Radula. Each row consists of 61–67 teeth with formula (30-33)-1-(30-33). Central tooth very small and triangular with pointed cusp. Lateral and marginal teeth undifferentiated, unicuspid and lanceolate. Latero-marginal teeth gradually reduce in size, with outermost teeth smaller and shorter than inner teeth (Fig. 22A).

Genital organs. Atrium (at) short; penis (p) long and slender. Penial sheath (ps) thin, extending about half to third-fourths of penis length; penial sheath retractor muscle (psr) very thin, originating at atrium and inserting at distal end of penial sheath (Fig. 11A). Vas deferens (vd) passes through a very short part of penial sheath before entering into penis distally (Fig. 11B). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Vagina (v) long, cylindrical, about two thirds of penis length. Gametolytic duct (gd) a long tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) short; oviduct (ov) enlarged and folded. Prostate gland inconspicuous and bound to oviduct. Talon (ta) small. Hermaphroditic duct (hd) bearing long seminal vesicle (sv) about one and half times longer than the length from talon to branching point of seminal vesicle (Fig. 11A).

Pallial system. Excretory system typically sigmurethran and without mantle gland. Heart (h, auricles and ventricle) located left of kidney (on right in Fig. 11C). Pulmonary cavity approximately three times longer than broad. Pulmonary vein (puv) and venation on lung roof distinct and well developed. Kidney (k) very short, located at posterior of pulmonary cavity. Ureter (ur) sigmoid, closed tube arising from apex of kidney, extending along right side of kidney, recurving adjacent to rectum (rt). Anus (a) adjacent to pneumostome (pn) on mantle collar.

Remarks. The type specimen discovered in the H. Cuming collection at NHMUK elucidates two issues. Firstly, *Streptaxis paradiscus* Möllendorff, 1900 has been recognized as a separate species in many works (Möllendorff 1900, Gude 1903, Kobelt 1906, Benthem Jutting 1954, Zilch 1960, 1961, Schileyko 2011). However, based on the type specimens, *D. discus* and *S. paradiscus* are identical in all shell characters. Therefore, we officially place *Streptaxis paradiscus* as a junior subjective synonym of *D. discus*. Second, *D. discus* had an unknown type locality and range (Pfeiffer 1851: 252). From the new material and the type locality of *S. paradiscus*, the distribution of this species is demarcated to several localities in the area of Da Nang, Vietnam (Schileyko 2011).

The record of *Streptaxis discus* from Brazil, mentioned in Bourguignat (1899) is almost certainly an error, since it is far beyond the distribution range of the genus. The specimen figured in Simone (2006: 191, fig. 708, reg. NHMUK Trechmann Acc. 2176) has the locality Annam [= central Vietnam].

2. *Discartemon planus* (Fulton, 1899)
http://species-id.net/wiki/Discartemon_planus
Figs 4D, 23

Streptaxis planus Fulton, 1899: 214, pl. 11, fig. 2. Type locality: South Celebes. Gude 1903: 227. Laidlaw 1933: 233. Sarasin and Sarasin 1899: 228.
Odontartemon (*Discartemon*) *planus* – Kobelt 1906: 100, 101, pl. 54, figs 15–17. Kobelt 1910: 150. Laidlaw 1929: 260.
Discartemon planus – Benthem Jutting 1954: 79. Bruggen 1972: 394. Richardson 1988: 183. Maassen 1997: 55. Marwoto 2008: 191–194, fig. 1.

Material examined. Celebes [=Sulawesi], Indonesia: NMW 1955.158.25252 (1 shell; Fig. 4D).

Remarks. The shell of this species is clearly distinct from all other recognized species. Shell flattened, with a concave spire and distinct suture. Shell surface smooth, varices present; whorls regularly coiled. Last whorl rounded with keel below periphery, rapidly expanded; umbilicus very wide, concave and showing all preceding whorls. Aperture triangular with long and narrow sinulus, peristome thickened and little reflected. Apertural dentition with one parietal, one palatal and one columellar lamella (Fig. 4D) (Fulton 1899, Kobelt 1906, Marwoto 2008).

The distribution of *D. planus* seems to be outside the ranges of all other *Discartemon* species, and is probably restricted to the limestone karst in the south of Sulawesi (Fulton 1899, Sarasin and Sarasin 1899, Laidlaw 1929, Bruggen 1972, Marwoto 2008). It does not closely resemble any other streptaxid genus more closely than *Discartemon*. However, the very wide umbilicus showing all preceding whorls and surrounded with a keel, with a long and narrow adapical sinulus, may indicate that *D. planus* comprises a distinct lineage within *Discartemon*. Both Bruggen (1972) and Marwoto (2008) discussed the possibility that it required a separate genus or subgenus, but anatomical or molecular evidence are desirable to support this assertion.

3. *Discartemon sykesi* (Collinge, 1902)

http://species-id.net/wiki/Discartemon_sykesi
Figs 4E, F, 23

Streptaxis sykesi Collinge, 1902: 72, pl. 4, figs 1, 2. Type locality: Biserat, State of Jalor. Laidlaw 1933: 233.
Odontartemon (*Discartemon*) *sykesi* – Kobelt 1906: 100, pl. 55, figs 1, 2. Kobelt 1910: 150.
Discartemon sykesi – Benthem Jutting 1954: 86, 87. Benthem Jutting 1959: 168. Richardson 1988: 184, 185. Maassen 2001: 88, 89. Hemmen and Hemmen 2001: 42.

Material examined. Paratypes NHMUK 1937.7.9.11 (1 shell; Fig. 4F) and NMW 1955.158.25257 (1 shell; Fig. 4E).

Remarks. The distinguishing characters of this species are the flattened shell and spire with a distinct suture. Shell surface nearly smooth with thin growth lines, varices present; following whorls regularly coiled. Last whorl angular, intermediately expanded; umbilicus very wide and showing all preceding whorls. Aperture semi-ovate with sinulus; peristome thickened, expanded and reflected; apertural dentition with only one parietal lamella (Fig. 4E).

Discartemon sykesi differs from *D. discus* in its smaller shell, in the presence of a sinulus, the intermediately expanded last whorl, and in being restricted to the Malay Peninsula. This species can be distinguished from *D. planus* in having a larger shell with flattened spire, the last whorl angular and intermediately expanded, a semi-ovate aperture, and in lacking palatal and columellar lamellae.

4. *Discartemon nummus* (Laidlaw, 1929)
http://species-id.net/wiki/Discartemon_nummus
Figs 2A, 4G, 11D, E, 17A–E, 22B, 23, Table 1

Odontartemon (*Discartemon*) *nummus* Laidlaw, 1929: 259, 260, fig. 1. Type locality: Tale Sap, Singgora. Laidlaw 1933: 234.
Discartemon nummus – Benthem Jutting 1954: 87, 88. Benthem Jutting 1959: 168. Richardson 1988: 183.

Material examined. Khao Ok Thalu, Phatthalung, Thailand (7°37'39.1"N, 100°5'19.1"E): CUMZ 3594 (24 shells; Fig. 4G) and 6208 (12 specimens in ethanol; Figs 2A, 11D, E, 17A–E, 22B).

Description. Shell. Shell flattened, white and semi-transparent; whorls 5½, spire flattened with distinct suture. Shell surface glossy with thin transverse ridges near suture and varices present. Embryonic shell about 2½ whorls; following whorls regularly coiled. Last whorl angular with strong peripheral keel, regularly expanded; umbilicus very wide and showing all preceding whorls. Aperture triangular with sinulus; peristome continuous, thickened, expanded and reflected. Apertural dentition with a Y-shaped parietal lamella adjoining at sinulus (Fig. 4G).

Radula. Each row consists of 39–41 teeth with formula (19-20)-1-(19-20). Central tooth very small and triangular with pointed cusp. Lateral and marginal teeth undifferentiated, unicuspid and lanceolate. Latero-marginal teeth gradually reduce in size, with outermost teeth smaller and shorter than inner teeth (Fig. 22B).

Genital organs. Atrium (at) long. Proximal penis (p) long, slender; distal penis globularly enlarged. Penial sheath (ps) thin, extending about two-thirds of penis length; penial sheath retractor muscle very thin (psr), originating at genital orifice wall and inserting distally on penial sheath (Fig. 11D). Vas deferens (vd) passes through about one-fifth of penial sheath length before entering into penis distally (Fig. 11E). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium generally smooth (Fig. 17A); penial wall with scattered, short and transparent penial hooks, about 5 hooks/200 μm^2 (Fig. 17B); hooks located on round-ovate penial papilla. Penial hooks of small size (<0.04 mm in length), slightly expanded at base, tip obtuse and directed towards genital orifice (Fig. 17C, D).

Vagina (v) short and stout, about half of penis length. Gametolytic duct (gd) a long tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) long and thick; oviduct (ov) enlarged and folded; prostate gland inconspicuous and bound to oviduct. Talon (ta) small, very short and club shaped. Hermaphroditic duct (hd) bearing long seminal vesicle (sv) about one and half times longer than the length from talon to branching point of seminal vesicle (Fig. 11D).

Vaginal wall generally with smooth surface of longitudinal vaginal folds (Fig. 17E).

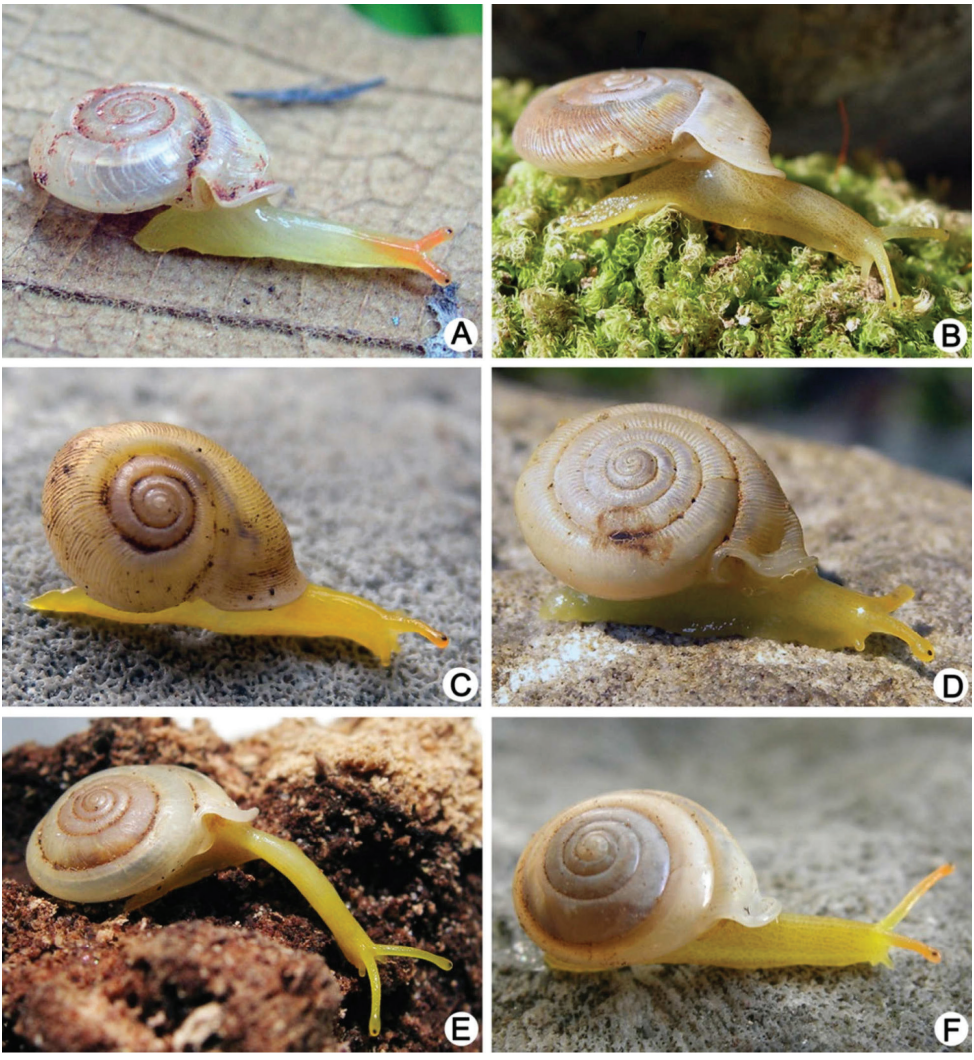

Figure 2. Living snails. **A** *Discartemon nummus* CUMZ 6208, from Patthalung (shell width about 6 mm) **B** *Discartemon discadentus* sp. n. paratype CUMZ 6209 (shell width about 12 mm) **C** *Discartemon leptoglyphus* CUMZ 6007, from Ipoh, Perak, Malaysia (shell width about 6 mm) **D** *Discartemon hypocrites* topotype CUMZ 6199 (shell width about 6 mm) **E, F** *Discartemon afthonodontia* sp. n. **E** paratype CUMZ 6210 (shell width about 9 mm), and **F** specimen CUMZ 6214, from Tam Khao Phlu, Chumphon (shell width about 8 mm).

Remarks. *Discartemon nummus* was described from Tale Sap (= Lake or Lagoon), Singgora (= Songkhla). In this study, living snails were found at an isolated limestone hill near the lake in Phatthalung, about 60 km north of the type locality.

Having the smallest shell size clearly discriminates *D. nummus* from all congeners. It is similar to *D. discus,* which has a larger shell and a peripheral keel, lacks a sinulus,

and has a semi-ovate aperture with a straight parietal lamella. *Discartemon nummus* can be distinguished from *D. khaosokensis* in having a flattened spire, the last whorl regularly expanded, a triangular aperture, and a Y-shaped parietal lamella.

5. *Discartemon khaosokensis* Panha & Burch, 1998

http://species-id.net/wiki/Discartemon_khaosokensis
Figs 4H, 23, Table 1

Discartemon khaosokensis Panha & Burch, 1998: 25, 26, fig. 2. Type locality: Khao Sok National Park, Suratthani, Thailand.

Material examined. Holotype CUMZ 6242 (Fig. 4H). Measurement: shell height 3.6 mm, shell width 11.4 mm, and with 5¾ whorls. Paratype CUMZ 6243 (4 shells).

Remarks. This species is known only from the type locality. The shell is flattened and semi-transparent and has a concave spire with a distinct suture. Shell surface with transverse ridges that diminish below periphery, with varices present; whorls regularly coiled. Last whorl angular with a strong peripheral keel, rapidly expanded; umbilicus very wide, showing all preceding whorls. Aperture semi-ovate with narrow sinulus; peristome thin and expanded; apertural dentition of only one parietal lamella (Fig. 4H).

Discartemon khaosokensis differs from *D. discus* in having a smaller shell, concave spire, a shell surface with tranverse ridges, a rapidly expanded last whorl with a strong peripheral keel, and a sinulus. *Discartemon khaosokensis* is also similar to *D. sykesi*, but has a larger shell, a concave spire with tranverse ridges, and a rapidly expanded last whorl with a strong peripheral keel.

6. *Discartemon discadentus* Siriboon & Panha, sp. n.

http://zoobank.org/E19CE74B-1858-4813-86E4-EACA08E703F0
http://species-id.net/wiki/Discartemon_discadentus
Figs 2B, 4I, J, 12A, B, 17F–I, 23, Table 1

Type material. Holotype CUMZ 6244 (Fig. 4I). Measurement: shell height 4.5 mm, shell width 12.1 mm, and with 6 whorls. Paratypes: CUMZ 6003 (2 shells), 6209 (1 specimen in ethanol; Figs 2B, 12A, B, 17F–I), 6258 (4 shells), NHMUK 20130672 (1 shell), and SMF (1 shell) from the type locality.

Type locality. Wat Tam Yai, Thachana, Suratthani, Thailand (9°32'21.5"N, 99°11'29.4"E).

Diagnosis. This new species can be distinguished from *D. discus* and *D. sykesi* by having transverse ridges that diminish below the periphery, and having an apertural dentition with five lamellae. In comparison, *D. sykesi* has a smaller shell and *D. discus* has a higher spire. The genitalia of *D. discus* have a short penis, penial sheath and free oviduct, and long vagina while *D. discadentus* sp. n. has a very long penis, penial

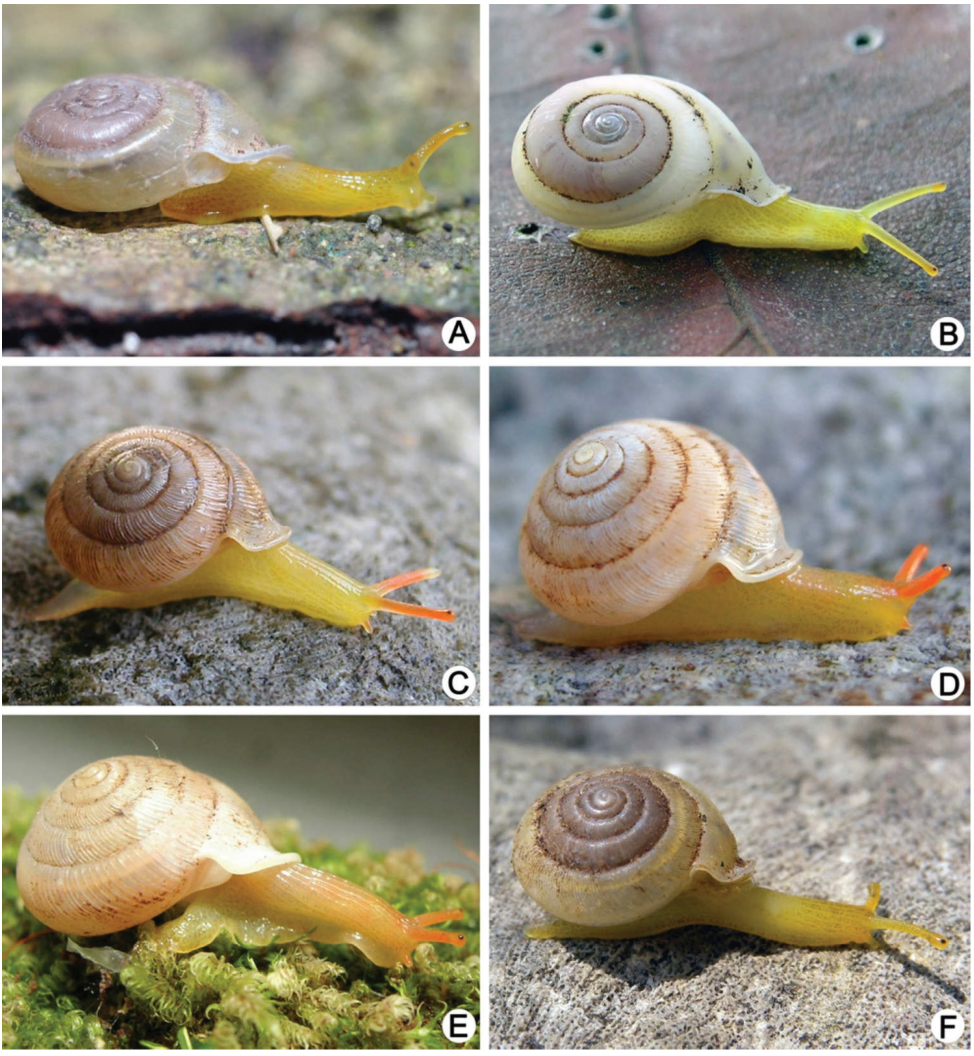

Figure 3. Living snails. **A** *Discartemon epipedis* sp. n. paratype CUMZ 6215 (shell width about 9 mm) **B** *Discartemon flavacandida* sp. n. paratype CUMZ 6216 (shell width about 12 mm) **C** *Discartemon roebeleni* topotype CUMZ 6217 (shell width about 9 mm) **D** *Discartemon kotanensis* sp. n. paratype CUMZ 6230 (shell width about 9 mm) **E** *Discartemon megalostraka* sp. n. CUMZ 6233, from Phangnga (shell width about 12 mm), and **F** *Discartemon triancus* sp. n. paratype CUMZ 6236 (shell width about 7 mm).

sheath and free oviduct, and short vagina. *Discartemon discadentus* sp. n. differs from *D. nummus* and *D. khaosokensis* in having a larger shell with higher spire, in lacking a peripheral keel, and in usually having five apertural lamellae. The last whorl of *D. khaosokensis* is rapidly expanded, while *D. nummus* has a regularly expanded last whorl and Y-shaped parietal lamella. The genitalia of *D. discadentus* sp. n. differ from those of

D. nummus in the long and slender penis, penial wall with reticulated folds, and long penial hooks located on conical penial papillae.

Description. Shell. Shell flattened, white and translucent; whorls 6; spire only slightly elevated; suture distinct. Shell surface glossy with transverse ridges that diminish below periphery; varices present. Embryonic shell large, about 2½ whorls, with smooth surface; following whorls regularly coiled. Last whorl angular, intermediately expanded; umbilicus very wide and showing all preceding whorls. Aperture semi-ovate; peristome discontinuous, thickened and expanded. Apertural dentition usually with one strong parietal, one palatal, one small basal and one strong columellar lamella. A small supracolumellar lamella is sometimes present (Fig. 4I).

