รายงานวิจัยฉบับสมบูรณ์

โครงการ สายวิวัฒนาการเชิงภูมิศาสตร์และซิสเทมาติกส์ของหอยงวงท่อสกุล *Rhiostoma* ในประเทศไทย

Phylogeography and Systematics of Snorkel Snail Genus *Rhiostoma* in Thailand

โดย ดร. ปิโยรส ทองเกิด

สิงหาคม 2553

สัญญาเลขที่ MRG4980202

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สนับสนุนโดยสำนักงานกองทุนสนับสนุนการวิจัย

กิตติกรรมประกาศ

ผู้วิจัยขอขอบพระคุณ ศ. ดร. สมศักดิ์ ปัญหา ที่ให้คำปรึกษา ชี้แนะแนวทางในการวิจัย และให้กำลังใจในการดำเนินการวิจัยแม้ว่าจะมีอุปสรรคต่างๆ ทำให้สามารถทำวิจัยต่อไปได้อย่างเข้มแข็ง ขอขอบคุณผู้ร่วมวิจัย ดร. จิรศักดิ์ สุจริต ดร. ผ่องพรรณ ประสารกก ดร. บังอรกองอิ้ม ดร. นนทิวิชญ์ ดัณฑวณิช และ Dr. Fred Naggs ขอบคุณนิสิตปริญญาโท-เอก ใน Animal Systematics Research Unit ที่ช่วยกันเก็บตัวอย่างและช่วยเหลืองานต่างๆในแลป ขอบคุณพิพิธภัณฑ์ธรรมชาติวิทยาจากหลายแห่ง (Natural History Museum, London, UK; National Museum of Wales, UK; Paris Museum of Natural History, France; Museum of Zoology, University of Copenhagen, Denmark; Senckenberg Natural History Museum, Frankfurt, German) ที่ให้เข้าไปเทียบตัวอย่างต้นแบบและยืมตัวอย่างมาศึกษา และขอขอบคุณทุนส่งเสริมนักวิจัยรุ่นใหม่-อาจารย์รุ่นใหม่ สกว. ที่ให้ทุนสนับสนุนงานวิจัยนี้

บทคัดย่อ

รหัสโครงการ: MRG4980202

ชื่อโครงการ: สายวิวัฒนาการเชิงภูมิศาสตร์และซิสเทมาติกส์ของหอยงวงท่อสกุล *Rhiostoma* ในประเทศไทย

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ระยะเวลาโครงการ: 2 ปี

หอยทากมีฝาปิดเปลือกสกุล *Rhiostoma* เป็นทรัพยากรหอยทากบกพบอยู่ในถิ่นอาศัยจำเพาะของเขตร้อนแถบเอเชียตะวันออกเฉียงใต้ และมาเลเซียเพนนินซูลา ลักษณะสำคัญที่แสดงให้เห็นถึงชื่อสามัญว่าหอยงวงท่อก็คือมีท่อหายใจบริเวณเปลือกวงสุดท้าย การศึกษาทางด้านอนุกรมวิธานของหอยกลุ่มนี้นั้นเริ่มขึ้นตั้งแต่ต้นศตวรรตที่ 19 พบว่ามีการกำหนดชื่อวิทยาศาสตร์โดยใช้ลักษณะเปลือกแต่เพียงอย่างเดียวจำนวน 25 ชนิด ทั่วการกระจายของหอยสกุลนี้ จากการเทียบตัวอย่างกับตัวอย่างต้นแบบในพิพิธภัณฑ์หลายแห่งพบว่าในประเทศไทยมีหอยงวงท่อที่ถูกกำหนดชื่อไว้แล้ว 15 ชนิด และพบเป็นชนิดใหม่อีก 5 ชนิด การศึกษาในระดับประชากรที่มีการกระจายกว้างด้วย allozyme ของ *R. housei* พบความแตกต่างทางพันธุกรรมที่เกิดขึ้นระหว่างประชากรในระดับสูง สอดคล้องกับข้อมูลการวิเคราะห์ด้วยไมโตคอนเดรียดีเอ็นเอเบื้องต้น และทำให้ทราบว่ามีอย่างน้อย 2 ประชากรที่มีแนวโน้มที่จะแยกชนิดกัน ส่วนการศึกษาในระดับโครโมโซมพบว่าหอยสกุล *Rhiostoma* มีจำนวน diploid และ haploid โครโมโซมเท่ากับหอยหอมซึ่งเป็นหอยชนิดเด่นของประเทศไทยสกุล *Cyclophorus* ซึ่งเป็นกลุ่มหอยทากบกที่มีฝาปิดเปลือกเช่นเดียวกัน อย่างไรก็ตามโครโมโซมของ *Rhiostoma* ก็มีความแตกต่างออกไปในเรื่องของตำแหน่งของ centromere ที่เป็น telocentric และ acrocentric โครโมโซม จึงทำให้ข้อมูลโครโมโซมสามารถนำมาใช้ในการจัดจำแนกชนิดของหอยสกุลนี้ได้อีกด้วย

คำหลัก: สายวิวัฒนาการเชิงภูมิศาสตร์, ซิสเทมาติกส์, หอยงวงท่อ

Abstract

Project Code: MRG4980202

Project Title: Phylogeography and Systematics of Snorkel Snail Genus *Rhiostoma* in Thailand

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Project Period: 2 year

The land operculate cyclophorid snail genus *Rhiostoma* Benson, 1860 is endemic to Indochina and the Malay Peninsula region. The peculiar appearance of the external breathing tube extending from the final whorl of the shell has given rise to its common name of 'snorkel snail'. These snails have received little attention beyond the original, largely nineteenth century, descriptions of about 25 species that were based purely on shell characters. After a critical study of type specimens and other reference collections from many museums and examination of recently collected specimens, we recognise 15 previously described species as valid and propose 5 new species. In addition, a large genetic distances value from allozyme variation analysis that is also supported by mt DNA analysis, may represent at least two distinct species within the current concept of *R. housei*.

Karyotypic analysis showed that *Rhiostoma* exhibits similar diploid and haploid numbers to the well-known cyclophorid genus *Cyclophorus* Montfort, 1810. However, *Rhiostoma* karyotypes exhibit differences in the appearance of telocentric and acrocentric chromosomes.