Genital organs. Atrium (at) short; penis (p) very long and slender. Penial sheath (ps) thin, extending about five-sixths of penis length; penial sheath retractor muscle very thin (psr), originating at genital orifice wall and inserting distally on penial sheath (Fig. 12A). Vas deferens (vd) passes through a very short part of penial sheath before entering into penis distally (Fig. 12B). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium generally corrugated (Fig. 17F). Penial wall with scattered and transparent penial hooks, about 6 hooks/200 μm^2 (Fig. 17G); hooks located on conical penial papillae (pp) separated by low reticulated folds. Penial hooks small (<0.03 mm in length), expanded at base, tips pointed and curved towards genital orifice (Fig. 17H).

Vagina (v) short, about one seventh of penis length. Gametolytic duct (gd) a long tube extending as far as albumin gland; gametolytic sac (gs) ovate. Proximal free oviduct (fo) convoluted and distally long and thick; oviduct (ov) enlarged and folded. Prostate gland inconspicuous and bound to oviduct. Talon (ta) small, short and club shaped. Hermaphroditic duct (hd) bearing long seminal vesicle (sv) about four times longer than the length from talon to branching point of seminal vesicle (Fig. 12A).

Vaginal wall generally with smooth surface of reticulated vaginal folds (Fig. 17I).

Etymology. The specific epithet "*discadentus*" is derived from the Latin "*discus*" meaning "disc" and "*dentatus*" meaning "teeth".

Distribution. This species seems to be restricted to limestone areas in Suratthani Province, Thailand. Tam Khuha, Kanchanadit District, is an isolated limestone hill about 40 km southeast of the type locality and Wat Tam Wararam, Phanom District, is in the limestone mountains near Ratchaprapa Dam, about 70 km southwest of the type locality.

Remarks. This species shows variation in shell size and the presence of the infrapalatal, upper palatal and supracolumellar lamellae. Some specimens from Phanom, Suratthani (CUMZ 3571, 3582) possess an upper palatal and supracolumellar lamella, and an infrapalatal lamella is present in one paratype shell (CUMZ 6003). Populations from Tam Khuha, Suratthani (CUMZ 6004) exhibit a relatively smaller shell size (width about 11 mm). This new species is apparently rare and only extensive searching revealed living animals.

7. *Discartemon discamaximus* Siriboon & Panha, sp. n.

http://zoobank.org/EE36EC6D-DDE1-420E-A325-CDF9C11EA5BB
http://species-id.net/wiki/Discartemon_discamaximus
Figs 5A, B, 23, Table 1

Type material. Holotype CUMZ 6245 (Fig. 5A). Measurement: shell height 4.7 mm, shell width 14.6 mm, and with 7 whorls. Paratypes: CUMZ 6005 (2 shells) and NHMUK 20130673 (2 shells) from the type locality.

Other material examined. Tam Kobe, Phangnga: CUMZ 3669, 6197.

Type locality. Tam Namphud, Phangnga, Thailand, 8°27'46.8"N, 98°32'30.5"E.

Diagnosis. The characters distinguishing *D. discamaximus* sp. n. from *D. sykesi* and *D. khaosokensis* are the larger shell with flattened to concave spire, the transverse ridges present near the suture, and the lack of a sinulus. *Discartemon discamaximus* sp. n. has similar shell morphology to *D. discus* and *D. discadentus* sp. n., but is distinguished by having the transverse ridges present only near the suture and the last whorl rapidly expanded. *Discartemon discadentus* sp. n. also has five apertural lamellae.

Description. Shell. Shell flattened, white and translucent; whorls 7, spire flattened to concave, with distinct suture. Shell surface glossy with transverse ridges near suture and varices present. Embryonic shell large, about 2½ whorls, with smooth surface; following whorls regularly coiled. Last whorl angular, rapidly expanded; umbilicus very wide and showing all preceding whorls. Aperture semi-ovate; peristome discontinuous, expanded and reflected; apertural dentition with one parietal lamella (Fig. 5A).

Etymology. The specific epithet "*discamaximus*" is derived from the Latin "*discus*" meaning "disc" and "*maximus*" meaning "large or broad".

Distribution. This new species is known from limestone karst near Phanganga Bay reaching about 100–400 meters amsl, surrounded by the Phuket mountain range.

Remarks. To date no living specimens have been found.

8. *Discartemon circulus* Siriboon & Panha, sp. n.

http://zoobank.org/C9CFC89A-F272-45C8-AF3C-1612828174D4
http://species-id.net/wiki/Discartemon_circulus
Figs 5C, D, 23, Table 1

Type material. Holotype CUMZ 6246 (Fig. 5C). Measurement: shell height 3.9 mm, shell width 7.7 mm, and with 6 whorls. Paratypes: CUMZ 3665 (9 shells), 6262 (8 shells), NHMUK 20130674 (2 shells), and SMF (2 shells) from the type locality.

Type locality. Tam Phannara, Nakhon Si Thammarat, Thailand, 8°25'18.8"N, 99°22'46.8"E.

Diagnosis. *Discartemon circulus* sp. n. differs from *D. discus* and *D. sykesi* in its narrower umbilicus, sub-quadrangular aperture, and apertural dentition with five lamellae. In addition, *D. discus* has a larger shell, while *D. sykesi* has an intermediately expanded

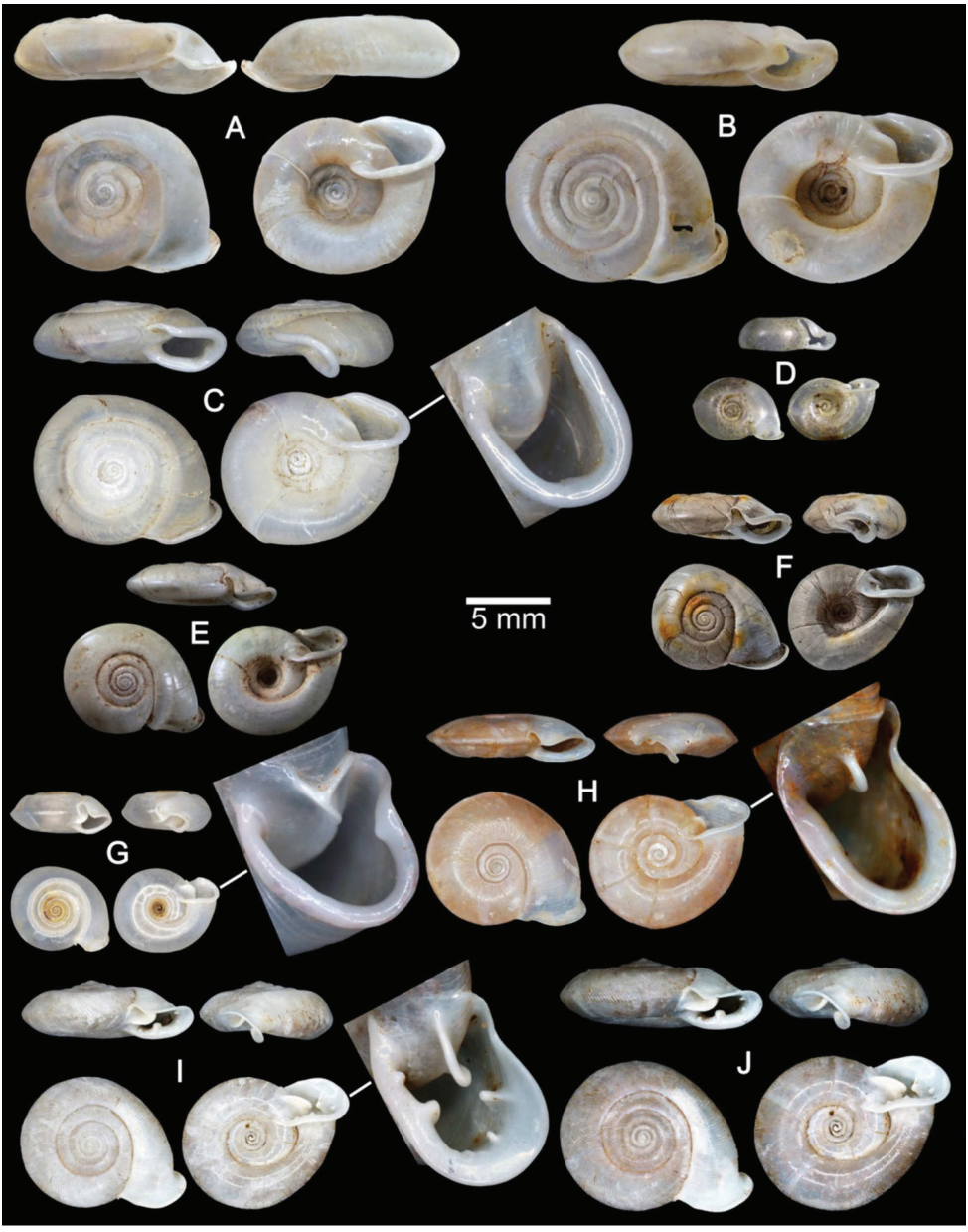

Figure 4. Shells of Group I: *Discartemon discus*-group. **A–C** *Discartemon discus* **A** holotype NHMUK 20130684 **B** lectotype SMF 108534 of "*Streptaxis paradiscus* Möllendorff, 1900", and **C** specimen CUMZ 6001, from Vietnam with apertural dentition **D** *Discartemon planus* specimen NMW 1955.158.25252, from Sulawesi, Indonesia **E, F** *Discartemon sykesi* **E** paratype NMW 1955.158.25257, and **F** paratype NHMUK 1937.7.9.11 **G** *Discartemon nummus* CUMZ 3594, from Patthalung with apertural dentition **H** *Discartemon khaosokensis* holotype CUMZ 6242 with apertural dentition **I, J** *Discartemon discadentus* sp. n. **I** holotype CUMZ 6244 with apertural dentition, and **J** paratype CUMZ 6209.

last whorl and a sinulus. Compared with *D. khaosokensis*, *D. circulus* sp. n. has a smaller shell, a flattened spire with weak transverse ridges, an angular last whorl, a sinulus, and five apertural lamellae. *Discartemon circulus* sp. n. differs from *D. discadentus* sp. n. and *D. discamaximus* sp. n. in having a smaller shell with weak transverse ridges and five apertural lamellae. Compared with *D. expandus* sp. n., *D. circulus* sp. n. has weaker transverse ridges, a regularly expanded peristome, and five apertural lamellae.

Description. Shell. Shell flattened, white and translucent; whorls 5½–6, spire flattened, with a distinct suture. Shell surface glossy with weak transverse ridges and varices present. Embryonic shell large, about 2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl angular, regularly expanded; umbilicus very wide, deep and showing all preceding whorls. Aperture sub-quadrangular; peristome discontinuous, thin and expanded. Apertural dentition with one parietal, one palatal, one small basal, one small columellar and one small supracolumellar lamella (Fig. 5C).

Etymology. The specific epithet is from the Latin "*circulus*" meaning "circle". It refers to the appearance of this new species when seen from the apex.

Distribution. This species is known only from the type locality, an isolated limestone hill which reaches about 200 meters amsl, about 20 km southwest of Tai Rom Yen National Park.

Remarks. Apparently rare and extensive searching revealed no living examples.

9. *Discartemon deprima* Siriboon & Panha, sp. n.

http://zoobank.org/B7EAE186-FD2D-40CB-BEFE-72E1CD7A5684
http://species-id.net/wiki/Discartemon_deprima
Figs 5E, F, 23, Table 1

Type material. Holotype CUMZ 6247 (Fig. 5E). Measurement: shell height 2.5 mm, shell width 8.2 mm, and with 5 whorls. Paratypes: CUMZ 3573 (2 shells), NHMUK 2013675 (1 shell), and SMF (1 shell) from the type locality. Paratype: CUMZ 6259 from Ban Tam Thong, Prathiew, Chumphon.

Other material examined. Khao Pu-Khao Ya National Park, Sri Banphot, Phatthalung: CUMZ 3670.

Type locality. Khao Hup Ta Hae, Prathiew, Chumphon, Thailand, 10°48'44.9"N, 99°25'9.0"E.

Diagnosis. This species closely resembles *D. sykesi*, but is distinct in having a concave spire and strong peripheral keel on the last whorl. Compared with *D. khaosokensis*, *D. deprima* sp. n. has a smaller shell with weaker transverse ridges, and the last whorl intermediately expanded. *Discartemon deprima* sp. n. differs from *D. nummus* by having a larger shell, a concave spire, and one straight parietal lamella. It differs from *D. circulus* sp. n. and *D. expandus* sp. n. in having a concave spire, the last whorl intermediately expanded with a strong peripheral keel, and in having only one parietal lamella and a sinulus. In addition, *D. expandus* sp. n. has transverse ridges that diminish below the periphery, and has a thin and widely expanded peristome.

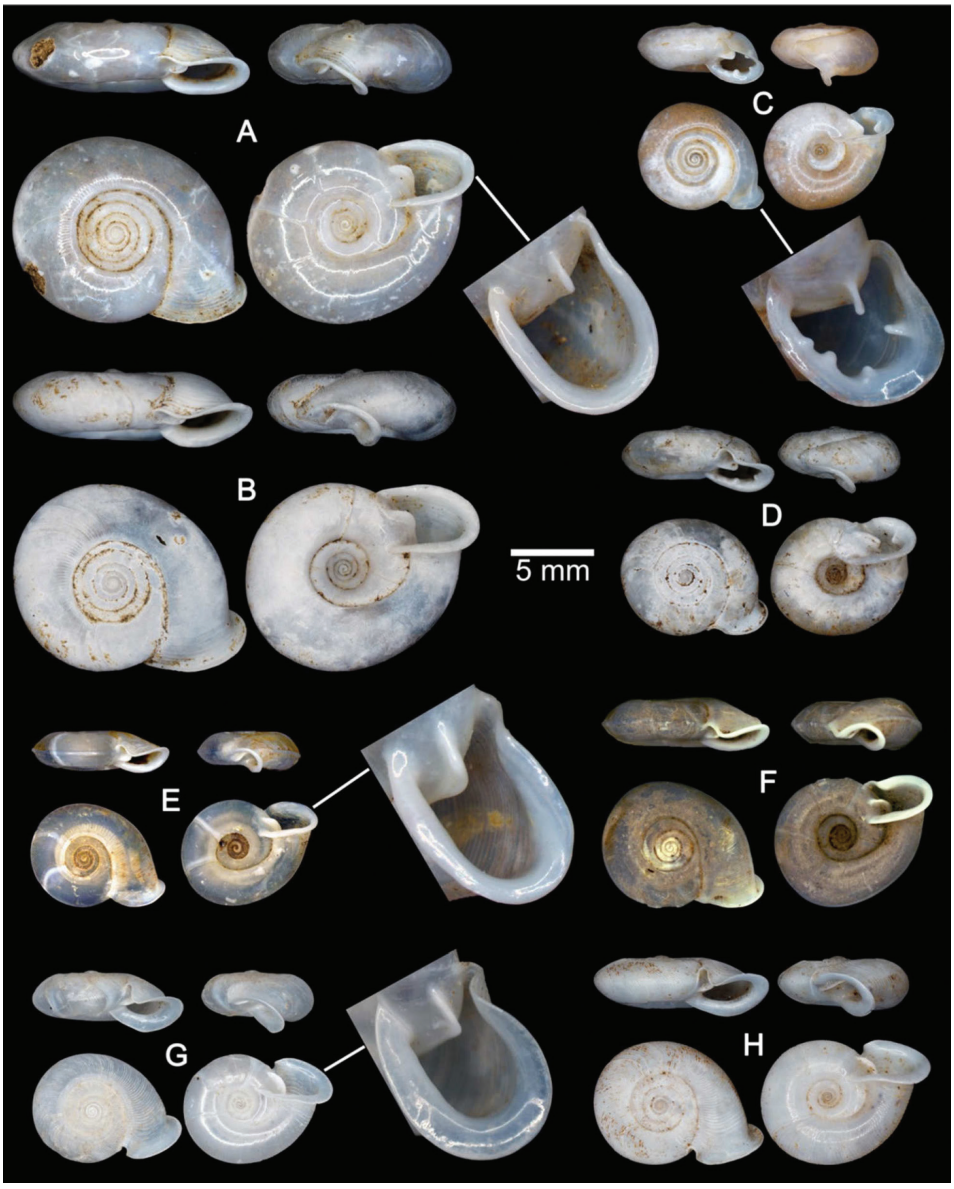

Figure 5. Shells of Group I: *Discartemon discus*-group. **A, B** *Discartemon discamaximus* sp. n. **A** holotype CUMZ 6245 with apertural dentition, and **B** paratype CUMZ 6005 **C, D** *Discartemon circulus* sp. n. **C** holotype CUMZ 6246 with apertural dentition, and **D** paratype CUMZ 3665 **E, F** *Discartemon deprima* sp. n. **E** holotype CUMZ 6247 with apertural dentition, and **F** paratype CUMZ 3573 **G, H** *Discartemon expandus* sp. n. **G** holotype CUMZ 6248 with apertural dentition, and **H** paratype CUMZ 3664.

Description. Shell. Shell flattened, white and semi-transparent; whorls 5, spire concave with a distinct suture. Shell surface glossy with weak transverse ridges that diminish below periphery and appear again near peristome; varices present. Embryonic

shell large, about 2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl angular with strong peripheral keel, intermediately expanded. Umbilicus very wide and showing all preceding whorls. Aperture semi-ovate with sinulus; peristome discontinuous, thin, expanded and reflected. Apertural dentition with only one parietal lamella (Fig. 5E).

Etymology. The specific epithet "*deprima*" is derived from the Latin "*deprimo*" meaning "depress". It refers to the depressed spire of this new species.

Distribution. This species is known from the east coast of Chumphon, on an isolated limestone hill reaching about 200 meters amsl, and from a more southerly locality in Patthalung, a limestone hill complex reaching about 200–400 meters amsl.

Remarks. There is some variation in this species in the discontinuous peristome and the presence of a sinulus. The samples from Patthalung (CUMZ 3670, 2 shells) have a continuous peristome and lack a sinulus. Currently, no living examples have been found.

10. *Discartemon expandus* Siriboon & Panha, sp. n.

http://zoobank.org/E1B561EF-83BF-4D71-A5BD-4F4C9A839F84
http://species-id.net/wiki/Discartemon_expandus
Figs 5G, H, 23, Table 1

Type material. Holotype CUMZ 6248 (Fig. 5G). Measurement: shell height 3.8 mm, shell width 8.3 mm, and with 5½ whorls. Paratypes: CUMZ 3664 (10 shells), NHMUK 20130676 (2 shells), and SMF (2 shells) from the type locality.

Type locality. Klong Hoy, Suratthani, Thailand, 8°57'18.1"N, 98°48'30.7"E.

Diagnosis. *Discartemon expandus* sp. n. differs from *D. discus* and *D. sykesi* in its smaller shell with transverse ridges, intermediately expanded last whorl, and widely expanded peristome. In addition, a sinulus is absent in *D. discus*. *Discartemon expandus* sp. n. can be distinguished from *D. khaosokensis* by having a flattened spire, an angular and intermediately expanded last whorl, and a widely expanded peristome. Compared with *D. discadentus* sp. n. and *D. discamaximus* sp. n., *D. expandus* sp. n. has a smaller shell with strong transverse ridges, a sinulus and a widely expanded peristome. Moreover, *D. discadentus* sp. n. has five apertural lamellae, and *D. discamaximus* sp. n. has a rapidly expanded last whorl.

Description. Shell. Shell flattened, white and semi-transparent; whorls 5½–6, spire flattened with a distinct suture. Shell surface glossy with transverse ridges that diminish below periphery; varices present. Embryonic shell large, about 2–2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl angular, intermediately expanded; umbilicus very wide, deep and showing all preceding whorls. Aperture semi-ovate with narrow sinulus; peristome discontinuous, thin and widely expanded. Apertural dentition of only one parietal lamella (Fig. 5G).

Etymology. The specific epithet "*expandus*" is derived from the Latin "*expandi*" meaning "expand". It refers to the expanded peristome of this species.

Distribution. The species is known only from the type locality and extensive searching revealed no living examples.

Remarks. Some variation has been observed in the spire, which is slightly convex rather than flattened in some specimens, and in the distinctness of the suture.

Group II: *Discartemon plussensis*-group: Species with depressed-heliciform shell.

11. *Discartemon plussensis* (Morgan, 1885)
http://species-id.net/wiki/Discartemon_plussensis
Figs 6A, B, 23, Table 2

Streptaxis plussensis Morgan, 1885a [Jan.]: 68. Type locality: Mont Tchéhèl, dans la Vallée de la rivière Pluss. Morgan 1885b [Aug.]: 371, 372, pl. 5, fig. 1. Tryon 1885: 251. Möllendorff 1887: 299, 300. Tenison-Woods 1888: 1009. Möllendorff 1891: 330, 331. Gude 1903: 226.

Odontartemon (*Discartemon*) *plussensis* – Kobelt 1906: 99, pl. 54, figs 12–14. Kobelt 1910: 150.

Discartemon plussensis – Benthem Jutting 1954: 79, fig. 2. Benthem Jutting 1959: 168. Richardson 1988: 184. Maassen 2001: 87, 88.

Material examined. Perak, Malaysia NHMUK 1939.4.13.22 (1 shell; Fig. 6A). Sungei Siput, Perak, Malaysia: NMW 1955.158.25253 (13 shells). RMNH Kaumans Reg. 598 (3 shells). Hot Springs, Tanjung Rambutan, Perak, Mlaysia: RMNH Drijver Coll. (1 shell). Yan Tao San, Perak, Malaysia: CUMZ 6008. Ipoh, Perak, Malaysia (4°36'34.6"N, 101°6'49.9"E): CUMZ 6009 (Fig. 6B; 3 shells).

Remarks. The original descriptions included informative figures (Morgan 1885a, b), and subsequently Benthem Jutting (1954: fig. 2) published excellent figures of topotype specimens. These allow unambiguous recognition of this species. Shell depressed-heliciform with a flattened spire. Shell surface with transverse ridges that diminish below periphery and varices present; following whorls regularly coiled. Last whorl rounded and regularly expanded; umbilicus widely open and deep. Aperture triangular with sinulus, and apertural dentition with one parietal and one palatal lamella (Fig. 6B).

Compared with *D. leptoglyphus* and *D. plussensis*, it differs in its smaller shell, with transverse ridges that diminish below periphery, last whorl rounded and more inflated, and sinulus present.

12. *Discartemon hypocrites* Benthem Jutting, 1954
http://species-id.net/wiki/Discartemon_hypocrites
Figs 2D, 6C, D, 12C, D, 18A–E, 22C, 23, Table 2

Discartemon hypocrites Benthem Jutting, 1954: 92–94, fig. 8. Type locality: Bukit Chuping, Perlis, Malaysia. Benthem Jutting 1959: 168. Richardson 1988: 183. Maassen 2001: 87.

Material examined. Holotype ZMA 3.34.017 (Fig. 6C). Paratypes: ZMA 3.54.018 (5 shells). Bukit Chuping, Perlis, Malaysia (6°29'36.2"N, 100°15'53.2"E): CUMZ 6011 (2 shells; Fig. 6D). Guplu Bukit, Perlis, Malaysia: CUMZ 6198. Kaki Bukit, Perlis, Malaysia: CUMZ 6199 (1 specimen in ethanol; Figs 2D, 12C, D, 18A–E, 22C).

Description. Shell. Shell depressed-heliciform, white and semi-transparent; whorls 5–5½, spire only slightly convex with distinct suture. Shell surface glossy with thin transverse ridges that diminish below periphery; varices present. Whorls regularly coiled; last whorl rounded, regularly expanded; umbilicus very wide, deep and showing all preceding whorls. Aperture triangular; peristome discontinuous, thickened, expanded and reflected. Apertural dentition with one sinuous parietal, one palatal, one columellar and one supracolumellar lamella (Fig. 6C).

Radula. Each row consists of 43 teeth with formula (21)-1-(21). Central tooth very small and triangular with a pointed cusp. Lateral and marginal teeth undifferentiated, unicuspid and lanceolate. Latero-marginal teeth gradually reduce in size, with outermost teeth much smaller and shorter than inner teeth (Fig. 22C).

Genital organs. Atrium (at) long and thick. Proximal penis (p) with short and stout penial appendix (pa) about two-thirds of penis length; distal penis slender (Fig. 12C). Penial sheath retractor muscle (psr) very thin, originating at genital orifice wall and inserting distally on penial sheath (Fig. 12C). Vas deferens (vd) passes through about a quarter of penial sheath length before entering into penis distally (Fig. 12D). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium generally smooth with numerous atrial pores (Fig. 18A). Penial wall with dense and brownish penial hooks, about 4 hooks/200 μm^2 (Fig. 18B). Hooks located on laterally-flattened penial papillae (pp), which are separated by thin reticulated folds. Penial hooks very small (< 0.01 mm in length), expanded at base, pointed at tip and curved towards genital orifice (Fig. 18C, D).

Vagina (v) short. Gametolytic duct (gd) enlarged and stout at base, and suddenly tapering to small and long tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) proximally large with equivalent diameter to vagina, tapering to smaller tube distally. Oviduct (ov) enlarged and folded; prostate gland inconspicuous and bound to oviduct. Talon (ta) small, short and club shaped. Hermaphroditic duct (hd) bearing long and thick seminal vesicle (sv) about one and half times longer than the length from talon to branching point of seminal vesicle (Fig. 12C).

Vaginal wall with reticulated vaginal folds (Fig. 18E).

Distribution. This species is known from several limestone hills in Perlis, Malaysia.

Remarks. *Discartemon hypocrites* can be distinguished from *D. plussensis*, *D. leptoglyphus* and *D. platymorphus* by the apertural dentition with one sinuous parietal, one columellar, and one supracolumellar lamella. The latter three species exhibit one straight parietal and one palatal lamella. In addition, *D. plussensis* has a lower spire, an inflated last whorl and a sinulus; *D. leptoglyphus* has transverse ridges over the entire shell; and *D. platymorphus* has a larger shell and lower spire. *Discartemon hypocrites* also differs from *D. leptoglyphus* in having a slender penis with short and stout penial appendix, the vas deferens passing through about a quarter of penial sheath length, the pointed penial hooks located on laterally-flattened penial papillae, and the vagina having reticulated folds.

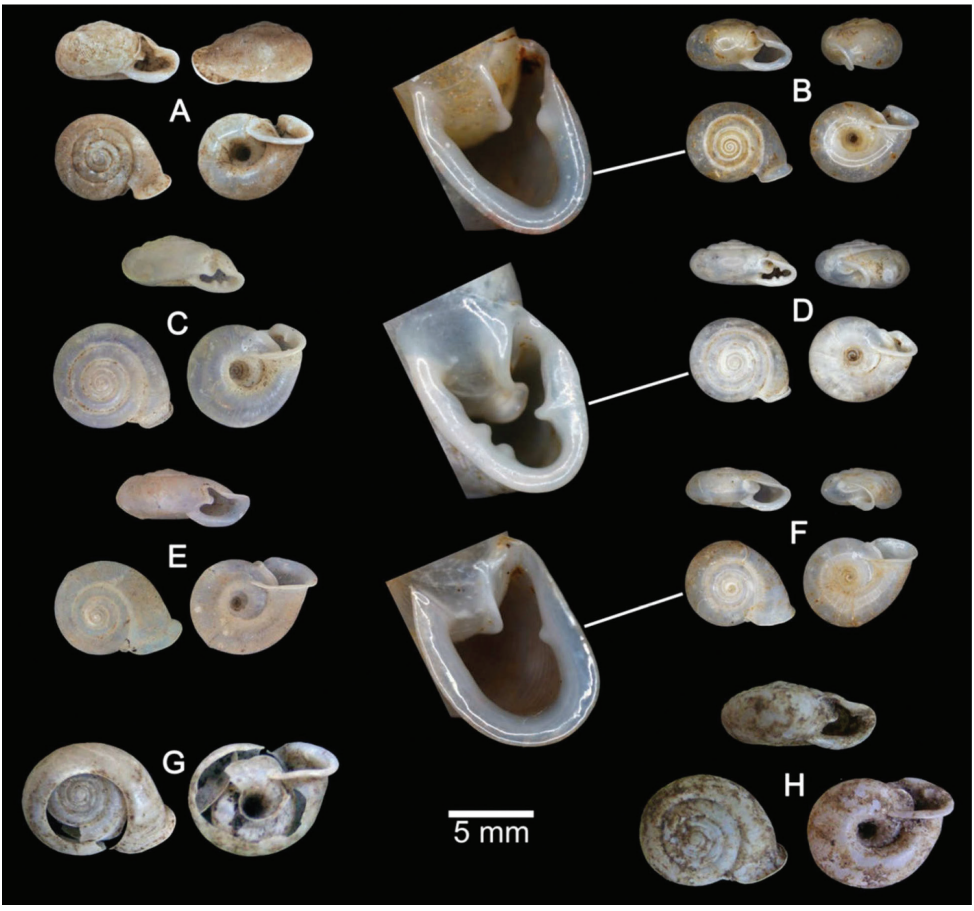

Figure 6. Shells of Group II: *Discartemon plussensis*-group. **A, B** *Discartemon plussensis* **A** specimen NHMUK 1939.4.13.22, from Perak, Malaysia, and **B** topotype CUMZ 6009 with apertural dentition **C, D** *Discartemon hypocrites* **C** holotype ZMA 3.34.017, and **D** topotype CUMZ 6011 with apertural dentition **E, F** *Discartemon leptoglyphus* **E** holotype ZMA 3.54.019, and **F** specimen CUMZ 6007, from Ipoh, Perak, Malaysia with apertural dentition **G, H** *Discartemon platymorphus* **G** holotype ZMA 3.54.022, and **H** paratype ZMA 3.54.023.

13. *Discartemon leptoglyphus* Benthem Jutting, 1954

http://species-id.net/wiki/Discartemon_leptoglyphus
Figs 2C, 6E, F, 13A, B, 18F–L, 23, Table 2

Discartemon leptoglyphus Benthem Jutting, 1954: 90–92, fig. 7. Type locality: Gunong Rapat, near Ipoh, Perak, Malaysia. Benthem Jutting 1959: 168. Maassen 2001: 87.

Material examined. Holotype ZMA 3.54.019 (Fig. 6E). Paratypes NHMUK 1954.4.3.3 (1 shell), ZMA 3.54.020 (1 shell), ZMA 3.54.021 (5 shells). Ampang Baru, Ipoh, Perak, Malaysia, 6°29'36.2"N 100°15'53.2"E, CUMZ 6010 (3 shells; Fig. 6F).

Table 2. Shell measurements of *Discartemon* spp (*D. plussensis*-group). Specimen collections and catalogue numbers indicated in parentheses.

Species and locality and CUMZ nos	No. of specimens	Ranges, mean ± S.D. in mm of:			Number of whorls
		Shell height	Shell width	H/W ratio	
Discartemon plussensis (Morgan, 1885)					
Yan Tao San, Perak, Malaysia: (6008)	24	3.0–3.8 3.4±0.22	5.8–7.5 6.6±0.45	0.4–0.6 0.5±0.03	5½–6
Ipoh, Perak, Malaysia: (6009)	3	2.9–3.3 3.0±0.23	5.6–6.2 6.0±0.36	0.5–0.5 0.5±0.04	5½–6
Discartemon hypocrites Benthem Jutting, 1954					
Gaplu Bukit, Perlis, Malaysia: (6198)	4	2.8–3.0 2.9±0.08	6.5–7.3 6.9±0.41	0.4–0.4 0.4±0.02	5–5½
Discartemon leptoglyphus Benthem Jutting, 1954					
Lost World, Perak, Malaysia: (6007, 6260)	15	2.7–3.1 2.9±0.13	6.8–8.0 7.2±0.30	0.4–0.4 0.4±0.02	5–5½
Ampang Baru, Ipoh, Perak, Malaysia: (6010)	3	2.9–3.2 3.1±0.13	6.6–7.5 7.0±0.41	0.4–0.5 0.4±0.02	5–5½
Discartemon afthonodontia sp. n.					
Tam Phitsadan, Chumphon: (4206, 6019, 6249)	29	3.9–5.4 4.7±0.35	8.3–9.6 9.0±0.29	0.4–0.6 0.5±0.04	6
Tam Khao Phlu, Chumphon: (3581, 3666)	31	3.4–4.4 3.9±0.26	7.0–8.4 7.9±0.31	0.4–0.6 0.5±0.03	6
Khao Maeo, Chumphon: (3589)	13	3.6–4.3 3.9±0.20	7.3–8.1 7.8±0.23	0.4–0.5 0.5±0.02	6
Wat Tam Phru-Takien, Chumphon: (6016)	6	4.2–5.0 4.6±0.25	6.7–7.6 7.3±0.26	0.5–0.6 0.6±0.03	6
Wat Uthai Tam, Chumphon: (6261)	28	4.0–5.3 4.8±0.32	7.8–9.1 8.3±0.32	0.5–0.6 0.6±0.03	6
Bang Saphan Noi, Prachuap Khirikhan: (3588)	7	4.6–6.1 5.2±0.33	6.8–8.5 7.6±0.50	0.5–0.7 0.6±0.05	6
Wat Tam Khao Marong, Prachuap Khirikhan: (6014)	17	4.2–5.0 4.6±0.25	6.7–7.6 7.3±0.26	0.6–0.7 0.6±0.02	6
Discartemon epipedis sp. n.					
Gua Matu Madu, Kelantan, Malaysia: (6020, 6250)	20	4.1–5.2 4.5±0.25	8.2–9.1 8.6±0.24	0.5–0.6 0.5±0.04	6
Discartemon flavacandida sp. n.					
Tam Phra Khayang, Ranong: (3574, 3576, 3675, 3676, 4214, 6006, 6251)	130	4.6–6.0 5.2±0.36	10.1–12.9 11.2±0.51	0.4–0.5 0.5±0.03	6–6½

Lost World, Tanjung Rambutan, Ipoh, Perak, Malaysia: CUMZ 6007 (9 specimens in ethanol; Figs 2C, 13A, B, 18F–L), 6260 (4 shells).

Description. Shell. Shell depressed-heliciform, white and semi-transparent; whorls 5–5½, spire only slightly convex with distinct suture. Shell surface glossy with transverse ridges and varices present. Whorls regularly coiled; last whorl angular, regularly expanded, ultimate part expanded; umbilicus very wide, deep and showing all preceding whorls. Aperture triangular, sometimes semi-ovate; peristome discontinuous, expanded and little reflected. Apertural dentition of one parietal and one small palatal lamella (Fig. 6E).

Genital organs. Atrium (at) short. Penis (p) long, swollen at middle and with a long and slender penial appendix (pa) about half of penis length. Penial sheath (ps) thin, extending about one-third of penis length; penial sheath retractor muscle (psr) very thin, originating at genital orifice wall and inserting distally on penial sheath (Fig. 13A). Vas deferens (vd) passes through entire length of penial sheath before entering into penis distally (Fig. 13B). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium with smooth surface (Fig. 18F). Penial wall with translucent penial hooks densely scattered, about 18 hooks/200 μm^2 (Fig. 18G). Hooks located on ovate penial papillae (pp). Penial hooks small (< 0.04 mm in length), tips obtuse and curved towards genital orifice (Fig. 18H–K).

Vagina (v) short, about one-third of penis length. Proximal gametolytic duct (gd) enlarged, stout; distally a long tube extending as far as albumin gland; gametolytic sac (gs) ovate. Proximal free oviduct (fo) enlarged then tapering to smaller tube distally. Oviduct (ov) enlarged and folded; prostate gland inconspicuous and bound to oviduct. Talon (ta) small and club shaped. Hermaphroditic duct (hd) bearing long and thick seminal vesicle (sv) about one and half times longer than the length from talon to branching point of seminal vesicle (Fig. 13A).

Vaginal wall generally smooth (Fig. 18L).

Distribution. This species is known from the limestone mountains around the type locality in Perak, Malaysia.

Remarks. Compared with *D. platymorphus*, this species differs in having a smaller shell, with transverse ridges appearing on the entire shell and a more inflated last whorl. *Discartemon leptoglyphus* can be distinguished from *D. stenostomus* by having a depressed-heliciform shell with lower spire, transverse ridges on the entire shell, the last whorl angular, and apertural dentition of one straight parietal lamella. In addition, the penial appendix in *D. leptoglyphus* is relatively much longer than that shown for *D. stenostomus* (see Berry 1965).

14. *Discartemon platymorphus* Benthem Jutting, 1954

http://species-id.net/wiki/Discartemon_platymorphus
Figs 6G, H, 23

Discartemon platymorphus Benthem Jutting, 1954: 88-90, fig. 6. Type locality: Gua Nenek, Kelantan, Malaysia. Benthem Jutting 1959: 168. Berry 1965: 28, 29. Richardson 1988: 184. Maassen 2001: 87. Marwoto 2008: 192.

Material examined. Holotype ZMA 3.54.022 (fragmented) (Fig. 6G). Paratype ZMA 3.54.023 (2 shells).

Remarks. The shell is depressed-heliciform with the spire only slightly convex and with a distinct suture. The shell surface has transverse ridges that diminish below the periphery, and varices are present. The following whorls are regularly coiled. Last whorl rounded, regularly expanded; umbilicus widely open and deep. Aperture tri-

angular; peristome discontinuous, thickened, expanded and little reflected; apertural dentition of one parietal and one palatal lamella (Fig. 6H).

Discartemon platymorphus is closely similar to *D. plussensis*, but that species has a larger shell with a higher spire and lacks a sinulus. *Discartemon platymorphus* differs from *D. epipedis* sp. n. by having a lower spire, transverse ridges that diminish below the periphery, a shouldered last whorl, and apertural dentition with four lamellae. Compared with *D. stenostomus*, *D. platymorphus* has a lower spire with fine transverse ridges that disappear below the periphery, and a straight parietal lamella and one palatal lamella.

15. *Discartemon afthonodontia* Siriboon & Panha, sp. n.

http://zoobank.org/423A1CDB-BEE3-4E34-B120-65F89617A73F
http://species-id.net/wiki/Discartemon_afthonodontia
Figs 2E, F, 7A, B, 13C–F, 19A–E, 22D, 23, Table 2

Type material. Holotype CUMZ 6249 (Fig. 7A). Measurement: shell height 4.8 mm, shell width 9.3 mm, and with 6½ whorls. Paratypes: CUMZ 4206 (1 shell), 6018 (4 shells), 6019 (23 shells), 6210 (7 specimens in ethanol; Figs 2E, 13C–F, 19A–E, 22D), NHMUK 20130677 (2 shells), and SMF (2 shells) from the type locality.

Other material examined. Wat Khao Pho, Bang Saphan, Prachuap Khirikhan: CUMZ 6012, 6013. Wat Tam Khao Marong, Bang Saphan, Prachuap Khirikhan: CUMZ 4219, 6014, 6211 (5 specimens in ethanol). Bang Saphan Noi, Prachuap Khirikhan: CUMZ 3588. Tam Khao Phlu, Prathiew, Chumphon: CUMZ 3581, 3666, 6214 (3 specimens in ethanol; Figs 2F, 7B). Khao Maeo, Prathiew, Chumphon: CUMZ 3589. Nam Tok Kapo, Tha Sae, Chumphon: CUMZ 3593. Wat Tam Phru-Takien, Tha Sae, Chumphon: CUMZ 6016. Wat Uthai Tam, Chumphon: CUMZ 6212 (6 specimens in ethanol), 6261. Wat Tam Khwan Meuang, Sawi, Chumphon: CUMZ 6015. Suan Somdet, Lang Suan, Chumphon: CUMZ 6017. Tam Khao Krieb, Lang Suan, Chumphon: CUMZ 6213 (3 specimens in ethanol).

Type locality. Tam Phitsadan, Prathiew, Chumphon, Thailand, 10°43'26.6"N, 99°15'23.6"E.

Diagnosis. This new species can be distinguished from *D. plussensis*, *D. leptoglyphus* and *D. platymorphus* in having a nearly smooth shell surface, a shouldered last whorl, and five to seven apertural lamellae. *Discartemon afthonodontia* sp. n. differs from *D. hypocrites* by having a nearly smooth shell surface and an aperture with two parietal, two palatal, one basal and two columella lamellae. The genitalia of *D. afthonodontia* sp. n. differ from those of *D. hypocrites* in lacking a penial appendix, in having the free oviduct long and slender, and in having the vas deferens passing straight through the penial sheath. They also differ from *D. afthonodontia* sp. n. in having conical penial papillae, long and slender penial hooks, and in having the penial wall with thick reticulated folds, and the vaginal wall with a smooth surface. Compared with *D. epipedis* sp. n., *D. afthonodontia* sp. n. has more apertural lamellae, lacks a penial appendix and has the vas deferens passing straight

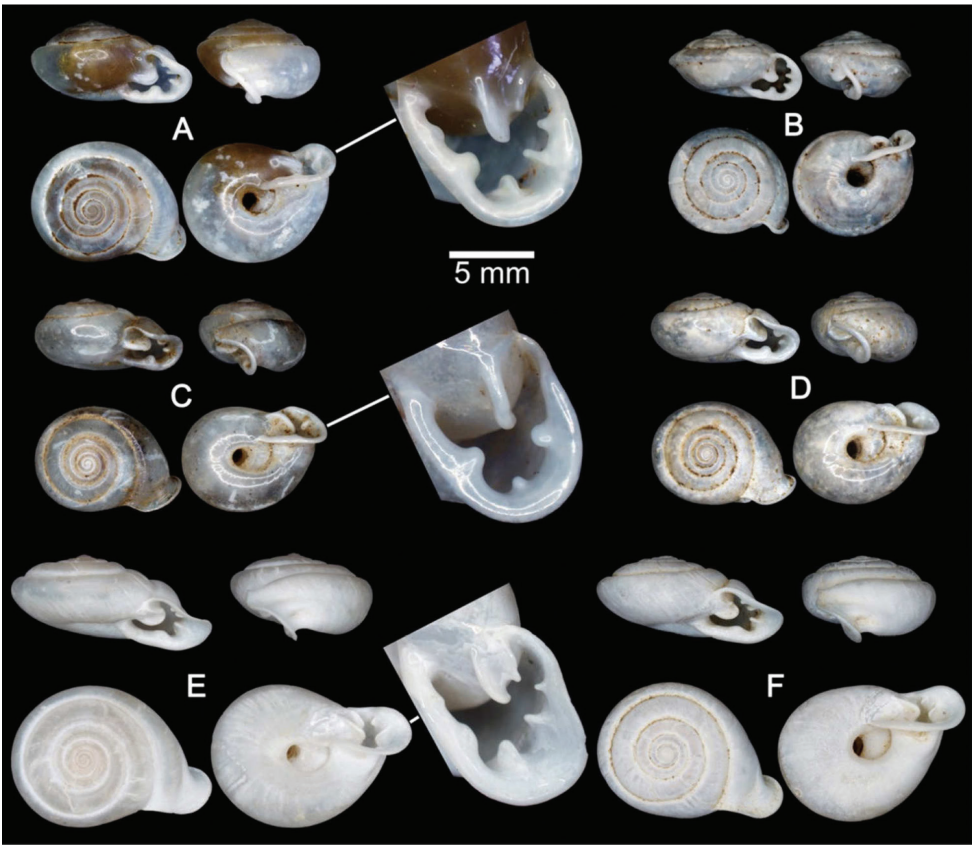

Figure 7. Shells of Group II: *Discartemon plussensis*-group. **A, B** *Discartemon afthonodontia* sp. n. **A** holotype CUMZ 6249 with apertural dentition, and **B** specimen CUMZ 3581, from Tam Khao Phlu, Chumphon **C, D** *Discartemon epipedis* sp. n. **C** holotype CUMZ 6250 with apertural dentition, and **D** paratype CUMZ 6020 **E, F** *Discartemon flavacandida* sp. n. **E** holotype CUMZ 6251 with apertural dentition, and **F** paratype CUMZ 3574.

through the penial sheath. They also differ from *D. afthonodontia* sp. n. in having a penial wall with thick reticulated folds, and in having a very long and slender free oviduct.