Keywords: Phylogeography, Systematics, *Rhiostoma*

บทนำ

หอยทากมีฝาปิดเปลือก (land operculate snails) เป็นทรัพยากรหอยทากบกที่พบอยู่ในถิ่นอาศัยที่กว้างขวางจำเพาะของเอเชีย ตั้งแต่เขตร้อนแถบเอเชียตะวันออกเฉียงใต้ ไปจนถึงเขตกึ่งร้อนในแถบญี่ปุ่น จีน ไปจนถึงเขตมรสุมเช่นฟิลิปปินส์ (Benthem Jutting, 1948; 1949; สมศักดิ์ ปัญหา และคณะ, 2546) หลายท้องที่ถือว่าเป็นดัชนีของภูเขา บางครั้งเรียก หอยภูเขา (mountain snails) กลุ่มที่ถือว่าเป็นหลักคือหอยวงศ์หอยหอม Family Cyclophoridae จัดว่าเป็นวงศ์หอยที่ใหญ่ที่สุดในบรรดาหอยมีฝาปิดเปลือกทั้งหมด พบทั้งในทวีปเอเชีย อาฟริกา ออสเตรเลีย ตลอดจนอเมริกาเหนือ (Morrison, 1955; Alcalde & Jacobson, 1959; Thompson, 1969; Burch, 1976) ปัจจุบันมีรายงานการพบหอยวงศ์นี้มากกว่า 600 สปีชีส์ มีสกุลใหญ่ ๆ อยู่หลายสกุล เช่น หอยหอม *Cyclophorus* หอยงวงท่อ *Rhiostoma* ฯลฯ หอยงวงท่อสกุล *Rhiostoma* ก็ถือได้ว่าเป็นหอยบกที่แสดงลักษณะมหัศจรรย์ทางวิวัฒนาการ ด้วยโครงสร้างทางสัณฐานวิทยาที่มีความจำเพาะตัว และมีพื้นที่การแพร่กระจายค่อนข้างจำกัด ในภาวะที่ป่าไม้ถูกทำลาย มีผลโดยตรงต่อการทำลายถิ่นที่อยู่อาศัย หอยงวงท่อจะอาศัยใต้ซากทับถมคล้ายกับหอยหอม แต่ทั้งหอยหอมและหอยงวงท่อ ต่างก็เป็นรอยต่อระหว่างหอยฝาเดียวน้ำจืดและหอยทากบก ถือว่าเป็นหอยเด่นในบริเวณซากทับถมในเขตเขาหินปูน หรือบริเวณพื้นที่ที่มีคาร์บอเนดเช่นพื้นที่ป่าละเมาะที่มีสารปูน ในประเทศไทยมีรายงานการพบหอยในพื้นที่ต่าง ๆ มามากกว่า 100 ปี (Moellendorff, 1894; Blandford, 1903; Gude, 1921; Habe, 1964; Solem, 1966 และ Abbott, 1989) การจำแนกหอยนั้นใช้ลักษณะสัณฐานวิทยาของเปลือก เช่นรูปทรง และลวดลาย ทำให้จำแนกหอยงวงท่อได้ 6 สปีชีส์ (Tumpeesuwan & Panha, 2003) การอาศัยอยู่ในซากทับถมทำให้มองเห็นการตัดขาดของประชากรในแต่ละพื้นที่อย่างเด่นชัด แต่เนื่องจากหอยกลุ่มนี้เป็นที่นิยมบริโภคของสัตว์ผู้ล่าหลากหลายชนิด เช่นสัตว์เลื้อยคลาน นก สัตว์เลี้ยงลูกด้วยน้ำนม โดยเฉพาะสัตว์ฟันแทะ และมนุษย์ ผู้ล่าดังกล่าวอาจเป็นตัวการพาสัตว์ในแต่ละพื้นที่ไปพบกันแล้วทำให้เกิดการแลกเปลี่ยนของยีนมาตั้งแต่อดีต การใช้สัณฐานวิทยาของเปลือกและอวัยวะภายใน จะไม่สามารถตอบคำถามในเรื่องขอบเขตที่ชัดเจนของสปีชีส์ ตามนิยามของ Phylogeographic species และความสัมพันธ์ทางวิวัฒนาการได้อย่างชัดเจน การวิจัยครั้งนี้จึงมุ่งเน้นการวิเคราะห์ในเชิงความสัมพันธ์ทางวิวัฒนาการโดยใช้อัลโลไซม์และดีเอ็นเอ ของหอยงวงท่อสกุล *Rhiostoma* แล้ววิเคราะห์สายสัมพันธ์ทางวิวัฒนาการเชิงภูมิศาสตร์ ผลการวิเคราะห์จะมีประโยชน์เป็นอย่างมากต่อการอนุรักษ์สายพันธุ์ และองค์ความรู้ทางวิวัฒนาการ เนื่องจากหอยในวงศ์ Cyclophoridae สกุล *Rhiostoma* แทบไม่มีการศึกษาในแง่มุมอื่น ๆ มาก่อนเลย หลังจากมีรายงานในเชิงอนุกรมวิธานพื้นฐานของเปลือกมาแล้ว

วิธีการทดลอง

1. การดำเนินงานในภาคสนาม
   1.1 ทำการเก็บตัวอย่างหอยงวงท่อจากพื้นที่เขาหินปูน และเขาอื่น ๆ ทั่วไป และเกาะต่าง ๆ ทั่วประเทศ
   1.2 เก็บรักษาตัวอย่างหอยที่ใช้ศึกษาทางกายวิภาคศาสตร์และสัณฐานวิทยาใน 70% เอทานอล และที่ใช้ศึกษาในเชิงพันธุศาสตร์โมเลกุลใน Freezer -80 °C และ -20 °C เปรียบเทียบโดยวิธี Allozyme Electrophoresis และวิเคราะห์ดีเอ็นเอ
2. การศึกษาตัวอย่างต้นแบบ (Type specimens) และตัวอย่างอ้างอิง (Reference specimens) เพื่อเปรียบเทียบให้ได้ชื่อวิทยาศาสตร์ที่ถูกต้อง

   ศึกษาตัวอย่างต้นแบบ และตัวอย่างอ้างอิงโดยเฉพาะสปีชีส์ของไทยและพื้นที่ใกล้เคียง มีรายละเอียดดังนี้
   - ทำการถ่ายภาพตัวอย่างทั้งหมด
   - จดรายละเอียดของข้อมูลประกอบตัวอย่างเช่น พื้นที่ที่เก็บตัวอย่าง (locality) พิกัดทางภูมิศาสตร์ (ถ้ามี) ลักษณะถิ่นที่อยู่อาศัย ข้อมูลทางเศรษฐกิจ เช่นการบริโภค และการจำหน่ายเป็นสินค้า ข้อมูลทางสาธารณสุข เช่น การเป็นโฮสท์ให้กับปรสิตประเภทใด
   - นับจำนวน และวัดตัวอย่างทั้งขนาด และค่า shell height, length, width, diameter, thickness, aperture ฯ ลฯ ตามมาตรฐานงานวิจัยทางสังขวิทยา
3. การวิเคราะห์ในห้องปฏิบัติการ เช่น การศึกษาอวัยวะภายใน แรดูลา การวิเคราะห์โปรตีน (allozyme electrophoresis) และการวิเคราะห์สายวิวัฒนาการเชิงภูมิศาสตร์โดยใช้สารชีวโมเลกุล
   - ศึกษาทางกายวิภาค ถิ่นที่อยู่อาศัย และบริเวณพื้นที่ทางภูมิศาสตร์ของหอยแต่ละชนิดอย่างละเอียด
   - ศึกษาลักษณะอื่นเพิ่มเติม เช่น อวัยวะภายใน แรดูลา ศึกษาด้วยกล้อง SEM
   - การวิเคราะห์โปรตีน (allozyme electrophoresis)
   - การวิเคราะห์สายวิวัฒนาการเชิงภูมิศาสตร์โดยใช้สารชีวโมเลกุล