Description. Shell. Shell depressed-heliciform, white and translucent; whorls 6, spire conical to convex with distinct suture. Shell surface glossy, smooth with transverse ridges near the peristome and varices present only on early whorls. Embryonic shell large, about 2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl shouldered, sometimes angular with strong peripheral keel, regularly expanded, and two shallow and short longitudinal furrows present. Umbilicus widely open and deep. Aperture sub-quadrangular; peristome discontinuous, thickened, expanded and reflected. Aperture dentition with one strong parietal, one palatal, one basal, one large columellar and one small supracolumellar lamella; sometimes upper parietal and upper palatal lamellae present (Fig. 7A).

Radula. Each row consists of 35–39 teeth with formula (17-19)-1-(17-19). Central tooth small with pointed cusp. Lateral and marginal teeth undifferentiated, unic-

uspid and lanceolate. Latero-marginal teeth gradually reduce in size, with outermost teeth much smaller and shorter than inner teeth (Fig. 22D).

Genital organs. Atrium (at) short. Proximal penis (p) short with very short, stout penial appendix (pa). Distal penis slender (Fig. 13D, E). Penial sheath (ps) thin, extending about one and half times penis length; penial sheath retractor muscle (psr) very thin, originating at genital orifice wall and inserting distally on penial sheath (Fig. 13C). Vas deferens (vd) passes straight through penial sheath before entering into penis distally (Fig. 13D). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium with numerous atrial pores (Fig. 19A). Penial wall with scattered brown penial hooks, about 5 hooks/200 μm^2 (Fig. 19B). Hooks located on conical penial papillae (pp) which are separated by thickened reticulated folds. Penial hooks small (<0.01 mm in length), expanded at base, tips pointed and curved towards genital orifice (Fig. 19C, D).

Vagina (v) short, about half of penis length. Gametolytic duct (gd) a long tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) a very long and slender tube; oviduct (ov) enlarged and folded; prostate gland inconspicuous and bound to oviduct. Talon (ta) small and slender. Hermaphroditic duct (hd) bearing long seminal vesicle (sv) about one and half times longer than the length from talon to branching point of seminal vesicle (Fig. 13C).

Vaginal wall surface generally smooth (Fig. 19E).

Etymology. The specific epithet "*afthonodontia*" is derived from the Greek "*afthonos*" meaning "plenty" and "*dontia*" meaning "teeth".

Distribution. This species is known from several limestone karsts in Chumphon and Prachuap Khirikhan Provinces, southern Thailand. This is a narrow range confined to the Isthmus of Kra area, from 9° to 11° N and 99° to 100° E.

Remarks. Shell variations are detected across populations. In the Tam Khao Phlu (CUMZ 3581, 3666, 6214) and Khao Maeo (CUMZ 3589) populations, shells have a stronger peripheral keel, a subcircular aperture, and lack the upper parietal lamella (Fig. 7B). The specimens from Wat Tam Khao Marong (CUMZ 4219, 6014, 6211), Wat Tam Khwan Meuang (CUMZ 6015), and Suan Somdet (CUMZ 6017) exhibit a convex spire, and the upper parietal and upper palatal lamellae are sometimes absent. However, these five populations exhibit similar genitalia characters including the penial sculpture. Therefore, we consider them all conspecific.

16. *Discartemon epipedis* Siriboon & Panha, sp. n.

http://zoobank.org/20AFF3F2-9EBE-4DF9-BFC1-B5551D93DDC4
http://species-id.net/wiki/Discartemon_epipedis
Figs 3A, 7C, D, 14A, B, 19F–I, 23, Table 2

Type material. Holotype CUMZ 6250 (Fig. 7C). Measurement: shell height 4.6 mm, shell width 8.7 mm, and with 6 whorls. Paratypes: CUMZ 6020 (15 shells), 6215 (5

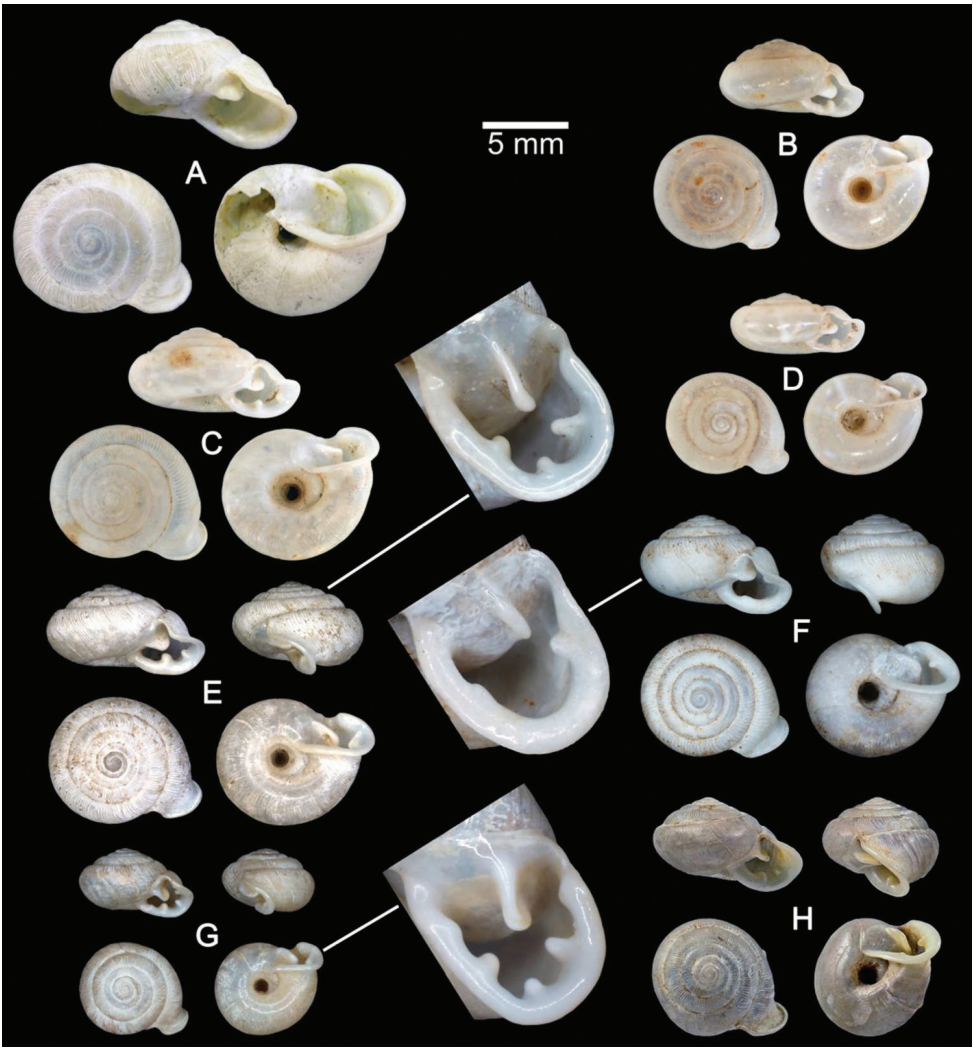

Figure 8. Shells of Group III: *Discartemon roebeleni*-group. **A** *Discartemon lemyrei* holotype MNHN **B–G** *Discartemon roebeleni* **B** lectotype SMF 108526 **C** holotype of forma *major* SMF 108531 **D** holotype of forma *minor* SMF 108533, **E** topotype CUMZ 3655 with apertural dentition **F** specimen CUMZ 3661, from Wat Suwankhuha, Phangnga with apertural dentition, and **G** specimen CUMZ 6256, from Ko Tarutao, Satun with apertural dentition. **H** *Discartemon collingei* syntype NHMUK 1937.7.9.20.

specimens in ethanol; Figs 3A, 14A, B, 19F–I), NHMUK 20130678 (2 shells), and SMF (2 shells) from the type locality.

Type locality. Gua Matu Madu, Gua Musang, Kelantan, Malaysia, 4°50'13.4"N, 101°56'56.3"E.

Diagnosis. *Discartemon epipedis* sp. n. differs from *D. plussensis* and *D. leptoglyphus* in having a higher spire, a nearly smooth shell surface, a semi-ovate aperture, and four apertural lamellae. Compared with *D. flavacandida* sp. n., *D. epipedis* sp. n. has

a smaller shell, lacks longitudinal furrows, has the last whorl rounded and regularly coiled, and has four apertural lamellae. The genitalia of *D. epipedis* sp. n. differ from those of *D. flavacandida* sp. n. in having a very short and swollen penial appendix, a long and enlarged vagina, short free oviduct, low conical penial hooks, penial papillae present, and in lacking vaginal pores. *Discartemon epipedis* sp. n. differs from *D. roebeleni* in having a depressed-heliciform shell, a nearly smooth shell surface, and a semi-ovate aperture. The genitalia have a very short and swollen penial appendix, long and enlarged vagina, long and slender free oviduct, dark brown penial hooks located on conical penial papillae, and a vaginal wall with smooth surface.

Description. Shell. Shell depressed-heliciform, white and translucent; whorls 6, spire only slightly convex with distinct suture. Shell surface glossy, nearly smooth with few transverse ridges near peristome; varices present. Embryonic shell large, about 2½ whorls. with a smooth surface; following whorls regularly coiled. Last whorl shouldered or rarely rounded, regularly expanded; umbilicus widely open and deep. Aperture semi-ovate; peristome discontinuous, thickened, expanded and reflected. Apertural dentition with a strong parietal lamella and one palatal, one basal and one columellar lamella (Fig. 7C).

Genital organs. Atrium (at) very short. Proximal penis (p) very short penial appendix (pa) swollen in middle, and distal penis slender. Penial sheath (ps) thin, extending about two-thirds of penis length; penial sheath retractor muscle (psr) very thin, originating at genital orifice wall and inserting distally on penial sheath (Fig. 14A). Vas deferens (vd) passes through about one-seventh of penial sheath length before entering into penis distally (Fig. 14B). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium generally smooth with sparse atrial pores (Fig. 19F); penial wall with scattered dark brown penial hooks, about 2 hooks/200 μm^2 (Fig. 19G). Hooks located on conical penial papillae (pp) separated by thin reticulated folds. Penial hooks small (<0.03 mm in length), low conical, expanded at base, tips pointed (Fig. 17H).

Vagina (v) long, enlarged, about half of penis length. Gametolytic duct (gd) expanded at base and tapering to long and tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) a long and narrow tube; oviduct (ov) enlarged and folded; prostate gland inconspicuous and bound to oviduct. Talon (ta) small, short and club shaped. Hermaphroditic duct (hd) bearing long seminal vesicle (sv) about three times longer than the length from talon to branching point of seminal vesicle (Fig. 14A).

Vaginal wall with smooth surface of strong recticulate vaginal folds (Fig. 17I).

Etymology. The specific epithet "*epipedis*" is derived from the Greek "*epipedos*" meaning "flat" It refers to the flattened- or depressed-heliciform shell.

Distribution. This species is known only from the type locality.

Remarks. Apparently rare and only extensive searching yielded living animals.

Figure 9. Shells of Group III: *Discartemon roebeleni*-group. **A, B** *Discartemon stenostomus* **A** holotype ZMA 3.54.024, and **B** paratype ZMA 3.54.025 **C, D** *Discartemon sangkarensis* **C** holotype ZMA 3.59.052, and **D** paratype ZMA 3.59.053 **E, F** *Discartemon vandermeermohri* **E** holotype ZMA 3.59.055, and **F** paratype ZMA 3.59.056. **G, H** *Discartemon kotanensis* sp. n. **G** holotype CUMZ 6252 with apertural dentition, and **H** paratype CUMZ 4220.

17. *Discartemon flavacandida* Siriboon & Panha, sp. n.

http://zoobank.org/D224A65B-6BD7-46A4-B7FE-45C7B143CA72
http://species-id.net/wiki/Discartemon_flavacandida
Figs 3B, 7E, F, 14C, D, 19J–N, 23, Table 2

Type material. Holotype CUMZ 6251 (Fig. 7E). Measurement: shell height 5.7 mm, shell width 11.7 mm, and with 6½ whorls. Paratypes: CUMZ 3574 (25 shells), 3576 (9 shells), 3579 (1 shell), 3580 (3 shells), 3675 (7 shells), 3676 (33 shells), 3677 (1 shell), 4214 (26 shells), 6006 (22 shells), 6216 (2 specimens in ethanol; Figs 3B, 14C, D, 19J–N), NHMUK 20130679 (2 shells), and SMF (2 shells) from the type locality.

Figure 10. Shells of Group III: *Discartemon roebeleni*-group. **A, B** *Discartemon megalostraka* sp. n. **A** holotype CUMZ 6253 with apertural dentition, and **B** paratype CUMZ 3657 **C, D** *Discartemon triancus* sp. n. **C** holotype CUMZ 6254 with apertural dentition, and **D** paratype CUMZ 6032 **E, F** *Discartemon conicus* sp. n. **E** holotype CUMZ 6255 with apertural dentition, and **F** paratype CUMZ 6033.

Type locality. Tam Phra Khayang, Kra Buri, Ranong, Thailand, 10°19'33.4"N, 98°45'54.7"E.

Diagnosis. This new species is distinguished from *D. plussensis*, *D. leptoglyphus*, *D. platymorphus, D. roebeleni* and *D. collingei* by having a larger shell with a smooth shell surface, a shouldered and slightly axially deflected last whorl, two longitudinal furrows and seven apertural lamellae. Its genitalia are distinctive in having a long but thick penial appendix.

Description. Shell. Shell depressed-heliciform, white and translucent; whorls 6–6½, spire only slightly convex, with distinct suture. Shell surface glossy, smooth with thin growth lines.

Embryonic shell large, about 2½ whorls and with smooth surface; following whorls regularly coiled. Last whorl shouldered, slightly axially deflected, regularly expanded, and two short longitudinal furrows present. Umbilicus widely open and deep. Aperture semi-ovate; peristome discontinuous, expanded and reflected. Apertural dentition with strong parietal and small upper parietal lamellae separated at right angle, one small upper palatal, one palatal, one basal, one columellar, and one small supracolumellar lamella (Fig. 7E).

Genitalia organs: Atrium (at) long and slender. Penis (p) long; proximal penis slender; middle part enlarged with a long but thick penial appendix (pa) about half of penis length; distal penis long and slender (Fig. 14C). Penial sheath (ps) thin, extending about half of penis length; penial sheath retractor muscle (psr) very thin, originating at atrium and inserting distally on penial sheath. Vas deferens (vd) passes through about one-fifth of penial sheath length before entering into penis distally (Fig. 14D). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium generally smooth with numerous atrial pores (Fig. 19J). Penial wall with scattered light brown penial hooks, about 10 hooks/200 μm^2 (Fig. 19K). Hooks located on penial wall. Penial hooks small (<0.03 mm in length), expanded at base, tips pointed and curved towards genital orifice (Fig. 19L, M).

Vagina (v) very short, about one-fourth of penis length. Gametolytic duct (gd) a long narrow tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) very long, slender, proximal with equivalent diameter with vagina, and tapering to smaller tube distally. Oviduct (ov) folded and prostate gland inconspicuous. Talon (ta) small, and very short. Hermaphroditic duct (hd) bearing long seminal vesicle (sv) about one and half times longer than the length from talon to branching point of seminal vesicle (Fig. 14C).

Vaginal wall generally smooth, surface with numerous pores (Fig. 19N).

Etymology. The specific epithet "*flavacandida*" is derived from the Latin "*flavus*" meaning "yellow" and "*candidus*" meaning "bright or transparent".

Distribution. This species seems to be restricted to limestone at the type locality.

Remarks. Apparently rare and only extensive searching yielded living animals.

Group III: *Discartemon roebeleni*-group: Species with globose-heliciform shell.

18. *Discartemon lemyrei* (Morlet, 1883)
http://species-id.net/wiki/Discartemon_lemyrei
Figs 8A, 23

Streptaxis lemyrei Morlet, 1883: 104, 105, pl. 4, fig. 1. Type locality: Kampot, Cambodge. Tryon 1885: 67, pl. 16, figs 12, 13. Morlet 1889: 122. Gude 1903: 227.

Odontartemon (*Discartemon*) *lemyrei* – Kobelt 1906: 98, pl. 55, figs 13, 14. Kobelt 1910: 150.

Discartemon lemyrei – Benthem Jutting 1954: 79. Benthem Jutting 1959: 168. Richardson 1988: 183.

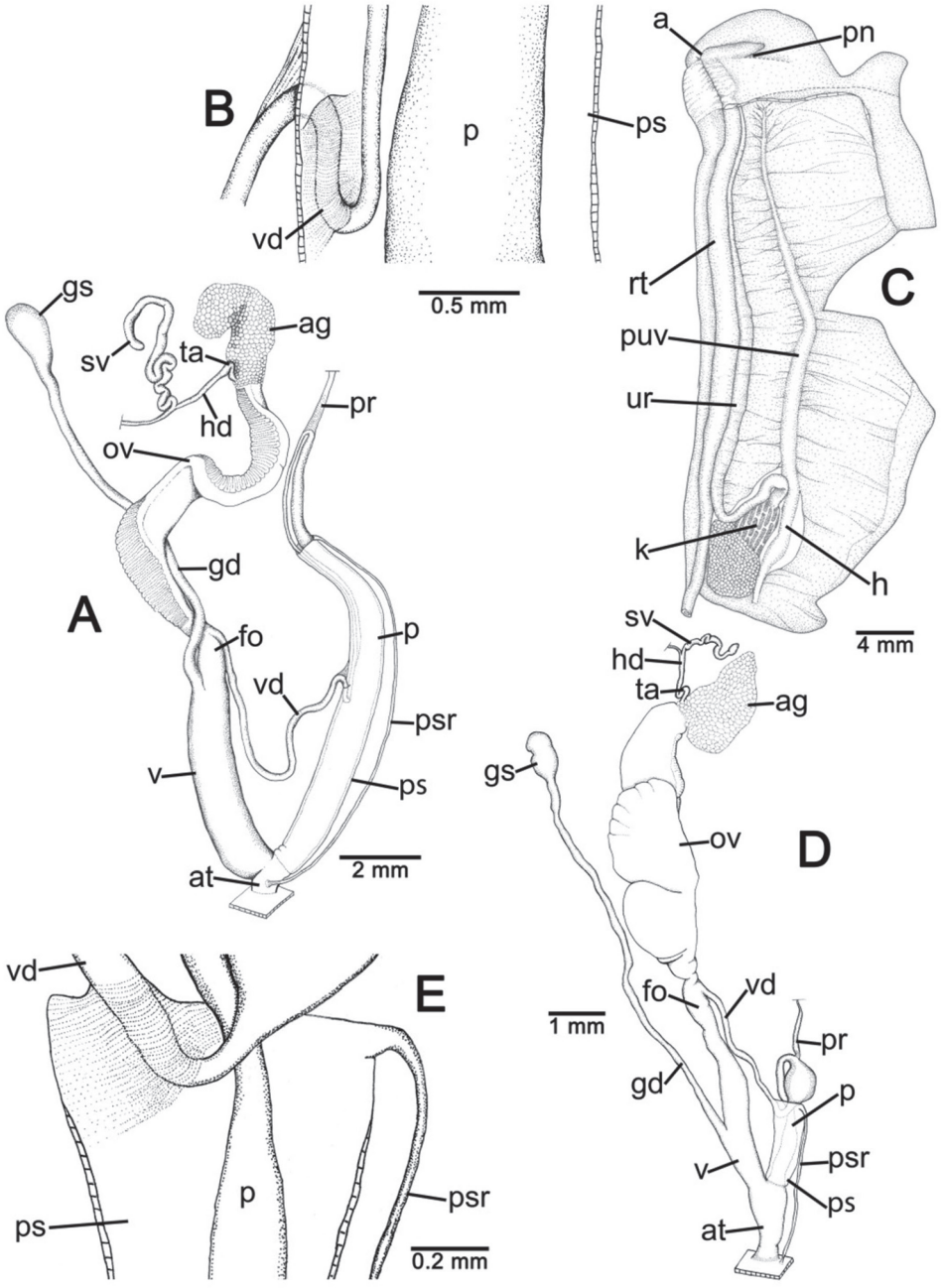

Figure 11. Genitalia and pallial complex. **A–C** *Discartemon discus* CUMZ 6257, from Vietnam **A** reproductive system **B** insertion of vas deferens into penial sheath, and **C** circular and excretory systems and mantle edge **D, E** *Discartemon nummus* CUMZ 6208, from Patthalung **D** reproductive system, and **E** insertion of vas deferens into penial sheath.

Material examined. Holotype MNHN (Fig. 8A).

Remarks. Shell globose-heliciform, spire elevated conical with distinct suture; following whorls regularly coiled. Shell surface with transverse ridges; last whorl rounded, regularly expanded; umbilicus unusually narrow. Aperture sub-quadrangular; peristome thickened, expanded and reflected. Apertural dentition with only one parietal lamella.

This species is very superficially similar to *D. roebeleni* and *D. collingei*, but has a larger shell with higher spire, unusually narrow umbilicus, and larger aperture with only a parietal lamella. In addition, the three species are allopatric, with *D. lemyrei* occurring in Kampot and Panompen of Cambodia, while *D. roebeleni* and *D. collingei* occur in southern Thailand and peninsular Malaysia.

19. *Discartemon roebeleni* (Möllendorff, 1894)

http://species-id.net/wiki/Discartemon_roebeleni
Figs 3C, 8B–G, 15A–C, 20A–E, 22E, 23, Table 3

Streptaxis roebeleni Möllendorff, 1894: 147, pl. 16, figs 3, 4. Type locality: Samui Island, Gulf of Siam. Gude 1903: 226. Gude 1920: 53. Laidlaw 1933: 233.

Odontartemon (*Discartemon*) *roebeleni* – Kobelt 1906: 99, pl. 54, figs 10, 11. Kobelt 1910: 150.

Discartemon roebeleni – Benthem Jutting 1954: 79, 81, fig. 3. Benthem Jutting 1959: 168. Zilch 1961: 82, pl. 5, fig. 4. Richardson 1988: 184. Maassen 2000: 88. Hemmen and Hemmen 2001: 42.

Material examined. Lectotype of *Streptaxis roebeleni* SMF 108526 (Fig. 8B), and paralectotypes SMF 108527 (5 shells), 108528 (2 shells), 108529 (1 shell), 108530 (1 shell).

Holotype of forma *major* SMF 108531 (Fig. 8C), and paratype 108532 (2 shells). Holotype of forma *minor* SMF 108533 (Fig. 8D).

Topotypes from Samui, Thailand: NMW 1955.158.25255 (1 shell), and Nam Tok Hin Lad, Samui, Suratthani, Thailand, 9°31'15.3"N, 99°57'20.1"E: CUMZ 3655 (Fig. 8E), 4217, 6217 (52 specimens in ethanol; Figs 3C, 15A–C, 20A–E, 22E).

Topotypes from Samui, Thailand: NMW 1955.158.25255 (1 shell), and Nam Tok Hin Lad, Samui, Suratthani, Thailand, 9°31'15.3"N, 99°57'20.1"E: CUMZ 3655 (Fig. 8E), 4217, 6217 (52 specimens in ethanol; Figs 3C, 15A–C, 20A–E, 22E). Samui Island, Gulf of Siam [Thailand]: NHMW 36538 (1 shell), NHMW Rusnov R284 (1 shell), RMNH Fulton Coll. Reg. 177 (2 shells), ZMB 43127 (2 shells). Kow Tao Is. [=Ko Tao], Thailand: NMW 1955.158.25254 (7 shells). Ko Tao, Suratthani: CUMZ 3577. Ko Wuatalub, Ang Thong National Park, Suratthani: CUMZ 6022, 6218 (1 specimen in ethanol). Ko Mae Ko, Ang Thong National Park, Suratthani: CUMZ 6219 (1 specimen in ethanol). Ban Ta Khun, Suratthani: CUMZ 3590. Ratchaprapha reservior, Ban Ta Khun, Suratthani: CUMZ 6220 (4 specimens in ethanol). Khlong Saeng Wildlife Sanctuary, Ban Ta Khun, Suratthani: CUMZ 3652. Wat Khao Khok, Wiang Sa, Suratthani: CUMZ 3658. Wat Na San, Ban Na San, Suratthani: CUMZ

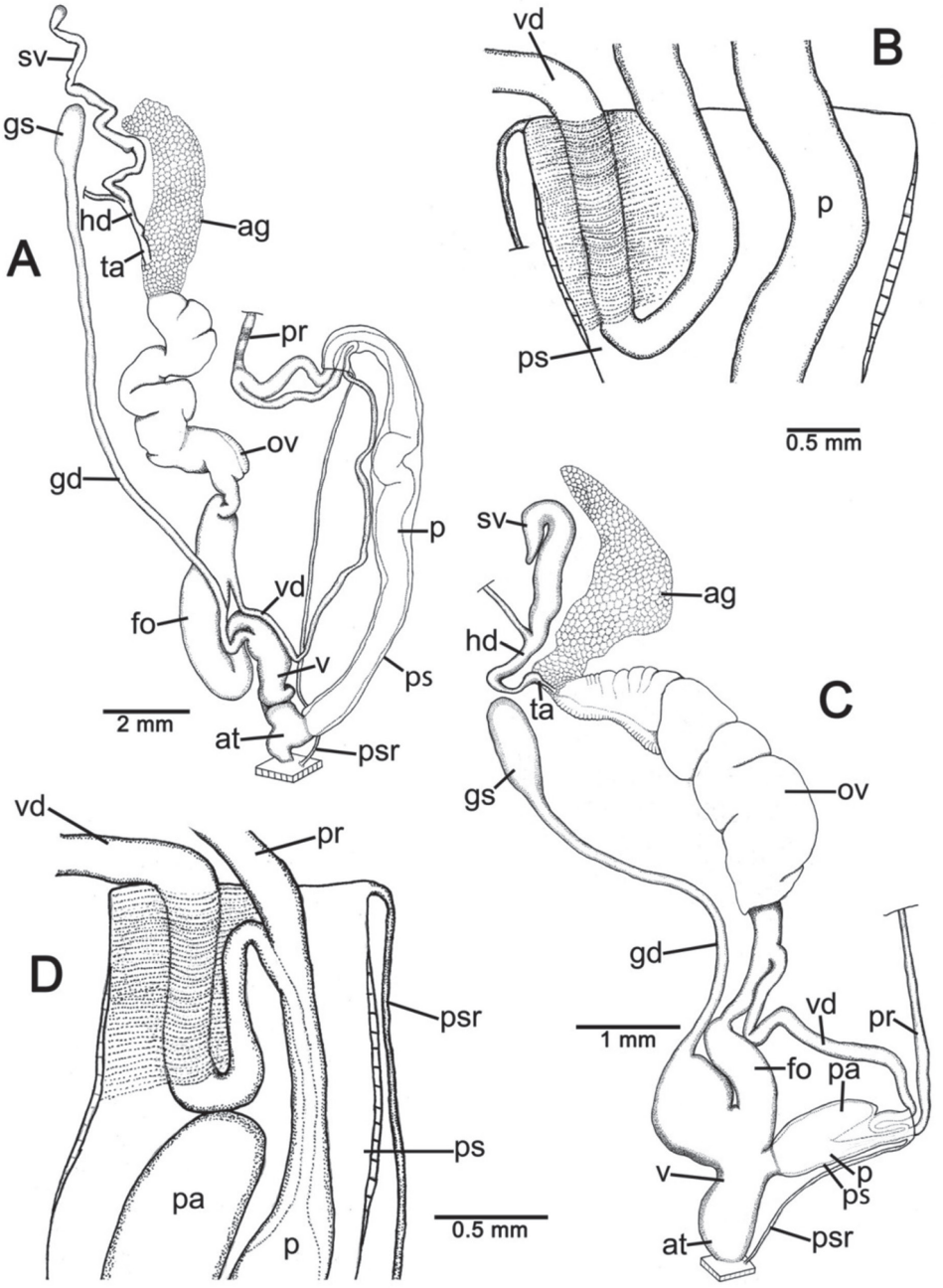

Figure 12. Genitalia. **A, B** *Discartemon discadentus* sp. n. paratype CUMZ 6209 **A** reproductive system, and **B** insertion of vas deferens into penial sheath **C, D** *Discartemon hypocrites* topotype CUMZ 6199 **C** reproductive system, and **D** insertion of vas deferens into penis sheath.

Table 3. Shell measurements of *Discartemon* spp (*D. roebeleni*-group). Specimen collections and catalogue numbers indicated in parentheses.

Species and locality and CUMZ nos	No. of specimens	Ranges, mean ± S.D. in mm of:			Number of whorls
		Shell height	Shell width	H/W ratio	
Discartemon roebeleni (Möllendorff, 1894)					
Ko Samui, Suratthani: (3655)	5	5.6–6.4 5.9±0.42	9.1–9.9 9.5±0.28	0.6–0.7 0.6±0.03	6–6½
Wat Khao Khok, Suratthani: (3658)	19	3.6–4.5 4.1±0.22	6.7–7.6 7.2±0.27	0.5–0.6 0.6±0.03	6–6½
Khao Nan N. P., Nakhon Si Thammarat: (4221)	10	4.5–5.3 4.8±0.27	7.1–9.1 8.1±0.61	0.6–0.6 0.6±0.03	6–6½
Wat Suwankhuha, Phangnga: (3661)	19	5.2–6.7 6.0±0.41	8.6–10.5 9.6±0.43	0.5–0.7 0.6±0.04	6–6½
Khao Pu-Khao Ya N. P., Phatthalung: (3596)	13	3.9–5.5 4.7±0.42	7.4–9.5 8.4±0.62	0.5–0.6 0.6±0.03	6–6½
Tam Wang Thong, Phatthalung: (3662, 6027)	15	4.4–5.6 4.9±0.31	7.0–8.0 7.6±0.29	0.6–0.7 0.6±0.03	6–6½
Khao Huai Hang, Trang: (3656)	9	4.8–5.6 5.2±0.34	8.2–9.5 9.1±0.52	0.5–0.6 0.6±0.02	6–6½
Botanic Garden, Trang: (3663)	9	5.1–6.4 5.6±0.38	8.0–10.3 8.9±0.81	0.6–0.7 0.6±0.04	6–6½
Sra Morakot, Krabi: (6023)	27	4.7–5.6 5.1±0.23	7.4–8.5 7.9±0.28	0.6–0.7 0.6±0.02	6–6½
Tam Tanan, Satun: (6025)	16	4.8–5.7 5.2±0.26	8.3–9.4 8.8±0.28	0.5–0.6 0.6±0.03	6–6½
Tam Khantiphon, Satun: (6026)	7	5.0–5.4 5.2±0.13	9.6–10.1 9.8±0.19	0.5–0.5 0.5±0.01	6–6½
Discartemon kotanensis sp. n.					
Ko Tan, Suratthani: (6230, 6252)	32	5.8–7.4 6.6±0.44	8.6–10.5 9.6±0.50	0.6–0.8 0.7±0.04	6–6½
Discartemon megalostraka sp. n.					
Nam Tok Tao Thong, Phangnga: (3657, 6031, 6253)	19	7.2–9.4 8.2±0.57	11.0–14.5 12.4±0.84	0.6–0.7 0.7±0.04	7–7½
Wat Tam Seua, Krabi: (6029)	6	6.5–7.3 6.9±0.3	10.7–11.6 11.2±0.34	0.6–0.6 0.6±0.02	7–7½
Ban Chong, Krabi: (6030)	10	7.7–9.4 8.5±0.52	12.0–12.9 12.6±0.32	0.6–0.7 0.7±0.04	7–7½
Discartemon triancus sp. n.					
Gunung Kilian, Perlis, Malaysia: (6234, 6254)	5	4.3–4.8 4.6±0.22	7.8–8.5 8.1±0.33	0.5–0.6 0.6±0.04	5½–6
Discartemon conicus sp. n.					
Gau Cerita, Langawi, Malaysia: (6033, 6255)	3	4.1–4.5 4.3±0.2	7.0–7.3 7.1±0.16	0.6–0.6 0.6±0.03	6

3578. Km 3, Khiri Rat Nikhom, Suratthani: CUMZ 6221 (1 specimen in ethanol). Wat Khao Phanom Wang, Suratthani: CUMZ 6222 (1 specimen in ethanol). Tam Hong, Khao Nan National Park, Nakhon Si Thammarat: CUMZ 4221. Tam Luang, Khao Nan National Park, Nakhon Si Thammarat: CUMZ 4231. Tam Phannara, Nakhon

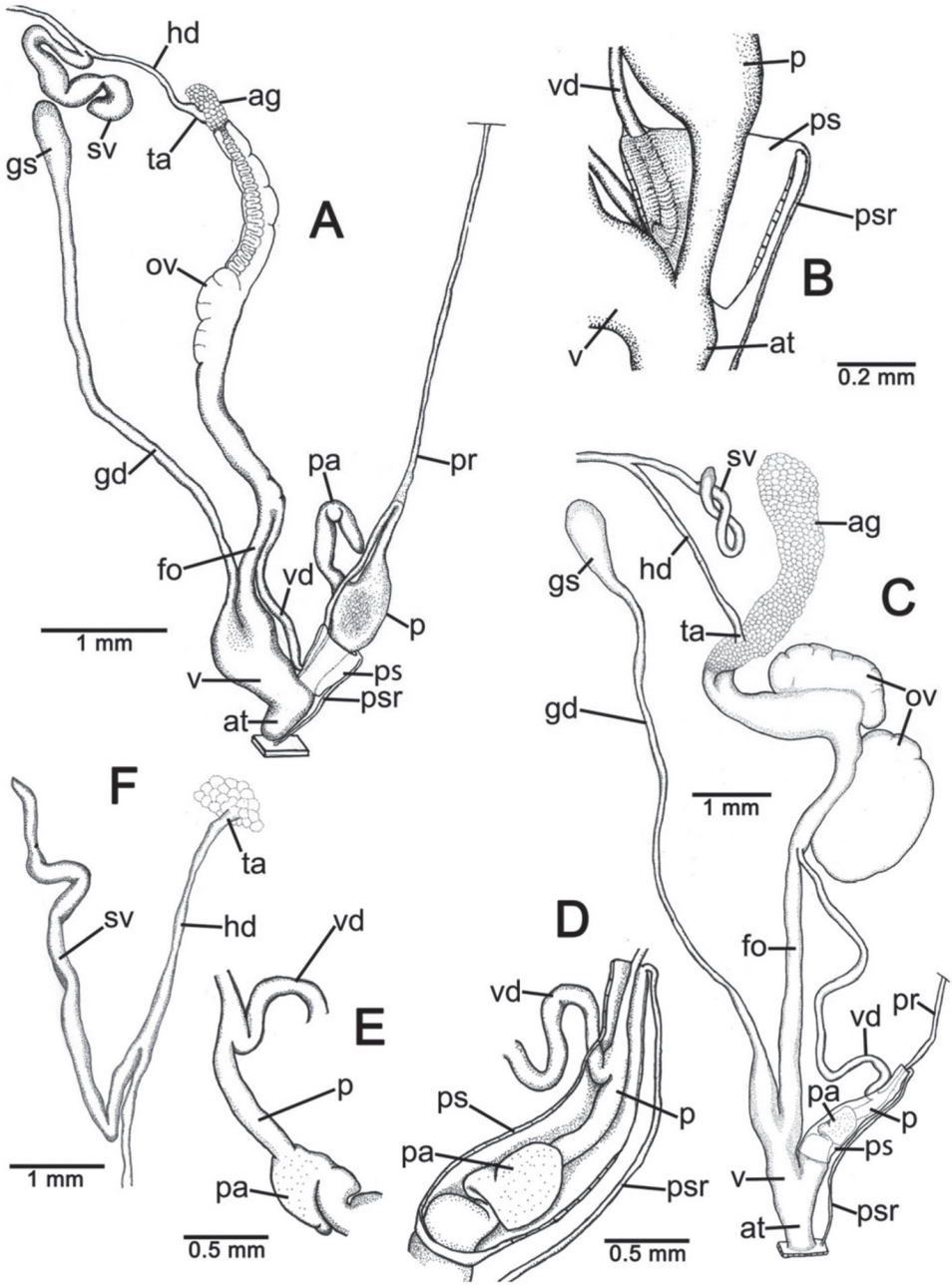

Figure 13. Genitalia. **A, B** *Discartemon leptoglyphus* CUMZ 6007, from Ipoh, Perak, Malaysia **A** reproductive system, and **B** insertion of vas deferens into penial sheath **C–F** *Discartemon afthonodontia* sp. n. paratype CUMZ 6210 **C** reproductive system **D** insertion of vas deferens into penial sheath **E** inflation of penis, and **F** details of hermaphroditic duct and seminal vesicle.

Si Thammarat: CUMZ 3667. Tam Khun Klung, Nopphitam, Nakhon Si Thammarat: CUMZ 6021. Khao Phrathong, Cha-uat, Nakhon Si Thammarat: CUMZ 3599. Wat Suwankhuha, Takua Thung, Phangnga: CUMZ 3661 (Fig. 8F), 6223 (14 specimens in ethanol). Sra Morakot, Krabi: CUMZ 6023, 6226 (7 specimens in ethanol). Ao Phra Nang, Krabi: CUMZ 3651. Khao Huai Hang, Huai Yot, Trang: CUMZ 3656. Tam Lay-Kao Krop, Huai Yot, Trang: CUMZ 3600. Botanic Garden, Trang: CUMZ 3663. Khao Pi-na, Na Yong, Trang: CUMZ 6024. Tam Sumno, Trang: CUMZ 6225 (1 specimen in ethanol). Khao Pu-Khao Ya National Park, Si Banphot, Phatthalung: CUMZ 3575, 3596. Tam Wang Thong, Phatthalung: CUMZ 3662, 6027, 6224 (6 specimens in ethanol). Wat Khaotupson, Phatthalung: CUMZ 3678. Khao Ok Thalu, Phatthalung: CUMZ 3595. Khao Chaison, Phatthalung: CUMZ 6028. Tam Tanan, Satun: CUMZ 6025. Tam Khantiphon, Satun: CUMZ 6026, 6227 (1 specimen in ethanol). Ko Buloan Pai, La Ngu, Satun: CUMZ 3591. Ko Tarutao, Satun: CUMZ 6228 (7 specimens in ethanol), 6256 (Fig. 8G). Ko Klang, Tarutao, Satun: CUMZ 6229 (9 specimens in ethanol). Khao Nui, Rattaphum, Songkhla: CUMZ 3598.

Description. Shell. Shell globose-heliciform, white and translucent; whorls 6–6½, spire conical with distinct suture. Shell surface glossy, with transverse ridges that diminish below periphery; varices present. Embryonic shell large, about 2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl rounded, regularly expanded; umbilicus widely open and deep. Aperture sub-quadrangular; peristome discontinuous, thickened, expanded and reflected. Apertural dentition with one strong parietal, one palatal, one basal and one columellar lamella (Fig. 8B). Sometimes basal lamella absent (Fig. 8F), or upper palatal and supracolumellar lamellae present (Fig. 8G).

Radula. Each row consists of 21–33 teeth with formula (10-16)-1-(10-16). Central tooth very small and triangular with a pointed cusp. Lateral and marginal teeth undifferentiated, unicuspid and lanceolate. Latero-marginal teeth gradually reduce in size, with outermost teeth much smaller and shorter than inner teeth (Fig. 22E).

Genitalia organs. Atrium (at) long. Penis short and slender. Penial sheath (ps) extending entire penis length; penial sheath retractor muscle (psr) very thin, originating at genital orifice wall and inserting distally on penial sheath (Fig. 15A). Vas deferens (vd) passes through about one-seventh of penial sheath length before entering into penis distally (Fig. 15B). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium generally corrugated (Fig. 20A). Penial wall with scattered, transparent penial hooks, about 8 hooks/200 μm^2. Hooks located on very short penial papilla (pp). Penial hooks small (<0.03 mm in length), short, expanded at base, tips pointed and curved towards genital orifice (Fig. 20C, D).

Vagina (v) short, about half of penis length. Gametolytic duct (gd) a long and slender tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) short, about same length as vagina; oviduct (ov) folded; prostate gland inconspicuous and bound to oviduct. Talon (ta) small, very short. Hermaphroditic duct (hd) bearing extremely long seminal vesicle (sv) (Fig. 15C).

Vaginal wall generally with longitudinal vaginal folds (Fig. 20E).