ผลการทดลอง

1. เก็บตัวอย่างหอยงวงท่อบริเวณภาคเหนือ ภาคกลาง ภาคตะวันออก ภาคตะวันออกเฉียงเหนือ ภาคตะวันตก และภาคใต้ ของประเทศไทย รวมถึงประเทศมาเลเซียรัฐ Perlis Perak Selangor และเกาะ Langkawi รวม 45 พื้นที่ ดังตารางที่ 1

ตารางที่ 1 แสดงพื้นที่เก็บตัวอย่างและชนิดของหอยงวงท่อที่ตรวจสอบและได้ทำการเทียบกับตัวอย่างต้นแบบ ณ พิพิธภัณฑ์สถานธรรมชาติในต่างประเทศแล้ว

ที่	สถานที่เก็บตัวอย่าง	ชนิดของหอยงวงท่อ
1	ถ้ำปลา, เชียงราย	*Rhiostoma* sp.1
2	ถ้ำผาจม, เชียงราย	*Rhiostoma* sp.1
3	อุทยานแห่งชาติดอยภูนาง, พะเยา	*Rhiostoma housei* (Haines, 1858)
4	เขาปฐวี, อุทัยธานี	*Rhiostoma pulchellus* (Morlet, 1889)
5	เขาน้อย, นครสวรรค์	*Rhiostoma* sp.2
6	ถ้ำเพชร ถ้ำทอง, ตาคลี, นครสวรรค์	*Rhiostoma housei* (Haines, 1858)
7	ถ้ำดาว เขาแก้ว, มวกเหล็ก, สระบุรี	*Rhiostoma housei* (Haines, 1858)
8	มวกเหล็ก, สระบุรี	*Rhiostoma housei* (Haines, 1858)
9	วัดเทพพิทักษ์, นครราชสีมา	*Rhiostoma housei* (Haines, 1858)
10	เขาลูกช้าง, นครราชสีมา	*Rhiostoma housei* (Haines, 1858)
11	สะแกย์ราช, นครราชสีมา	*Rhiostoma housei* (Haines, 1858)
12	ศูนย์เพาะพันธุ์สัตว์ป่าเขาเขียว, ชัยภูมิ	*Rhiostoma* sp.3
13	น้ำตกตรอกนอง, จันทบุรี	*Rhiostoma hainesi* Pfeiffer, 1862
14	ศูนย์เพาะพันธ์สัตว์ป่าเขาสอยดาว, จันทบุรี	*Rhiostoma hainesi* Pfeiffer, 1862
15	เขาสุกิม, ท่าใหม่, จันทบุรี	*Rhiostoma hainesi* Pfeiffer, 1862
16	น้ำตกมะกอก, จันทบุรี	*Rhiostoma hainesi* Pfeiffer, 1862
17	อุทยานแห่งชาติน้ำตกพลิ้ว, จันทบุรี	*Rhiostoma hainesi* Pfeiffer, 1862
18	เขาชะอางค์, บ่อทอง, ชลบุรี	*Rhiostoma pulchellus* (Morlet, 1889)
19	วัดพลวงทอง, ชลบุรี	*Rhiostoma pulchellus* (Morlet, 1889)
20	สำนักสงฆ์ เขาหินไผ่,แกลง, ระยอง	*Rhiostoma* sp.4
21	ถ้ำสีทอง, คลองหาด, สระแก้ว	*Rhiostoma* sp.4
22	วัดถ้ำเขาฉกรรจ์, สระแก้ว	*Rhiostoma* sp.4
23	วัดถ้ำเขาฉกรรจ์, สระแก้ว	*Rhiostoma cambojense* (Morelet, 1875)
24	วัดถ้ำเขาม้าร้อง, บางสะพาน, ประจวบคีรีขันธ์	*Rhiostoma housei* (Haines, 1858)
25	เขาล้อมหมวก, อ่าวมะนาว, ประจวบคีรีขันธ์	*Rhiostoma housei* (Haines, 1858)

26	ถ้ำพิสดาร, ประทิว, ชุมพร	*Rhiostoma housei* (Haines, 1858)
27	เขาพนมวัง, กาญจนดิษฐ์, สุราษฎร์ธานี	*Rhiostoma* sp.5
28	เขาช้าง, ดอนสัก, สุราษฎร์ธานี	*Rhiostoma chupingense* Tomlin, 1939
29	ถ้ำวังทอง, ขนอม, สุราษฎร์ธานี	*Rhiostoma chupingense* Tomlin, 1939
30	ถ้ำคีรีวงศ์, ปากแพรก, ดอนสัก, สุราษฎร์ธานี	*Rhiostoma chupingense* Tomlin, 1939
31	น้ำตกหินลาด, เกาะสมุย, สุราษฎร์ธานี	*Rhiostoma samuiense* Tomlin, 1932
32	น้ำตกหน้าเมือง, เกาะสมุย, สุราษฎร์ธานี	Rhiostoma samuiense Tomlin, 1932
33	เกาะแตน, สุราษฎร์ธานี	Rhiostoma samuiense Tomlin, 1932
34	เกาะสามเส้า, อุทยานแห่งชาติหมู่เกาะอ่างทอง, สุราษฎร์ธานี	*Rhiostoma asiphon* MÖellendorff, 1932
35	เกาะวัวตาหลับ, อุทยานแห่งชาติหมู่เกาะอ่างทอง, สุราษฎร์ธานี	*Rhiostoma asiphon* MÖellendorff, 1932
36	เขาห้วยแห้ง, ห้วยยอด, ตรัง	*Rhiostoma chupingense* Tomlin, 1939
37	เขาปู่ เขาย่า, พัทลุง	*Rhiostoma chupingense* Tomlin, 1939
38	น้ำตกเต่าทอง, พังงา	*Rhiostoma jalorensis* Sykes, 1903
39	วัดถ้ำสุวรรณคูหา, พังงา	*Rhiostoma jalorensis* Sykes, 1903
40	ถ้ำโกบ, ทับผุด, พังงา	*Rhiostoma jalorensis* Sykes, 1903
41	ถ้ำน้ำผุด, พังงา	*Rhiostoma jalorensis* Sykes, 1903
42	วัดถ้ำเสือ, กระบี่	*Rhiostoma jalorensis* Sykes, 1903
43	เขารูปช้าง, สะเดา, สงขลา	*Rhiostoma chupingense* Tomlin, 1939
44	Sungai Jenis, Perlis, มาเลเซีย	*Rhiostoma chupingense* Tomlin, 1939
45	Bhukit Chuping, Perlis, มาเลเซีย	*Rhiostoma chupingense* Tomlin, 1939