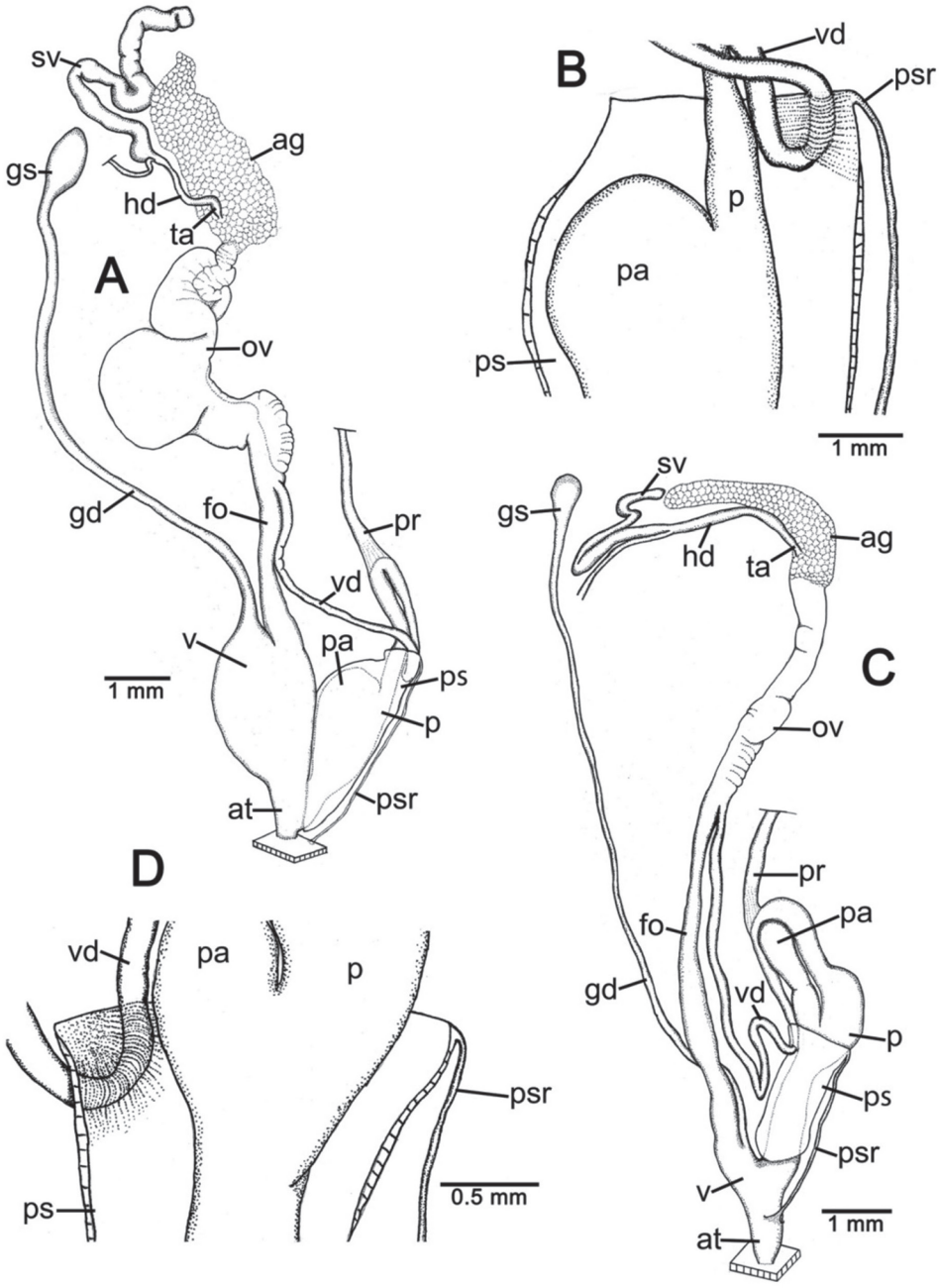

Figure 14. Genitalia. **A, B** *Discartemon epipedis* sp. n. paratype CUMZ 6215 **A** reproductive system, and **B** insertion of vas deferens into penis sheath **C, D** *Discartemon flavacandida* sp. n., paratype CUMZ 6216 **C** reproductive system, and **D** insertion of vas deferens into penis sheath.

Distribution. This species is found in limestone habitats and is common in southern Thailand. The geographic distribution records are in eight Provinces, ranging from 10°N to 6°N: Suratthani, Nakhon Si Thammarat, Krabi, Phangnga, Phatthalung, Trang, Satun, and Songkhla.

Remarks. *Discartemon roebeleni* can be distinguished from *D. collingei* by its rounded, regularly coiled last whorl and wider umbilicus. It differs from *D. stenostomus* in the higher spire with transverse ridges that diminish below the periphery, a sub-quadrangular aperture, and in having a basal lamella.

20. *Discartemon collingei* (Sykes, 1902)

http://species-id.net/wiki/Discartemon_collingei
Figs 8H, 23

Streptaxis collingei Sykes, 1902: 22, 60, pl. 3, figs 8–10. Type locality: Kelantan, Malay Peninsula. Gude 1903: 214. Laidlaw 1933: 233.
Streptaxis (*Discartemon*) *collingei* – Möllendorff 1902: 136.
Odontartemon (*Discartemon*) *collingei* – Laidlaw 1929: 260.
Discartemon collingei – Benthem Jutting 1954: 79, 83, fig. 4. Benthem Jutting 1959: 168. Berry 1965: 28, 29. Richardson 1988: 182. Maassen 2001: 87. Marwoto 2008: 192.

Material examined. Syntype NHMUK 1937.7.9.20 (1 shell; Fig. 8H). Kelantan, Malaysia: NMW 1955.158.25250 (2 shells). Kelantan, Malaysia: NHMW 40716 (1 shell).

Remarks. Shell globose-heliciform, translucent, with a conical spire with a distinct suture. Shell surface with transverse ridges that diminish below periphery; varices present. Later whorls slightly axially deflected. Last whorl shouldered and regularly expanded; umbilicus wide and deep. Aperture sub-quadrangular; peristome thick, expanded and reflected. Apertural dentition with one parietal, one palatal, one basal and one columellar lamella (Fig. 8H).

Discartemon collingei is similar to *D. lemyrei*, but the latter species has a larger shell with a higher spire, a shell surface with transverse ridges, the last whorl rounded and more inflated, a narrower umbilicus, and only one parietal lamella.

21. *Discartemon stenostomus* Benthem Jutting, 1954

http://species-id.net/wiki/Discartemon_stenostomus
Figs 9A, B, 23

Discartemon stenostomus – Benthem Jutting 1954: 83, 86, fig. 5. Type locality: Kaki Bukit, Perlis, Malaysia. Benthem Jutting 1959: 168. Berry 1965: 221–228, figs 1–3. Richardson 1988: 184. Maassen 2001: 88. Maassen 2003: 119. Marwoto 2008: 192.

Material examined. Holotype ZMA 3.54.024 (Fig. 9A). Paratypes ZMA 3.54.025 (8 shells), and NHMUK 1957-4-3.1-2 (2 shells). Kaki Bukit, Perlis: NMW 1955.158.25256 (10 shells).

Remarks. Shell globose-heliciform, semi-transparent, spire only slightly convex and with a distinct suture. Shell surface glossy with thin transverse ridges at suture; following whorls regularly coiled. Last whorl rounded and regularly expanded; umbilicus widely open and deep. Aperture triangular; peristome thickened, expanded and reflected. Apertural dentition with one sinuous parietal, one palatal, one columellar and one supracolumellar lamella (Fig. 9A).

The genital anatomy was described by Berry (1965). Atrium and penis short with blunt penial appendix, penial sheath extending almost entire penis length, vas deferens passing through about one-fifth of penial sheath length. Internal wall of penis corrugated with cornified ridges, penial hooks absent, but with a large hollow "stylet" presumably protrudable from the tip of the everted penis. Vagina very short, proximal gametolytic duct enlarged, distally a long slender tube. Free oviduct short; talon small, club shaped; seminal vesicle about the same length from talon to branching point of seminal vesicle. Internal wall of vaginal elaborated with parallel vaginal folds.

This species resembles *D. lemyrei* and *D. collingei*, but differs in having thin transverse ridges near the suture, a triangular aperture, and apertural dentition with a sinuous parietal lamella, one palatal, one columellar and one supracolumellar lamella. In addition, *D. lemyrei* has a larger shell, narrower umbilicus, and only one parietal lamella, while *D. collingei* has a shouldered and slightly axially reflected last whorl, and apertural dentition with a straight parietal, one palatal, one basal and one columellar lamellae. A penial stylet has not yet been found in any other *Discartemon* species.

22. *Discartemon sangkarensis* Benthem Jutting, 1959

http://species-id.net/wiki/Discartemon_sangkarensis
Figs 9C, D, 23

Discartemon sangkarensis – Benthem Jutting 1959: 168–170, fig. 10. Type locality: Batu Sangkar, near Pajakombo, Padang Highlands, Indonesia. Richardson 1988: 184. Marwoto 2008: 191.

Material examined. Holotype ZMA 3.59.052 (Fig. 9C). Paratypes: ZMA 3.59.053 (1 shell), ZMA 3.59.054 (4 shells), and ZMA 3.59.057 (9 shells).

Remarks. Shell globose-heliciform, semi-transparent, with a conical spire and distinct suture. Shell surface glossy with fine transverse ridges; following whorls regularly coiled. Last whorl rounded and regularly expanded; umbilicus widely open and deep. Aperture triangular, with sinulus; peristome thickened, expanded and reflected. Apertural dentition of only one parietal lamella (Fig. 9C).

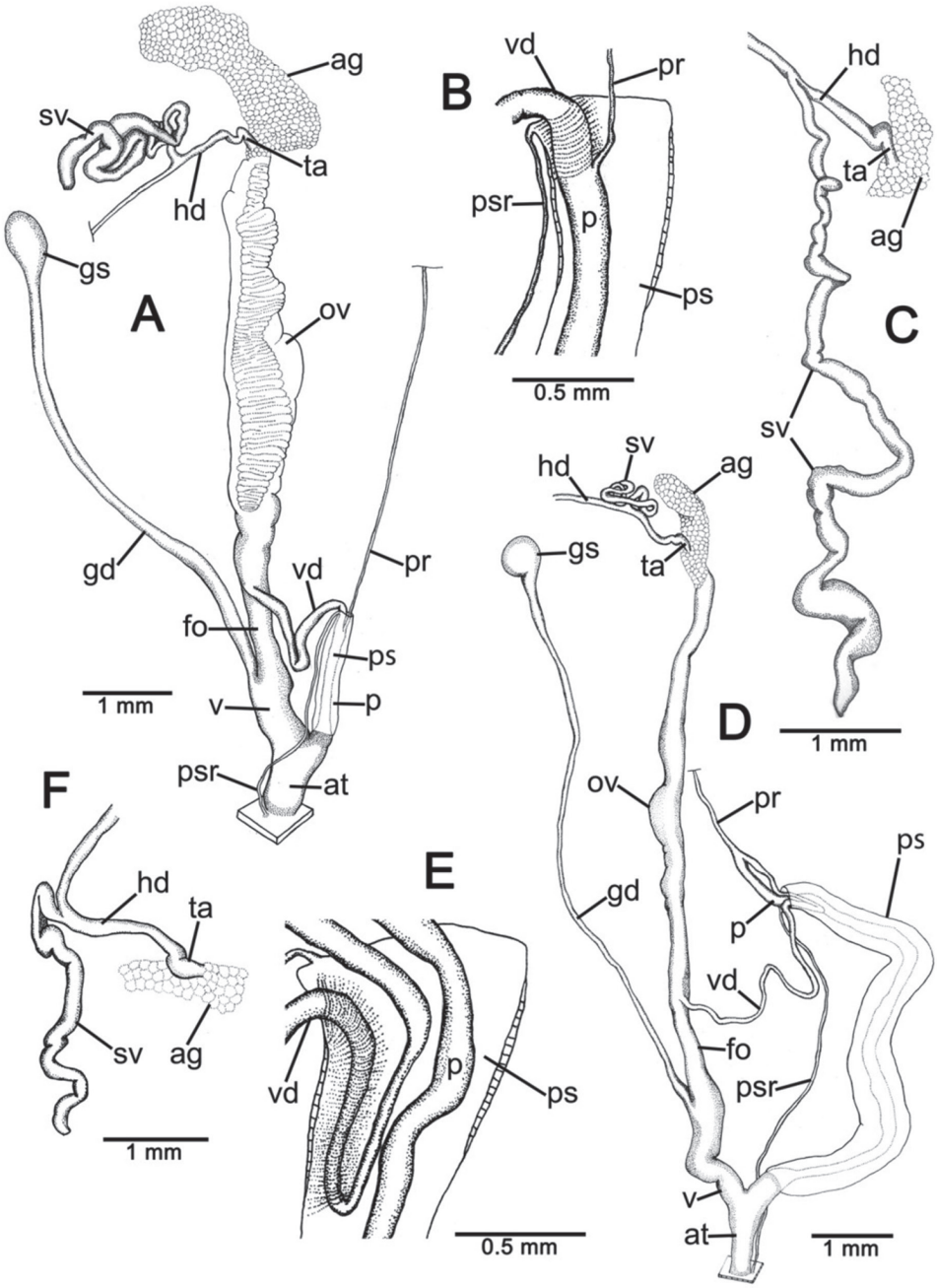

Figure 15. Genitalia. **A–C** *Discartemon roebeleni* topotype CUMZ 6217 **A** reproductive system **B** insertion of vas deferens into penial sheath, and **C** details of hermaphroditic duct and seminal vesicle **D–F** *Discartemon kotanensis* sp. n. paratype CUMZ 6230 **D** reproductive system, **E** insertion of vas deferens into penis sheath, and **F** details of hermaphroditic duct and seminal vesicle.

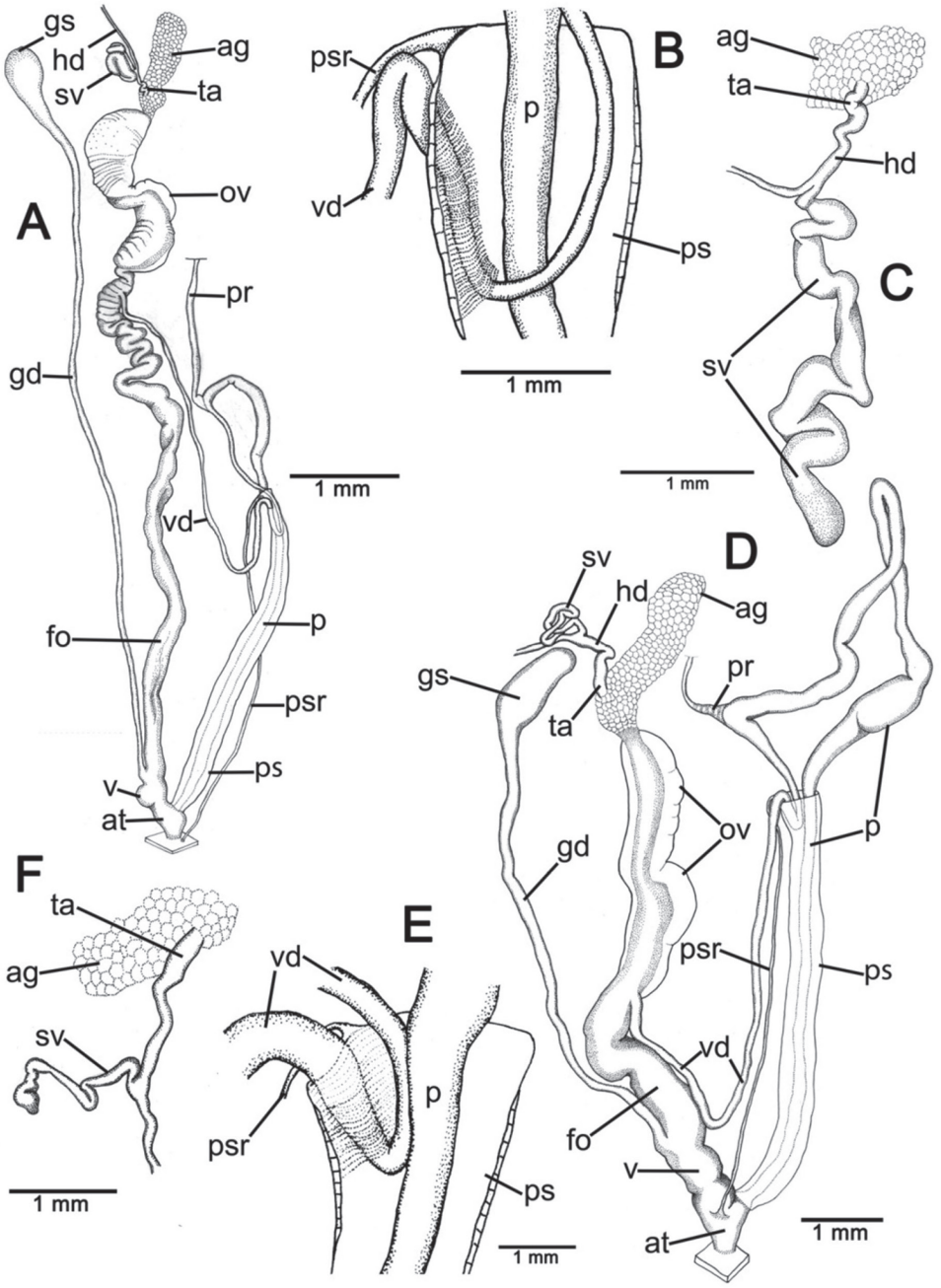

Figure 16. Genitalia. **A–C** *Discartemon megalostraka* sp. n., paratype CUMZ 6233 **A** reproductive system **B** insertion of vas deferens into penial sheath, and **C** details of hermaphroditic duct and seminal vesicle **D–F** *Discartemon triancus* sp. n., paratype CUMZ 6236 **D** reproductive system **E** insertion of vas deferens into penis sheath, and **F** details of hermaphroditic duct and seminal vesicle.

Discartemon sangkarensis differs from *D. roebeleni* in having a more inflated last whorl, a triangular aperture, in having a sinulus, and the apertural dentition of only one parietal lamella. Compared with *D. lemyrei* and *D. vandermeermohri*, *D. sangkarensis* differs in having a sinulus. Also, *D. lemyrei* has a relatively larger shell and narrow umbilicus, while *D. vandermeermohri* has a small basal lamella. *Discartemon sangkarensis* differs from *D. collingei* in having a higher spire, the last whorl rounded, more inflated and regularly coiled, and in having a sinulus, a triangular aperture, and only one parietal lamella. Also, *D. collingei* is slightly axially deflected.

23. *Discartemon vandermeermohri* Benthem Jutting, 1959

http://species-id.net/wiki/Discartemon_vandermeermohri
Figs 9E, F, 23

Discartemon vandermeermohri Benthem Jutting, 1959: 166–168, fig. 9. Type locality: Batu Sok, Pulu Weh, Indonesia. Richardson 1988: 185. Marwoto 2008: 191.

Material examined. Holotype ZMA 3.59.055 (Fig. 9E). Paratypes ZMA 3.59.056 (2 shells) and RMNH Brandhorst Reg. 387 (1 shell).

Remarks. Shell thickened, globose-heliciform, with a conical spire and distinct suture. Shell surface with strong transverse ridges; varices present; following whorls regularly coiled. Last whorl rounded and regularly expanded; umbilicus widely open and deep. Aperture triangular; peristome thickened, expanded and reflected. Apertural dentition of one parietal and one columellar lamella (Fig. 9E).

This species differs from *D. lemyrei* in its smaller shell, widely open umbilicus, triangular aperture, and in having two apertural lamellae. *Discartemon vandermeermohri* is readily distinguished from *D. roebeleni* and *D. collingei* in its having a triangular aperture, and in lacking a basal lamella. Also, *D. collingei* is slightly axially deflected.

24. *Discartemon kotanensis* Siriboon & Panha, sp. n.

http://zoobank.org/4707CE37-6404-485D-9DCD-B58753958FB5
http://species-id.net/wiki/Discartemon_kotanensis
Figs 3D, 9G, H, 15D–F, 20F–J, 22F, 23, Table 3

Type material. Holotype CUMZ 6252 (Fig. 9G). Measurement: shell height 6.3 mm, shell width 9.2 mm, and with 6 whorls. Paratypes: CUMZ 4220 (27 shells), 6230 (15 specimens in ethanol; Figs 3D, 15D–F, 20F–J, 22F), NHMUK 20130680 (2 shells), and SMF (2 shells) from the type locality.

Type locality. Ko Tan, Samui, Suratthani, Thailand, 9°22'18.9"N, 99°56'53.7"E.

Other material examined. Nam Tok Tone Nga Chang, Had Yai, Songkhla**:** CUMZ 6231 (4 specimens in ethanol). Ban Chang Lang, Si-kao, Trang: CUMZ 6232 (2 specimens in ethanol).

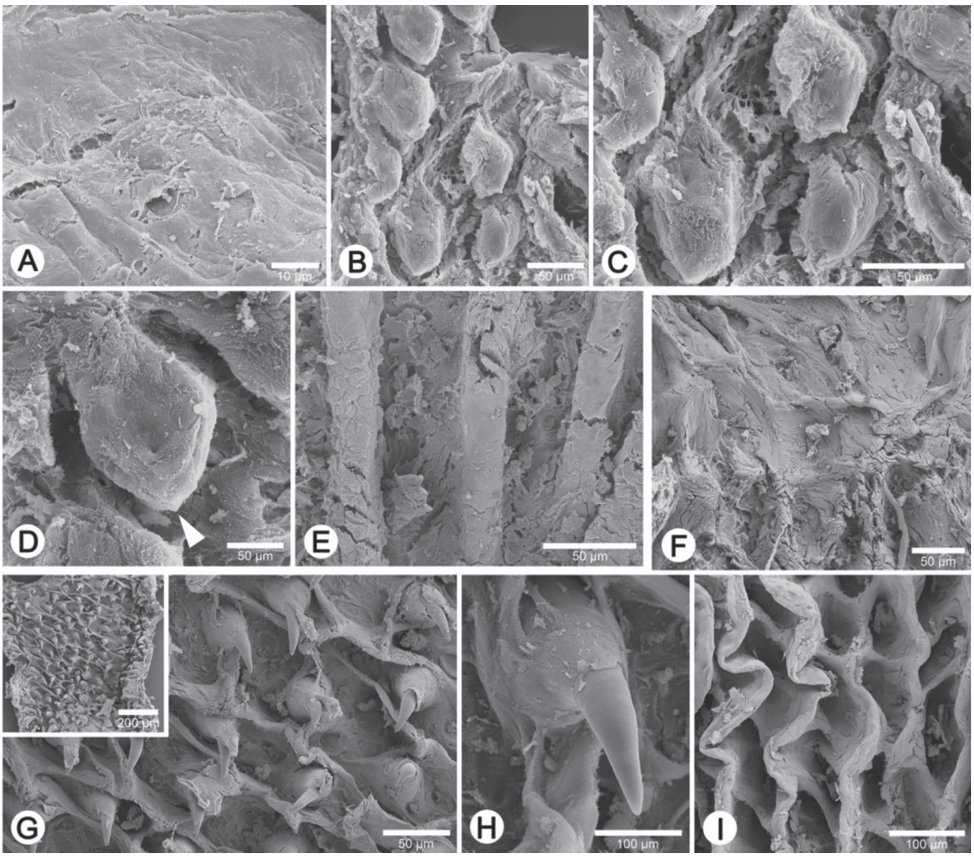

Figure 17. Internal sculpture of genitalia. **A–E** *Discartemon nummus* CUMZ 6208, from Patthalung **A** details of atrium surface **B** low magnification shows arrangement of penial hooks **C** high magnification of penial hooks **D** top view of penial hooks, white arrow indicate tip of hook, and **E** arrangement of vaginal folds **F–I** *Discartemon discadentus* sp. n., paratype CUMZ 6209 **F** details of atrium surface **G** high magnification of penial hooks with (inset) shows in low magnification **H** top view of penial hook, and **I** arrangement of reticulated vaginal folds.

Diagnosis. Conchologically this new species superficially resembles *D. roebeleni* and *D. megalostraka* sp. n. It differs from *D. roebeleni* in having a higher spire, a very long penis, a penial sheath extending fourth-fifths of the penis length, a smooth atrium wall with atrial pores, and a short seminal vesicle. It differs from *D. megalostraka* sp. n. in having a smaller shell and apertural dentition of four lamellae, and a shorter free oviduct, vas deferens and seminal vesicle. *Discartemon kotanensis* sp. n. differs from *D. stenostomus* and *D. collingei* in having a higher spire, transverse ridges reaching the periphery, the last whorl rounded and regularly coiled, and apertural dentition of one straight parietal, one basal and one columellar lamella. Also, *D. collingei* is slightly axially deflected.

Description. Shell. Shell globose-heliciform, white and translucent; whorls 6–6½, spire elevated conical, with distinct suture. Shell surface glossy, with trans-

verse ridges that diminish below periphery; varices present. Embryonic shell large, about 2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl rounded and regularly expanded; umbilicus widely open and deep. Aperture sub-quadrangular; peristome discontinuous, thickened, expanded and reflected. Apertural dentition of one strong parietal, one palatal, one basal and one columellar lamella (Fig. 9G).

Radula. Each row consists of 27–31 teeth with formula (13-15)-1-(13-15). The central tooth is very small and triangular with a pointed cusp. Lateral and marginal teeth are undifferentiated, unicuspid and lanceolate. Latero-marginal teeth gradually reduce in size, with outermost teeth much smaller and shorter than inner teeth (Fig. 22F).

Genital organs. Atrium (at) short. Penis (p) very long and slender. Penial sheath (ps) thin and extending about fourth-fifths of penis length, and penial sheath retractor muscle (psr) very thin, originating at genital orifice wall and inserting distally on penial sheath (Fig. 15D). Vas deferens (vd) passes a very short distance through penial sheath before entering into penis distally (Fig. 15E). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium generally smooth with atrial pores (Fig. 20F). Penial wall with dense and transparent penial hooks, about 20 hooks/200 μm^2 (Fig. 20H). Hooks located on short penial papillae (pp). Penial hooks small (<0.03 mm in length), expanded at base, tips pointed and curved towards genital orifice (Fig. 20I).

Vagina (v) short, about one-fifth of penis length. Gametolytic duct (gd) a long tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) short, of about same length as vagina. Oviduct (ov) slender and folded; prostate gland inconspicuous. Talon (ta) small, very short and club shaped. Hermaphroditic duct (hd) bearing long seminal vesicle (sv) about twice as long as the length from talon to branching point of seminal vesicle (Fig. 15F).

Vaginal wall generally with longitudinal vaginal folds (Fig. 20J).

Etymology. The specific epithet is derived from the type locality of this new species, the Ko Tan, Ko Samui, Suratthani Province.

Distribution. This species is known from the type locality and few limestone outcrops on the southern mainland.

Remarks. Shells of this species from Samui, Suratthani were originally thought to belong to *D. roebeleni.* After the genital system of *D. kotanensis* sp. n. was examined and critically investigated, it was considered distinct enough to be a separate species.

25. *Discartemon megalostraka* Siriboon & Panha, sp. n.

http://zoobank.org/05A48225-70FB-406F-857B-0B05C9D07754
http://species-id.net/wiki/Discartemon_megalostraka
Figs 3E, 10A, B, 16A–C, 21A–F, 22G, 23, Table 3

Type material. Holotype CUMZ 6253 (Fig. 10A). Measurement: shell height 8.0 mm, shell width 12.0 mm, and with 7 whorls. Paratypes: CUMZ 3657 (5 shells), 6031

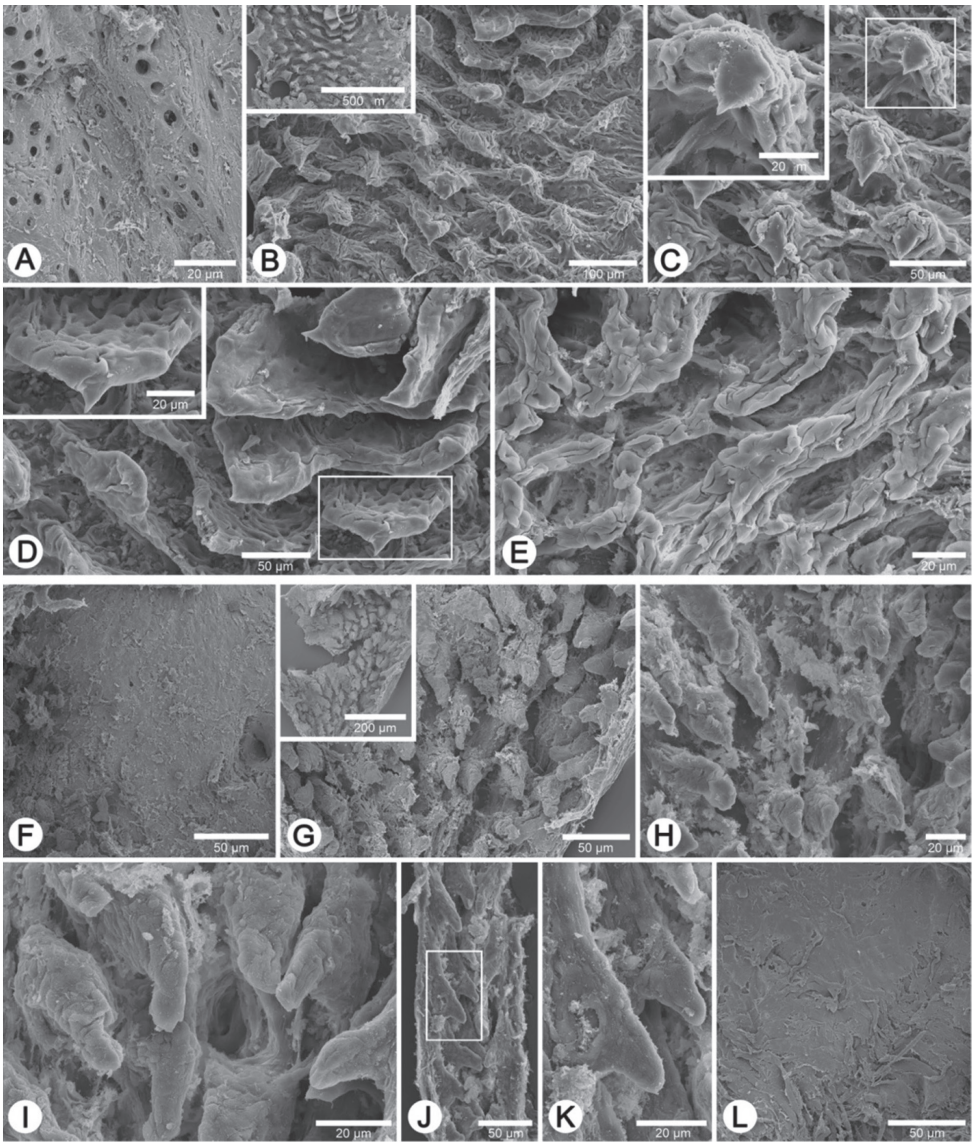

Figure 18. Internal sculpture of genitalia. **A–E** *Discartemon hypocrites*, topotype CUMZ 6199 **A** details of atrial pore on atrium surface **B** arrangement of penial hooks with high magnification, and (inset) shows in low magnification, **C** penial hooks with (inset) shows top view of the hook **D** penial hooks with (inset) shows lateral view of the hook, and **E** arrangement of vaginal folds **F–L** *Discartemon leptoglyphus* CUMZ 6007, from Ipoh, Perak, Malaysia **F** details of atrium surface **G** arrangement of penial hooks with (inset) low magnification **H** high magnification of penial hooks **I** top view of penial hook **J** low magnification shows lateral view of penial hooks **K** high magnification shows lateral view of penial hooks, and **L** details of vaginal surface.

(9 shells), 6233 (3 specimens in ethanol), NHMUK 20130681 (2 shells), and SMF (2 shells) from the type locality.

Type locality. Nam Tok Tao Thong, Tub Pud, Phangnga, Thailand, 8°29'0.8"N, 98°35'4.8"E.

Other material examined. Wat Tam Seua, Krabi: CUMZ 6029. Ban Chong, Krabi: CUMZ 6030. Wat Sathit Khirirom, Khirirat Nikhom, Suratthani: CUMZ 6234 (1 specimen in ethanol). Tam Wang Badan, Suratthani: CUMZ 6235 (2 specimens in ethanol).

Diagnosis. This species differs from *D. lemyrei* in its widely open umbilicus and apertural dentition of six lamellae. It differs from *D. roebeleni* in having a much larger shell, higher spire, upper palatal and supracolumellar lamellae, a very long penis, penial sheath and free oviduct, shorter seminal vesicle, and in having atrial pores. *Discartemon megalostraka* sp. n. can be distinguished from *D. stenostomus* in its larger shell, higher spire, transverse ridges, sub-quadrangular aperture, its straight parietal lamella, and in having upper palatal and basal lamellae.

Description. Shell. Shell globose-heliciform, white and translucent; whorls 7–7½, spire elevated conical, with a distinct suture. Shell surface glossy with fine transverse ridges that diminish below periphery; varices present. Embryonic shell large, about 2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl rounded and regularly expanded; umbilicus widely open and deep. Aperture sub-quadrangular; peristome discontinuous, thickened, expanded and reflected. Apertural dentition of one strong parietal, one small upper palatal, one palatal, one basal, one columellar and one small supracolumellar lamella (Fig. 10A).

Radula. Each row consists of 19–21 teeth with formula (9-10)-1-(9-10). The central tooth is small and triangular with a pointed cusp. Lateral and marginal teeth are undifferentiated and large, unicuspid and lanceolate. Latero-marginal teeth gradually reduce in size, with outermost teeth much smaller and shorter than inner teeth (Fig. 22G).

Genital organs. Atrium (at) very short. Penis (p) very long and slender. Penial sheath (ps) thin, extending about third-fourths of penis length. Penial sheath retractor muscle (psr) very thin, originating at genital orifice wall and inserting distally on penial sheath (Fig. 16A). Vas deferens (vd) passes a very short distance through penial sheath before entering into penis distally (Fig. 16B). Penial retractor muscle (pr) thin and long, inserting at penis and vas deferens junction.

Internal wall of atrium with large atrial pores (Fig. 21A). Penial wall with scattered and transparent penial hooks, about 9 hooks/200 μm^2 (Fig. 21B). Hooks located on penial wall. Penial hooks small (<0.02 mm in length), expanded at base, tips pointed and curved towards genital orifice (Fig. 21C–E).

Vagina (v) very short. Gametolytic duct (gd) a long and narrow tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) extremely long, proximal part a straight cylindrical tube, distal part corrugated. Oviduct (ov) enlarged and folded; prostate gland inconspicuous. Talon (ta) small, very short and club shaped. Hermaphroditic duct (hd) bearing a long seminal vesicle (sv) about four times as long as the length from talon to branching point of seminal vesicle (Fig. 16C).

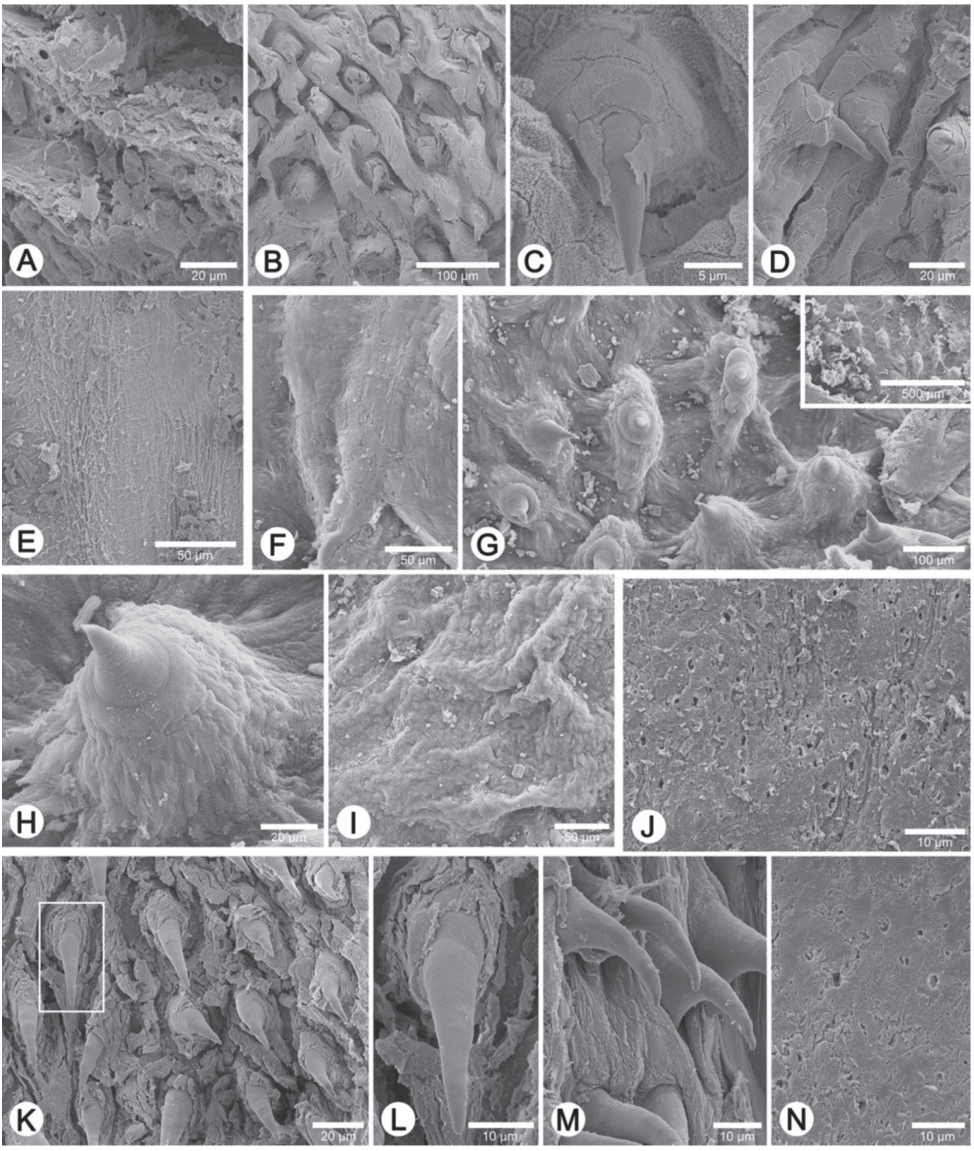

Figure 19. Internal sculpture of genitalia. **A–E** *Discartemon afthonodontia* sp. n. paratype CUMZ 6210 **A** details of atrial pore on the atrium surface **B** high magnification shows arrangement of penial hooks **C** top view of penial hook **D** lateral view of penial hook, and **E** details of vaginal surface **F–I** *Discartemon epipedis* sp. n. paratype CUMZ 6215 **F** details of the atrium surface **G** scattered arrangement of penial hooks with high magnification, and (inset) shows in low magnification **H** top view of penial hook, and **I** details of vaginal surface **J–N** *Discartemon flavacandida* sp. n. paratype CUMZ 6216 **J** details of atrial pore on the atrium surface **K** high magnification shows arrangement of penial hooks with top view of penial hook in white square **L** top view of penial hook (from white square in **K**) **M** lateral view of penial hook, and **N** details of vaginal surface.

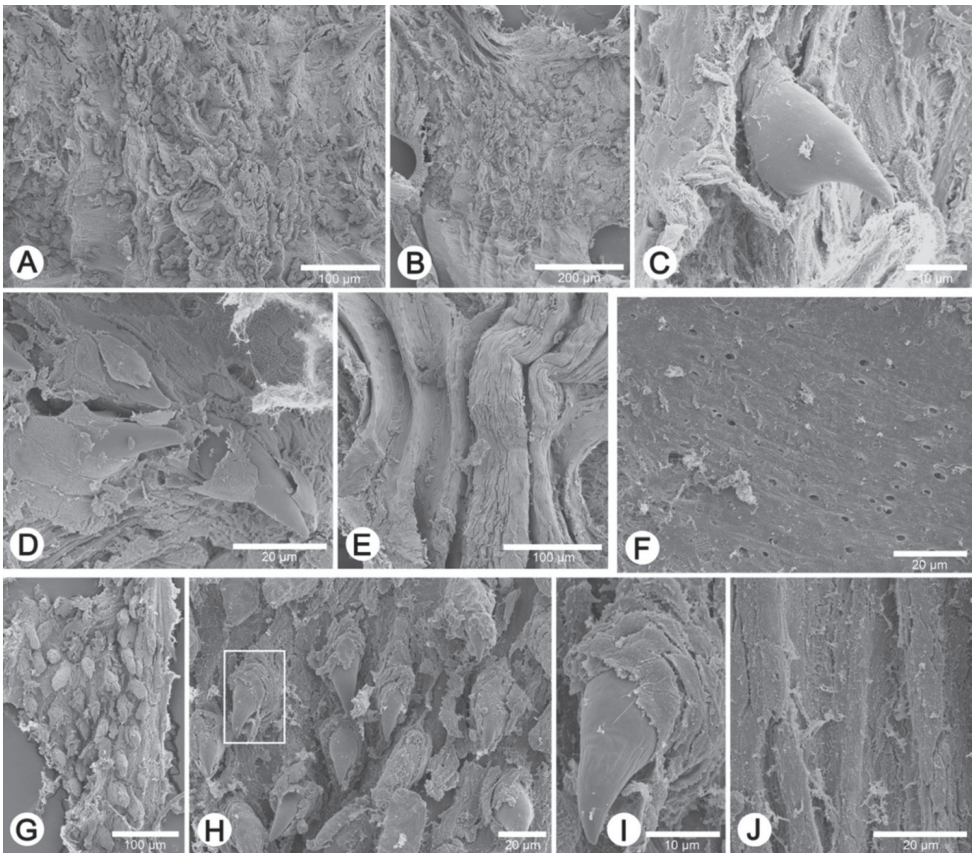

Figure 20. Internal sculpture of genitalia. **A–E** *Discartemon roebeleni* topotype CUMZ 6217 **A** details of atrium surface **B** low magnification shows arrangement of penial hooks **C** lateral view of penial hook **D** top view of penial hook, and **E** arrangement of vaginal folds **F–J** *Discartemon kotanensis* sp. n. paratype CUMZ 6230 **F** details of atrial pore on the atrium surface **G** low magnification shows arrangement of penial hooks **H** high magnification of penial hooks with top view of penial hook in white square **I** top view of penial hook (from white square in **H**), and **J** arrangement of vaginal folds.

Vaginal wall with longitudinal vaginal folds (Fig. 21F).

Etymology. The specific epithet "*megalostraka*" is derived from the Greek "*megalos*" meaning "big" and "*ostrako*" meaning "shell".

Distribution. This species is known from several limestone hills in southern Thailand, particularly in the western part of the southern mainland. The animals can be found at altitudes up to 20 meters amsl.

Remarks. The genital system discriminates this new species from large individuals of *D. roebeleni*, which is distributed throughout southern Thailand.