2. เทียบตัวอย่างกับตัวอย่างต้นแบบในพิพิธภัณฑ์ Natural History Museum (London), Natural History Museum of Wales, National Museum of Natural History (Paris) และ Senckenberg Museum of Natural History, Frakfurt โดยเดินทางไปเทียบตัวอย่างและยืมตัวอย่างจากพิพิธภัณฑ์ดังกล่าว พบว่ามีหอยงวงท่อจำนวน 15 ชนิด ดังต่อไปนี้

    1. *Rhiostoma asiphon*
    2. *Rhiostoma chupingense*
    3. *Rhiostoma hainesi*
    4. *Rhiostoma housei*
    5. *Rhiostoma jalorensis*
    6. *Rhiostoma pullceria*

7. *Rhiostoma samuiense*
8. *Rhiostoma cambojens*
9. Rhiostoma sp.1
10. Rhiostoma sp.2
11. Rhiostoma sp.3
12. Rhiostoma sp.4
13. Rhiostoma sp.5
14. Rhiostoma sp.6
15. Rhiostoma sp.7

3. ตรวจสอบเอกสารที่เกี่ยวข้อง ทั้งในเรื่องของอนุกรมวิธาน งานด้านอณูชีววิทยา และประวัติทางภูมิศาสตร์ของประเทศไทย ได้รวบรวมงานอนุกรมวิธานตั้งแต่อดีตถึงปัจจุบันที่มีการศึกษาในหอยกลุ่มนี้และกลุ่มใกล้เคียง

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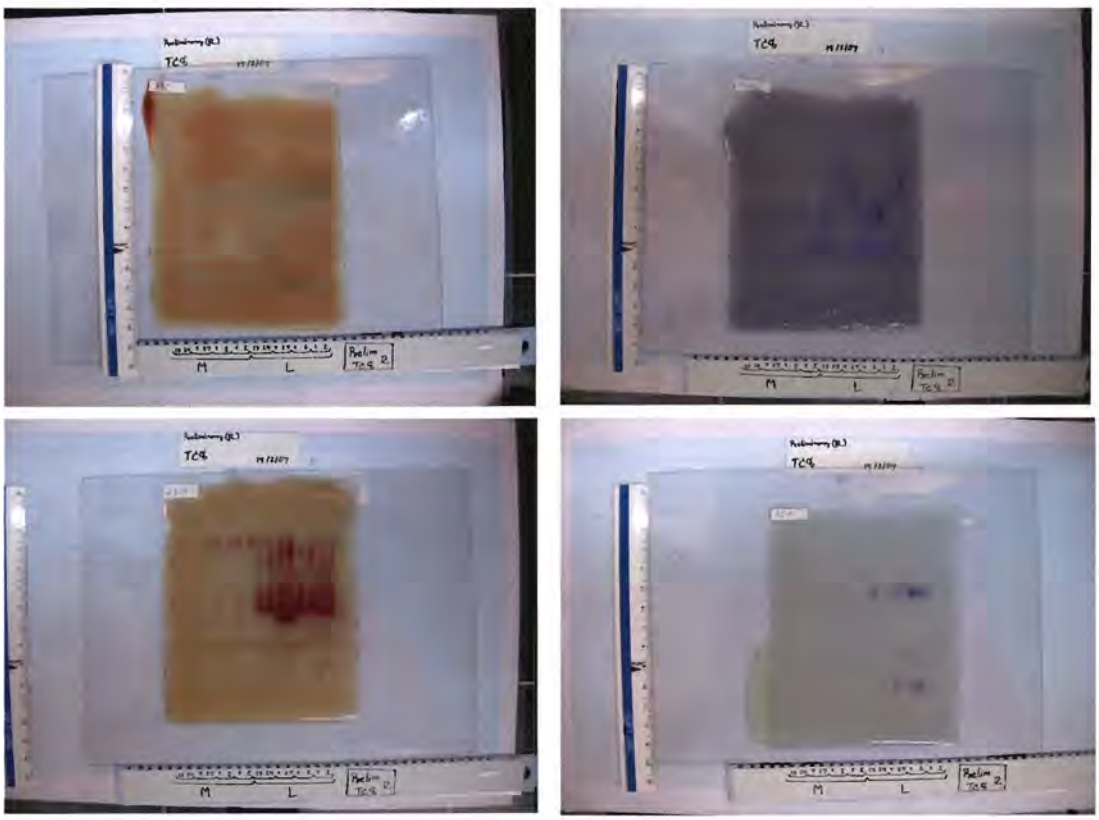
4. จัดเก็บตัวอย่างเข้าพิพิธภัณฑ์สถานธรรมชาติวิทยาแห่งจุฬาลงกรณ์มหาวิทยาลัย เป็นระบบฐานข้อมูลมาตรฐาน
5. แยกตัวอย่างที่ได้เป็นสองส่วน เก็บแช่แข็งที่อุณหภูมิ -20 องศาเซลเซียส เพื่อศึกษาอัลโลไซม์และเก็บใน 95% แอลกอฮอล์ เพื่อศึกษา DNA
6. สกัดดีเอ็นเอของตัวอย่างที่ได้ทั้งหมด และคัดเลือกตำแหน่งของยีนที่เหมาะสมในการศึกษาความสัมพันธ์ทางวิวัฒนาการ (Phylogeny) ใช้การสกัดโดยวิธี Phenol-Chloroform extraction แล้วคัดเลือกตำแหน่งของยีน cytochrome c oxidase subunit I (COI) ที่ทำการศึกษาโดยวิธี PCR โดยใช้ Universal primers LCO1490/HCO2198 (Folmer et al., 1994) จากหาลำดับเบสโดยการ sequencing ขณะนี้อยู่ในขั้นตอนการเพิ่มจำนวนดีเอ็นเอโดยวิธี PCR sequencing และวิเคราะห์ผลด้วยโปรแกรม PAUP 4.10b
7. ทำการศึกษา allozyme ขั้นต้นในระดับประชากรของชนิด *Rhiostoma housei* มีการกระจายตัวบริเวณภาคกลางและภาคตะวันออกและภาคเหนือของไทย เป็นที่น่าสนใจในการตรวจสอบความใกล้ชิดทางพันธุกรรม รวมถึงการเป็นประชากรเดียวกันตาม Biological Species Concept ดังภาพที่ 1 ตัวอย่างผลการศึกษา Loci บน Starch Gel โดยดูความแตกต่างของ enzyme activity ในระบบ Buffer TC8