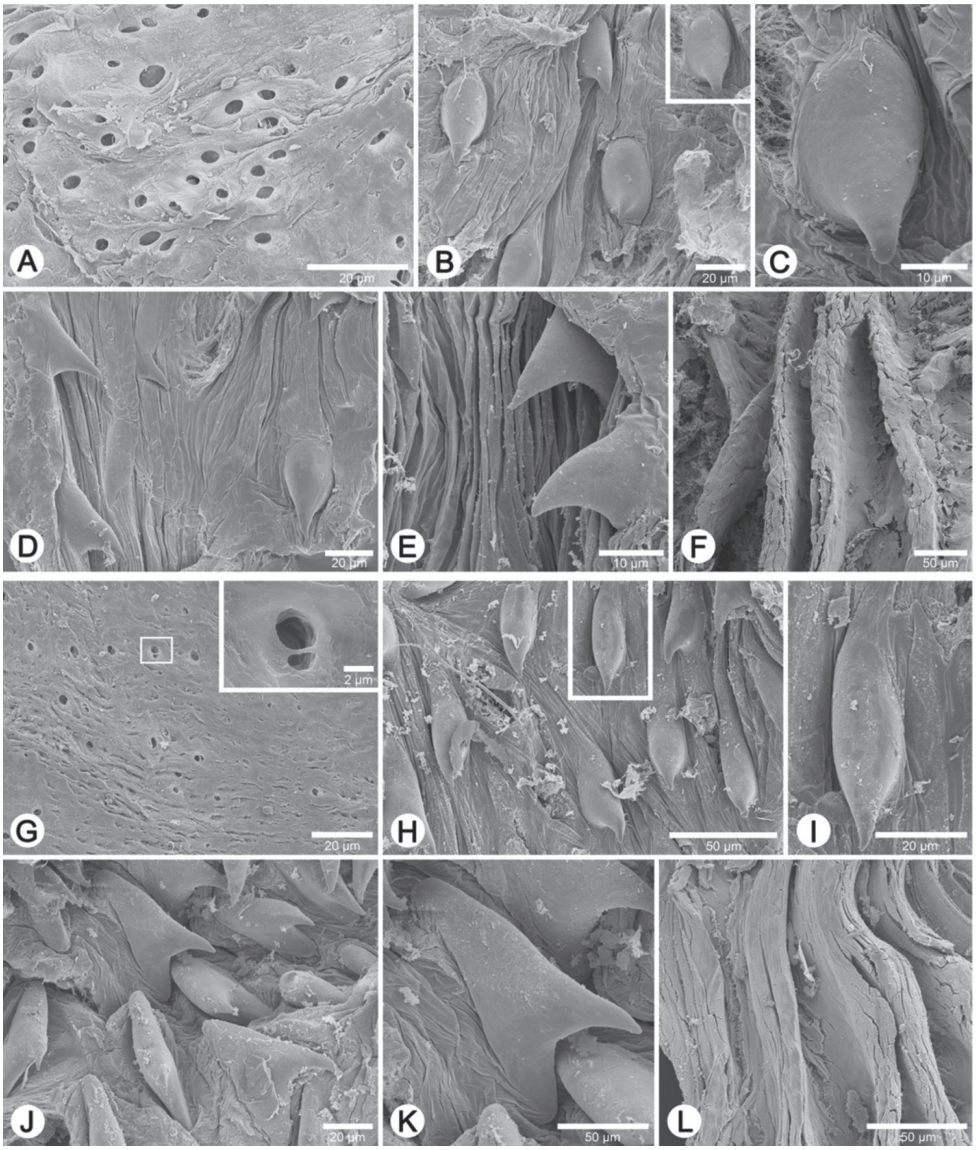

Figure 21. Internal sculpture of genitalia. **A–F** *Discartemon megalostraka* sp. n. paratype CUMZ 6233 **A** details of atrial pore on the atrium surface **B** high magnification of penial hooks with top view of penial hook in white square **C** top view of penial hook (from white square in **B**) **D** low magnification shows arrangement of penial hooks **E** lateral view of penial hook, and **F** arrangement of vaginal folds **G–L** *Discartemon triancus* sp. n. paratype CUMZ 6236 **G** details of atrial pore on the atrium surface with (inset) high magnification of atrial pore **H** high magnification of penial hooks with top view of penial hook in white square, **I** top view of penial hook (from white square in **H**) **J** arrangement of penial hooks **K** lateral view of penial hooks, and **L** arrangement of vaginal folds.

26. *Discartemon triancus* Siriboon & Panha, sp. n.
http://zoobank.org/B067FBAC-0911-44A2-9949-D8C3DDDA2397
http://species-id.net/wiki/Discartemon_triancus
Figs 3F, 10C, D, 16D–F, 21G–L, 22H, 23, Table 3

Type material. Holotype CUMZ 6254 (Fig. 10C). Measurement: shell height 4.6 mm, shell width 7.3 mm, and with 6 whorls. Paratypes: CUMZ 6032 (2 shells), 6236 (6 specimens in ethanol), and NHMUK 20130682 (2 shells) from the type locality.

Type locality. Gunung Kilian, Perlis, Malaysia, 6°34'8.0"N, 100°11'44.4"E.

Diagnosis. This new species is superficially similar to *D. roebeleni* and *D. kotanensis* sp. n., but the distinguishing characters are the smaller shell, lower spire, angular last whorl, very long penis and free oviduct, short seminal vesicle, and penial hooks with elongated bases. *Discartemon triancus* sp. n. can be distinguished from *D. megalostraka* sp. n. by having a smaller shell, lower spire, four apertural lamellae, a longer penis, short free oviduct, and slender penial hooks with elongated bases. *Discartemon triancus* sp. n. differs from *D. conicus* sp. n. in having a lower spire with shallow suture, transverse ridges, in lacking a sinulus, and in having four apertural lamellae.

Description. Shell. Shell globose-heliciform, white and translucent; whorls 5½–6, spire only slightly convex, with distinct suture. Shell surface glossy with transverse ridges that diminish below the periphery; varices present. Embryonic shell large, about 2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl angular, regularly expanded; umbilicus widely open and deep. Aperture subcircular; peristome discontinuous, thin and expanded. Apertural dentition of one parietal, one palatal, one small basal and one columellar lamella (Fig. 10C).

Radula. Each row consists of 27–43 teeth with formula (13-21)-1-(13-21). The central tooth is very small with pointed cusp. Lateral and marginal teeth are undifferentiated, unicuspid and lanceolate. Latero-marginal teeth gradually reduce in size, with outermost teeth much smaller and shorter than inner teeth (Fig. 22H).

Genital organs. Atrium (at) very short. Penis (p) extremely thin, long; becoming enlarged distally. Penial sheath (ps) thin, extending about half of penis length. Penial sheath retractor muscle very thin (psr), originating at atrium and inserting distally on penial sheath (Fig. 16D). Vas deferens (vd) passes a very short distance through penial sheath before entering into penis distally (Fig. 16E). Penial retractor muscle (pr) thin and very long, inserting at penis and vas deferens junction.

Internal wall of atrium generally smooth with pores (Fig. 21G). Penial wall with scattered and transparent penial hooks, about 11 hooks/200 μm^2 (Fig. 21H). Hooks located on penial wall. Penial hooks small (<0.04 mm in length), short, with strongly elongated bases, tips pointed, and curved towards genital orifice (Fig. 21I–K).

Vagina (v) short. Gametolytic duct (gd) a long and slender tube extending as far as albumin gland; gametolytic sac (gs) ovate. Free oviduct (fo) with almost same diameter as vagina and about twice as long as vagina. Oviduct (ov) enlarged and folded; prostate gland inconspicuous. Talon (ta) small, short and slender. Hermaphroditic duct (hd)

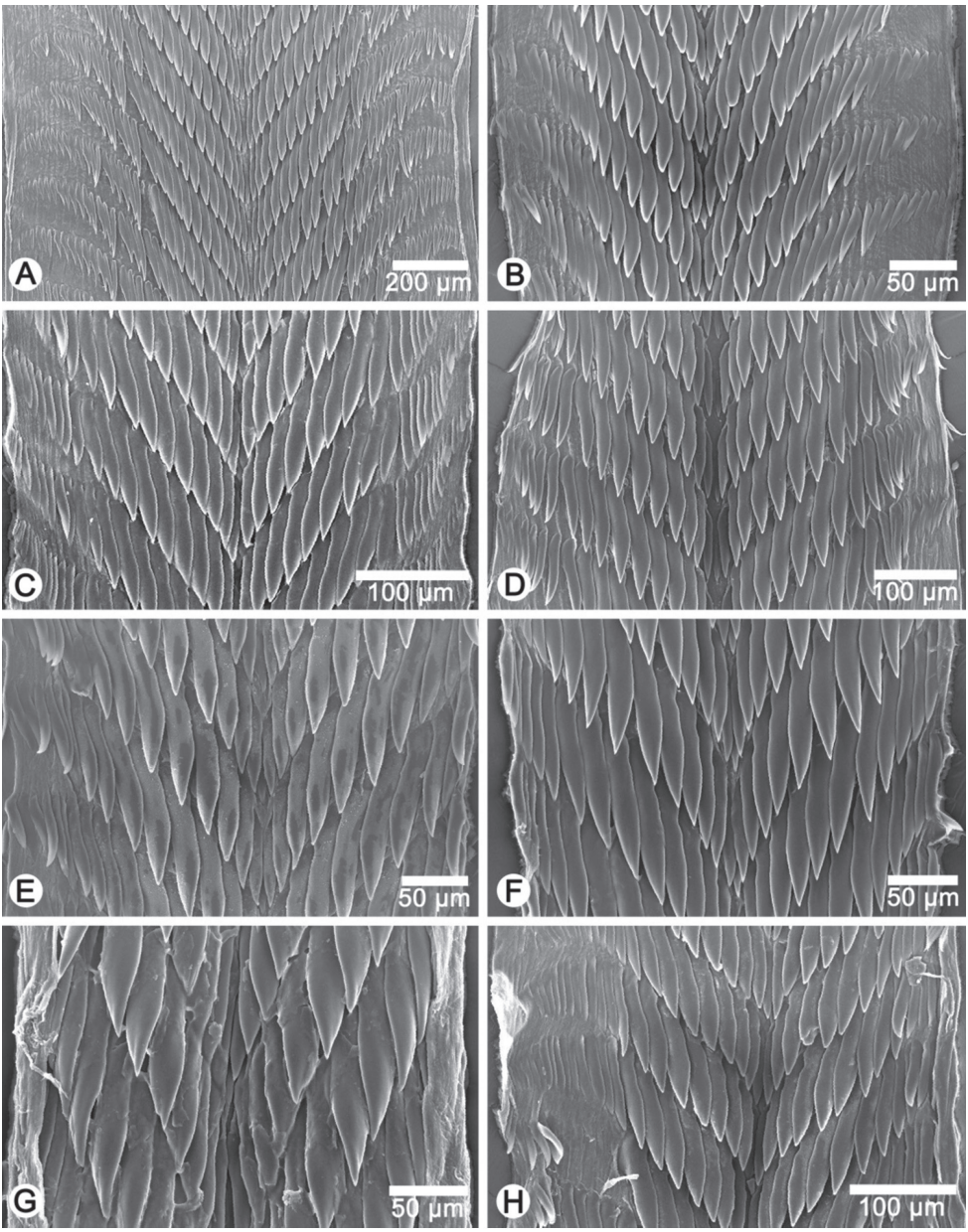

Figure 22. Radula morphology of **A** *Discartemon discus* CUMZ 6257, from Da Nang, Vietnam **B** *Discartemon nummus* CUMZ 6208, from Patthalung **C** *Discartemon hypocrites*, topotype CUMZ 6199 **D** *Discartemon afthonodontia* sp. n., paratype CUMZ 6210 **E** *Discartemon roebeleni*, topotype CUMZ 6217 **F** *Discartemon kotanensis* sp. n. paratype CUMZ 6230 **G** *Discartemon megalostraka* sp. n. paratype CUMZ 6233 **H** *Discartemon triancus* sp. n. paratype CUMZ 6236.

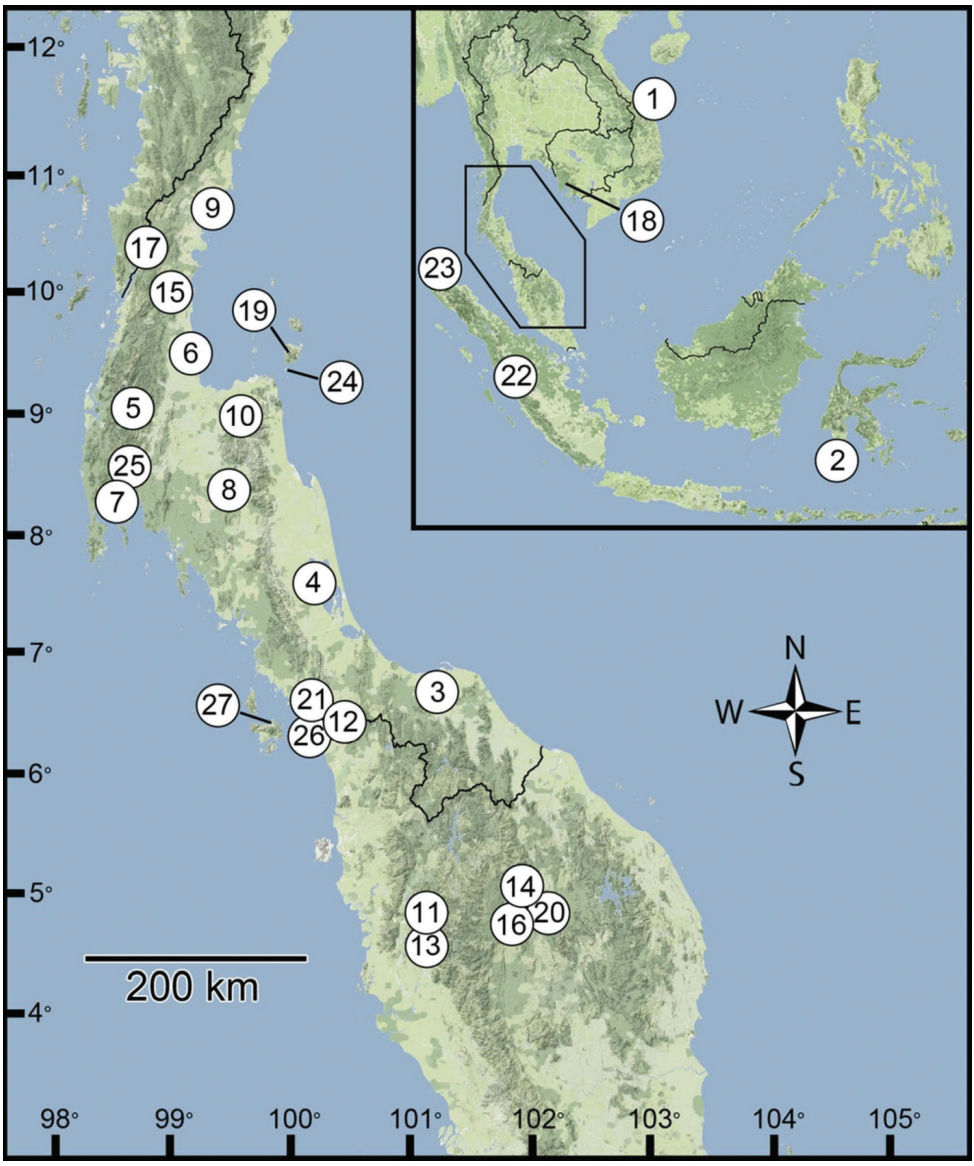

Figure 23. Approximate locations of the type locality of *Discartemon* species. (1) *D. discus*, (2) *D. planus*, (3) *D. sykesi*, (4) *D. nummus*, (5) *D. khaosokensis*, (6) *D. discadentus* sp. n., (7) *D. discamaximus* sp. n., (8) *D. circulus* sp. n., (9) *D. deprima* sp. n., (10) *D. expandus* sp. n., (11) *D. plussensis*, (12) *D. hypocrites*, (13) *D. leptoglyphus*, (14) *D. platymorphus*, (15) *D. afthonodontia* sp. n., (16) *D. epipedis* sp. n., (17) *D. flavacandida* sp. n., (18) *D. lemyrei*, (19) *D. roebeleni*, (20) *D. collingei*, (21) *D. stenostomus*, (22) *D. sangkarensis*, (23) *D. vandermeermohri*, (24) *D. kotanensis* sp. n., (25) *D. megalostraka* sp. n., (26) *D. triancus* sp. n., and (27) *D. conicus* sp. n.

bearing a short seminal vesicle (sv) nearly equal to the length from talon to branching point of seminal vesicle (Fig. 16F).

Vaginal wall with longitudinal vaginal folds (Fig. 21L).

Etymology. The specific epithet "*triancus*" is derived from the Latin "*triangulum*" meaning "triangle" and "*uncus*" meaning "hook".

Distribution. Known only from the type locality.

Remarks. Material from Gunung Kilian, Perlis, Malaysia was firstly identified as *D. roebeleni* (Möllendorff, 1894) by Benthem Jutting (1954), without any anatomical comparison. However, clear anatomical differences between this new species and *D. roebeleni*, so it is considered a new species.

27. *Discartemon conicus* Siriboon & Panha, sp. n.

http://zoobank.org/AE61F42F-34C8-4A3E-8825-1730EFAA23FA
http://species-id.net/wiki/Discartemon_conicus
Figs 10E, F, 23, Table 3

Type material. Holotype CUMZ 6255 (Fig. 10E). Measurement: shell height 4.5 mm, shell width 7.2 mm, and with 6 whorls. Paratypes: CUMZ 6033 (2 shells) from the type locality.

Type locality. Gau Cerita, Langawi, Malaysia, 6°27'21.8"N, 99°49'29.8"E.

Diagnosis. This species differs from *D. roebeleni*, *D. sangkarensis*, *D. vandermeermohri* and *D. kotanensis* sp. n., in having a smaller shell, higher spire, a nearly smooth shell surface, an angular last whorl, a sub-quadrangular aperture with a sinulus, and in having only one parietal lamella.

Description. Shell. Shell globose-heliciform, white and translucent; whorls 6, spire elevated conical, with distinct suture. Shell surface glossy, smooth with thin transverse ridges near aperture; varices present. Embryonic shell large, about 2½ whorls, with a smooth surface; following whorls regularly coiled. Last whorl angular, inflated and regularly expanded. Umbilicus open and deep. Aperture sub-quadrangular with sinulus; peristome discontinuous, expanded and reflected. Apertural dentition of only one parietal lamella (Fig. 10E).

Distribution. Known only from the type locality among limestone karsts up to 100 meters amsl, surrounded by mangrove forests on the northeast Langkawi Island coastline.

Remarks. The new species is apparently rare and extensive searching yielded only three examples.

Discussion

Systematics

All species of *Discartemon* whose genital anatomy is known have a penial sheath through which the vas deferens passes for a short distance. This is typical of many streptaxid genera included in the subfamilies Streptaxinae Gray, 1860 and Gibbinae

Steenberg, 1936 by Schileyko (2000). In contrast a penial appendix is a much less common feature and does not occur in any of these genera as treated by Schileyko (2000), although he did not cite Berry's (1965) study of *D. stenostomus*.

The species of *Discartemon* vary in whether an appendix is present and in other respects that correspond only approximately to the subdivision of the genus into three groups based on shell morphology. The groupings are as follows. Group I: *D. discus*-group have a short to long, slender penis and transparent penial hooks. The genitalia of Group II: *D. plussensis*-group have a short penis generally with a penial appendix, and transparent to brown penial hooks. A stout seminal vesicle may be present, and the gametolytic duct is usually enlarged and stout at the base. Group III: *D. roebeleni*-group have a short to very long penis, sometimes with a blunt appendix, penial hooks are transparent, short, and expanded at the base. In one case *D. stenostomus*, no penial hooks are present but a stylet is. The latter is the only *Discartemon* species whose genital anatomy was known prior to this study. Although its shell is not unusual for the genus, the species is apparently atypical in having a hollow stylet in the apex of the penis, which was not noted in other species. The function of the appendix and stylet are not known.

Genital anatomy does appear to be useful in the characterization and diagnosis of species-group taxa, however, particularly in the *D. plussensis*-group.

Biogeography

The distributional range of this genus is more extensive than previously known. Twenty-two of the species recorded in this study occur in the area from Isthmus of Kra to the western part of Malaysia including the Lankawi Islands. The other five species can be found in other limestone areas; Cambodia, central Vietnam, Sumatra and Sulawesi.

The genus apparently usually occurs in limestone habitats such as karst islands, isolated limestone hills and limestone mountains. Many Southeast Asian mollusks are restricted to such areas which are often threatened (Tweedie 1961; Clements et al. 2006). Furthermore many of the species here have very restricted distributions. Most are allopatric and a number appear to be endemic to single limestone hills. Others range throughout a limestone complex.

Three syntopic occurrences where one of the few common and widespread species, *D. roebeleni,* occurs near restricted endemics were observed in this study. These were *D. nummus*, *D. circulus* sp. n., and *D. deprima* sp. n. at Khao Ok Thalu, Phatthalung, Khao Pu-Khao Ya National Park, Patthalung, and Tam Phannara, Nakhon Si Thammarat respectively, all in southern Thailand.

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