ภาพที่ 1 แสดงผลการศึกษา Loci บน Starch Gel โดยดูความแตกต่างของ enzyme activity ในระบบ Buffer TC8 ขณะนี้อยู่ในขั้นตอนการศึกษาเพิ่มเติมและวิเคราะห์ผล

บทวิจารณ์

การดำเนินงานได้เป็นไปตามเป้าหมายที่ได้วางแผนไว้ตามวัตถุประสงค์ในการศึกษาเชิงซิสเทมาติกส์ด้วยอัลโลไซม์ และดีเอ็นเอ ในหอยงวงท่อของไทย และ วิเคราะห์การแพร่กระจายและสายวิวัฒนาการเชิงภูมิศาสตร์ของหอยงวงท่อของไทย ในการวิจัยมีอุปสรรคอยู่บ้างแต่ก็สามารถแก้ไขปัญหาไปได้ด้วยดี โดยได้ทำการเก็บตัวอย่างหอยงวงท่อบริเวณ ภาคเหนือ ภาคกลาง ภาคตะวันออก ภาคตะวันออกเฉียงเหนือ ภาคตะวันตก และภาคใต้ ของประเทศไทย รวมถึงประเทศมาเลเซียรัฐ Perlis Perak Selangor และ เกาะ Langkawi รวมไปถึงการเก็บตัวอย่างในประเทศลาว (Vangvieng) ทั้งนี้ได้เดินทางไปเก็บตัวอย่างเฉลี่ยสองเดือนต่อครั้ง รวมเป็นพื้นที่ที่เก็บทั้งสิ้น 44 พื้นที่ คาดว่าจะครอบคลุมพื้นที่ทั้งหมดที่ต้องการศึกษา และจะมีการออกภาคสนามเพื่อไปตามจุดที่ยังได้ตัวอย่างไม่เพียงพอในการศึกษาอีกประมาณ 2 ครั้ง เนื่องการการเก็บตัวอย่างที่ได้ผลอย่างเต็มที่จะต้องเป็นช่วงหน้าฝน ตั้งแต่เดือนพฤษภาคมเป็นต้นไป จากการวิเคราะห์ความหลากหลายของสปีชีส์ โดยการเทียบตัวอย่างต้นแบบ (Type specimens) ที่พิพิธภัณฑสถานธรรมชาติวิทยา ณ กรุงลอนดอน ปารีส และ แฟรงเฟริต พบว่ามีหอยงวงท่อที่พบในประเทศไทยจำนวน 12 ชนิด ในจำนวนนี้มี 7 ชนิดที่คาดว่าจะเป็นชนิดใหม่ของโลก (จากการเก็บตัวอย่างครั้งล่าสุด พบอีก 2 ชนิดที่น่าจะเป็นชนิดใหม่ จากเดิม 5 ชนิด) ขณะนี้ได้ทำการตั้งชื่อและเตรียมตีพิมพ์ผลงานในวารสารระดับนานาชาติที่มี impact factor ได้เตรียมเขียนผลงานด้านการบรรยายลักษณะ เปรียบเทียบกับตัวอย่างต้นแบบ และรูปภาพที่จะลงตีพิมพ์ ส่วนผลการศึกษาในเรื่องของอณูชีววิทยาเพื่อให้รายละเอียดเกี่ยวกับลักษณะทางพันธุกรรมและความสัมพันธ์ทางวิวัฒนาการ ได้ทำการสกัดดีเอ็นเอของหอยงวงท่อจำนวน 72 ตัวอย่างจากพื้นที่ต่างๆ และคัดเลือกตำแหน่งของยีนที่เหมาะสมในการศึกษาความสัมพันธ์ทางวิวัฒนาการ โดยใช้ตำแหน่งของยีนบนไมโตครอนเดรียลดีเอ็นเอ cytochrome c oxidase subunit I (COI) ในการศึกษาเปรียบเทียบลำดับเบสประมาณ 700 เบส ในแต่ละตัวอย่าง ขณะนี้อยู่ในขั้นตอนการเพิ่มจำนวนดีเอ็นเอ ด้วยวิธี PCR และ Sequencing จากนั้นนำไปวิเคราะห์ด้วยโปรแกรม PAUP 4.10b การศึกษาขั้นต้นในระดับประชากรของหอยงวงท่อชนิดที่มีการกระจายตัวกว้าง *Rhiostoma housei* ด้วย allozyme electrophoresis เพื่อตรวจสอบความใกล้ชิดทางพันธุกรรมรวมถึงการเป็นประชากรเดียวกันตาม Biological Species Concept คาดว่าจะทำการตรวจสอบใน 11 loci เนื่องจากการทดสอบในเบื้องต้น มีแนวโน้มที่จะให้ผลการวิเคราะห์ที่ดี ขณะนี้ได้ทำการศึกษาเพิ่มในตัวอย่างที่เก็บมาจากภาคตะวันออกเฉียงเหนือและภาคเหนือของสปีชีส์ดังกล่าว ผลที่ได้มีแนวโน้มว่าจะพบสปีชีส์ที่เป็น Cryptic species เกิดขึ้นในประชากรที่มีถิ่นอาศัยที่แตกต่างกันไป

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Output จากโครงการวิจัยที่ได้รับทุนจาก สกอ. และ สกว.

1. ได้นำผลงานวิจัยที่ได้บางส่วนไปเสนอผลงานในรูปแบบโปสเตอร์และการเสนอผลงานแบบปากเปล่าที่งานประชุมวิชาการระดับนานาชาติ World Congress of Malacology ณ เมือง Antwerp ประเทศ Belgium เมื่อวันที่ 16-20 กรกฎาคม 2550 ในหัวข้อเรื่อง

- Phylogenetic relationships of the southeast Asian land operculate snails of the genus *Cyclophorus* (Prosobranchia: Cyclophoridae) using DNA sequence data (เสนอผลงานแบบปากเปล่า ได้นำตัวอย่างหอยงวงท่อ *Rhiostoma* เป็น outgroup และเปรียบเทียบกับหอยในกลุ่ม Land Operculate ด้วยกัน)
- Karyotypes of land operculate snails genus *Pterocyclus* and *Rhiostoma* (Prosobranchia: Cyclophoridae) from Thailand and Malaysia (ได้เสนอผลงานแบบโปสเตอร์ร่วมกับอาจารย์มหาวิทยาลัยมหาสารคามในเรื่องของลักษณะสัณฐานวิทยาโครโมโซมของหอยในกลุ่ม Genus *Rhiostoma* และกลุ่มอื่นๆเปรียบเทียบกับหอยในกลุ่ม Land Operculate ด้วยกัน)

สามารถเข้าไปดูโปรแกรมการเสนอผลงานระดับนานาชาติที่:
http://www.naturalsciences.be/institute/structure/invertebrates/malacology/new/institute/structure/invertebrates/malacology/program

2. งานประชุม Molluscan Forum ที่ Natural History Museum of London ประเทศอังกฤษ ณ วันที่ 13 พฤศจิกายน 2550 และวันที่ 20 พฤศจิกายน 2551 ในหัวข้อเรื่อง

- Biochemical assessment of taxonomic diversity in the operculate land snail *Cyclophorus fulguratus* (Gastropoda: Cyclophoridæ) in Thailand (ได้เสนอผลงานแบบโปสเตอร์ร่วมกับอาจารย์มหาวิทยาลัยศรีนครินทรวิโรฒ ประสานมิตร ในเรื่องของการวิเคราะห์ในระดับประชากรศาสตร์ หอยเปรียบเทียบกับกลุ่มที่ได้ศึกษาวิจัยอยู่)
- The snorkel snail genus *Rhiostoma* (Caenogastropoda: Cyclophoridae) from Thailand(ได้เสนอผลงานแบบโปสเตอร์)

สามารถเข้าไปดูโปรแกรมการเสนอผลงานระดับนานาชาติที่:
www.malacsoc.org.uk/**forum/Forum2007**-Programme.pdf
http://www.malacsoc.org.uk/The_Malacologist/BULL52/BULL52_files/Page482.htm

3. เสนอผลงานแบบปากเปล่าที่งานประชุมวิชาการระดับนานาชาติ World Congress of Malacology ที่จังหวัดภูเก็ต ในวันที่ 22 กรกฎาคม 2553 ในหัวข้อเรื่อง

- The Land Snail Genus *Rhiostoma* Benson, 1860

สามารถเข้าไปดูโปรแกรมการเสนอผลงานระดับนานาชาติที่:

http://www.wcm2010.com/download/WCM_2010_Schedule.pdf

4. ชื่อเรื่องที่คาดว่าจะตีพิมพ์

Taxonomic Revision of the Snorkel Snail Genus *Rhiostoma* Benson, 1860 (Caenogastropoda: Cyclophoridae) with Description of New Species

ชื่อวารสารที่คาดว่าจะตีพิมพ์

JOURNAL OF MOLLUSCAN STUDIES

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Taxonomic Revision of the Snorkel Snail Genus *Rhiostoma* Benson, 1860 (Caenogastropoda: Cyclophoridae) with Description of New Species

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ABSTRACT

Taxonomic Revision of the Snorkel Snail Genus *Rhiostoma* Benson, 1860 (Caenogastropoda: Cyclophoridae), with Description of New Species

INTRODUCTION

An operculated land snail of the Cyclophoridae have conspicuously and substantially represent by the vast range in there habitats, and are ecologically importance groups of the land snails occurring in the tropical forest. They represent a great variety in number of species and their morphology from turbinate or discoidal shaped to an eluded last whorl. In Southeast Asia, more than 30 genera of the cycophorids have been reported (Kobelt, 1902; Gude, 1921; Yen, 1939; Azuma, 1982). One of these is the "Snorkel Snail" *Rhiostoma* Benson, 1860, the most poorly investigated group, and are the endemic to the Indochina and Pinsular Malaysia regions. Up to now, approximately 25 nominal species-group names have been introduced to this genus, of which utilised only the shell morpholog to distinguish between species (e.g. Benson, 1860; Pfeiffer, 1862; Sykes, 1903; Tomlin, 1932, 1938; Salisbury, 1949). In fact, the recent classification of the *Rhiostoma* species is rooted to the classical work of Kobelt (1902; 1911-1914) and Gude (1921), who had complied only species descriptions with included 10 species. Subsequently, ten additional taxa had been described from the Southeast Asia region, but none of an efficient taxonomic revision has been implemented. There classification received a superficial attention, and the significant characteristics and systematics position of the *Rhiostoma* are remaining enigmatic until today. Foremost difficulty is an inapplicable the species-group names and species boundary on the recent field collections through out their range. The peculiar freely and extended part of last whorl (collar), calcareous cup-shaped operculum and usually hold an accessory breathing device (breathing tube) closed to an aperture have made these snails obviously distinct from all other closely related genera (e.g. *Cyclotus*, *Pearsonia*, *Pterocyclus*, *Theobaldius*) from Sri Lanka and India.

The present revision has the following aims: 1) to revise the taxonomy of the *Rhiostoma* based on genitalia, radula and external shell morphology, and 2) to clarify the identities of each recognized species with the primary type specimens and characters differences among those recognized species. In addition, the hitherto undiscovered species are carefully described. The relationship among the species will be implementing using molecular technique for further purpose.

MATERIALS AND METHODS

Areas were surveyed throughout Thailand, peninsular Malaysia and Laos. Living snails were freeze up and transferred into 70% (v/v) ethanol for fixation and preservation. Adult shells were measured for height and diameter as shown

in Figure 1A. Features of the genitalia were examined in at least 5 specimens. Radulae were extracted, and examined under a Scanning Electron Microscope (JEOL, JSM-5410 LV). Radula shape and teeth formulae were described.

We have examined both male and female reproductive organs of all species recognized here, except *R. hughtoni*, *R. simplicilarbre*, *R. strubelli*, *R. morleti* and *R. prestoni*. The result showed that the reproductive system and external penis are seemed to conserve and less in distinguishing the congener species or even difficulty undistinguishing of the confamily. Therefore, only reproductive organ of the representative species, *R. housei*, are shown here for fulfil the soft body characteristic of the *Rhiostoma*.

The morphological terms (Fig. 1A), 'collar' referred to the part of last whorl, which is short or long disconnected or freely from the preceding whorl, and 'siphon' denoted the various types of accessory breathing device attached to the apertural lip, used through this study are modified from Rees (1964) and Little (1984).

For the anatomical descriptions, following anatomical terms used in the descriptions as described by Schneider (1922) and Welber (1925): an, anus; bc, bursa copulartrix; cm, columellar muscle; ct, cephalic tentacle; dg, digestive gland; es, eye spot; f, foot; fc, feces; go, genital opening; h, heart; int, intestine; kd, kidney; lc, lung cavity; mc, mantle collar; od, oviduct; op, operculum; ov, ovary; p, external penis; pg, prostate gland; re, rectum; sg, sperm groove; sn, snout; sr, seminal receptacle; sto, stomach; te, testis; ut, uterus; v, vein; vd, vas deferens;

Registration numbers all refer to the collections of the Chulalongkorn University, Museum of Zoology, Bangkok, Thailand (**CUMZ**), unless otherwise stated. The abbreviations for type material from other museum collections are as follows: **AMNH**, American Museum of Natural History, New York; **BMNH**, The Natural History Museum, London; **CUMZ**, Chulalongkorn University, Museum of Zoology, Bangkok; **MNHN**, Muséum National d'Histoire Naturelle, Paris; **NMNH**, National Museum of Natural History, Smithsonian Institute, Washington D.C; **NMW**, National Museum of Well, Cardiff; **NSMT**, National Science Museum and Technology, Tokyo; **RBINS**, Royal Belgian Institute of Natural Sciences, Brussels; **SMF**, Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt, a.m.; **UMZC**, University Museum of Zoology Cambridge, Cambridge.

SYSTEMATIC ACCOUNT

Family Cyclophoridae Gray, 1847
Genus *Rhiostoma* Benson, 1860

Rhiostoma Benson, 1860: 96. Blanford, 1864: 251. Kobelt, 1902: 176. Kobelt, 1911: 754. Gude, 1921: 127, 128. Wenz, 1938: 462.

Pterocyclus (Rhiostoma)—Nevill, 1878: 262.

Type species: *Rhiostoma haughtoni* Benson, 1860 by original designation in Benson, 1860: 96.

Diagnosis: Shell depressed to subdiscoidal, solid, and widely umbilicate which shows all preceding whorls. Collar (disconnected part of last whorl) detach or solute from preceding whorl, which short to long and curved descending. Periostracum thicken corneous or thin transparent. Shell colour uniform brownish to purplish and/or with brownish variegated streaks. Peristome continuous and circular; lip thickens and/or expanded. Siphon (accessory breathing devices) vary form notch shape (Fig. 2C), canal shape (Fig. 2D), incomplete siphon (Fig. 2E) and complete siphon (Fig. 2F). Operculum calcareous, cylindrical, concaved with shallow to deep cup-shaped, anti-clockwise multi-lamellar (Fig. 1B), and diameter considerably smaller than aperture.

External feature: Animal blackish, light brown, whitish or dark grey, and often with light dark-brown patches or black mottle on pale yellow background with fade down near mantle cavity (Figs 3, 4). Cephalic tentacle (ct) long, each with dark eye (es) on the side at outer base of tentacles (Fig. 3A, B). Snout (sn) broad and furrowed, and genital groove present at right side running downwards from anterior end of pallial gonoduct. Animal dioecious: male with long conical penis (p) on right side below cephalic tentacle, and sperm groove pass along to tip of penis (Fig. 3B); female with only vaginal groove (vg) on right side (Fig. 3A).

Internal anatomy: Kidney (k) brownish, with triangular shaped (Fig. 3C, D). Heart (h) located on the left side of kidney; pericardium thin, atrium slightly larger than ventricle. Lung cavity (lc) with reticulated vessels (v). Rectum (re) large, placed on genital apparatus (prostate gland in male/ uterus in female), inside contained elliptical-shaped feces (fc), and anteriorly tapering to small anus (an) opened closed to mantle collar edge. Ctenidium and osphradium absent. Mantle collar (mc) smooth and slightly thicken. Columellar muscle (cm) broad and thicken (Fig. 3A, B).

Reproductive organ: Testis (te) with branched tubules, bright orange and occupies around 2-3 whorls from apex (Fig. 3B, E). Vas deferens (vd) thin and slender-straight tube attached to prostate gland at around two-third of its length proximal to external penis. Prostate gland (pg) large and long slender with pale yellowish; proximally with genital opening (go). Sperm groove (sg) narrow, distinct and connected from genital opening on right side of snail to external penis. External penis (p) with digitiform, short and locates posteriorly below cephalic tentacles (Fig. 3B).

Ovary (ov) with bright orange colour and multi-lobulate gland embedded with digestive gland (Fig. 3A, F). Oviduct (od) with pale yellowish colour, thin tube, and connected between ovary and uterus at near base of seminal receptacle. Bursa copulatrix (bc) large with approximately half length of uterus, and creamy to whitish colour with soft peanut shape. Seminal receptacle (sr) with digitiform, small and locate posteriorly of uterus and with pale orange colour. Uterus (ut) large, curved pea pod shape, posterior end rounded and anterior end tapering and with genital opening (Fig. 3F).

Spermatophore whitish (Fig. 4F) with about 10 mm long (Fig. 3G). Anterior part slightly depressed, with two weak keels (see cross-section) and narrow sperm sac. Middle part with swollen sperm sac, circular in cross-section, and with one prominent keel. Posterior part tapered, with pointed end, and sperm sac disappeared.

Remarks: The genus *Rhiostoma* seems to be limited distribution only in the Indochina region ranged from Burma to Thailand, Laos, Cambodia, peninsular Malaysia, and some parts of Vietnam (Benson, 1860; Ancey, 1898; Bavay & Dautzenberg, 1908, 1909; Kobelt, 1902, 1911-1914; Gude, 1921; Tomlin, 1932, 1938;). Within the overall limits of it total geographical range (Table 1); *Rhiostoma* occupies more restricted area than other cyclophorids such as *Pterocyclus* and *Cyclotus*. The limits of the genus demarcated with the endemic genera *Pearsonia* and *Theobaldeous* of western Asia and Burma, the *Ptychopoma* Möllendorff, 1885 and *Scabrina* Blandford, 1863 of China in the northern range (Yen, 1939), and in the south, Sundaic islands and the Philippine seem to be dominated with a closely related genus *Pterocyclus*.

The species arrangements are following the initially grouping of the species, mainly based on the similarity of shell morphology. This informal subdivision composed of 3 species groups, which possibly reflecting the evolutionary relationship and assisting in the species identifications. No formal names or descriptions are given, only the general characteristic that can be represented in the species names of the groups.

Group I: *Rhiostoma housei* group usually exhibit a long collar (sometime short collar) and siphon always present with complete tubular shaped. This group contained 9 species: *R. housei*, *R. breviocollar breviocollar* s. ssp. and *R. breviocollar uthaiensis* n. ssp., *R. hainesi*, *R. simplicilabre*, *R. marioni*, *R. jalorensis*, *R. tigris tigris* n. ssp., *R. tigris lannaensis* n. ssp., *R. aquilozonatus* n. sp., *R. furfurosus* n. sp.

Group II: *Rhiostoma haughtoni* group can be distinguished by short to long collar and siphon usually absent or replaced with knob or canal shaped. This group composed of 6 species: *R. haughtoni*, *R. strubelli*, *R. samuiense*, *R. chupingense*, *R. parahainesi* n. sp., and *R. proboscidius* n. sp.

Group III: *Rhiostoma cambodjensis* group can be separated by a very short to absent collar, and siphon performs knob or slit-knob shaped. There are 5

species belonging to this group: *R. cambodjensis*, *R. asiphon*, *R. morleti*, *R. prestoni*, and *R. pygmaeus* n. sp.

Key to species of the Rhiostoma *recognized in this study.*

1a. Siphon incomplete (Fig. 2E) or complete (Fig. 2F); collar present with short to long or absent 2
1b. Siphon notch shaped (Fig. 2C) or canal shaped (Fig.2 D); collar present with short to long 14
2a. Collar absent or present with short (shorter than apertural width) or medium (equivalent length to apertural width); complete or incomplete siphon 3
2b. Collar long (longer than aperture width); complete siphon 12
3a. Complete siphon; collar short or medium 4
3b. Incomplete siphon; collar absent or present with very short 9
4a. Periostracum thicken and brownish; shell uniform yellowish or brownish .. 5
4b. Periostracum thin; shell with brownish zigzag pattern 7
5a. Peripheral band very wide and dark brown to blackish colour..... ..... *R. aquilozonatus* n. sp.
5b. Peripheral band narrow dark brown colour or absent 6
6a. Shell large; elevated spire; collar long; lip expanded; complete siphon (excepted some specimens perform canal shaped siphon) ..... *R. hainesi*
6b Shell medium; depressed spire; collar short; short complete siphon perpendicular to collar ..... *R. marioni*
7a. Whorl slender with clear brownish zigzag pattern; short to long complete siphon; collar short (excepted some specimens perform very long collar) ... . *R. tigris tigris* n. sp.
7b. Whorl stout; complete siphon with short or long, straight or curved 8
8a. Periostracum thin; apex with darker colour than following whorls; collar medium; shell with brownish zigzag pattern; siphon usually curved and attached to last whorl ..... *R. housei*
8b. Periostracum thicken and brownish; depressed spire; siphon usually perpendicular to collar ..... *R. simplicilarbe*
9a. Collar short; shell with uniform reddish-brown (sometime with pale zigzag pattern); apex blackish; spire slightly depressed ..... *R. furfurosus* n. sp.
9b. Collar short or absent; shell small to large and with brownish zigzag pattern; apex bright colour 10
10a. Shell large; collar absent; lip with expansion at base of siphon ... *R. morleti*
10b. Shell small to large; collar short; periostracum thin; lip without expansion .. .. *R. breviocollar* n. sp. 11
11a. Shell larger, thin and with brownish or zigzag pattern; spire depressed; periostracum thin ..... *R. breviocollar breviocollar* n. ssp.
11b. Shell small, thicken and with uniform reddish brown (sometime with brownish pattern); spire little elevated ..... *R. breviocollar uthaiensis* n. ssp.

12a. Whorl stout; shell uniform blackish to brownish; long complete siphon .... *R. jalorensis*
12b. Whorl slender; shell with distinct brownish zigzag pattern; short to long complete siphon ..... *R. tigris* n. sp.....13
13a. Operculum with dense multi-spiral; collar short to long; siphon usually attached to last whorl ..... *R. tigris tigris* n. ssp.
13b. Operculum with loose multi-spiral; collar extremely long and curved; siphon detached from last whorl ..... *R. tigris lannaensis* n. ssp.
14a. Siphon canal shaped 15
14b. Siphon notch shaped 20
15a. Collar wanting; shell with brownish pattern or uniform colour 16
15b. Collar shorter to longer than aperture width; shell usually with uniform colour 18
16a. Shell relatively large; spire depressed; periostracum thicken and brownish; shell colour vary from uniform brownish to with brownish pattern; apertural lip with expansion at based of siphon ..... *R. prestoni*
16b. Shell relatively small; spire elevated 17
17a. Apex with darker colour than following whorls; shell thicken and with uniform blackish or brownish; collar wanting ..... *R. cambodjensis*
17b. Apex indistinct colour from following whorls; shell thin and with brownish zigzag pattern (sometime uniform whitish); collar short .... *R. pygmaeus* n. sp.
18a. Shell uniform brownish, yellowish or whitish colour; collar short to medium ..... *R. haughtoni*
18b. Shell with thin brownish zigzag pattern; collar short to long; apex with darker colour than following whorl 19
19a. Shell large; collar long; periostracum thicken and brownish .... *R. parahainesi* n. sp.
19b. Shell small; collar short; periostracum thin ..... *R. strubelli*
20a. Collar very short; shell medium with uniform brownish to purplish colour; spire depressed ..... *R. asiphon*
20b. Collar long; spire elevated; periostracum thick or thin 21
21a. Shell relatively small and thin; periostracum thicken and brownish; collar usually medium length ..... *R. samuiense*
21b. Shell large and thicken; periostracum thick or thin; collar long 22
22a. Collar normally long and curved ..... *R. chupingensis*
22b. Collar extremely long (proboscis like), twisted and curved .... *R. proboscidius* n. sp.

Rhiostoma housei (Haines, 1858)
(Figures 3A-F, 4A, 5A-H, 9A; Table 2)

Cyclostoma housei Haines, 1855: 157, pl. 5, figs 12-15. Type locality: Siam.

Pterocyclus housei—Pfeiffer, 1858: 29.
Rhiostoma housei—Benson, 1860: 97. Pfeiffer, 1862: 117, pl. 12, fig. 9. Martens, 1867: 63. Fischer, 1891: 101. Möllendorff, 1894: 152. Kobelt & Möllendorff, 1897: 115. Kobelt, 1902: 178. Fischer & Dautzenberg, 1904: 427. Kobelt, 1911: 757, 758, pl. 110, figs 8-10, pl. 113, fig. 2. Zilch, 1956: 174. Rees, 1964: 67, pl. 4, fig. 15. Habe, 1965: 128, pl. 2, fig 10. Solem, 1966: 11. Fischer, 1973: 47. Abbott, 1989: 29, 42; 3 figures.
Pterocyclos (Spiraculum) housei—Martens, 1860: 10
Pterocyclos housei—Reeve, 1863: Pterocyclos pl. 4, species 21.
Pterocyclus (Rhiostoma) housei—Nevill, 1878: 263.
Rhiostoma dalyi Blanford, 1902: 34-35, fig. 1. Type locality: Phitsanulok, Thailand. Blanford, 1903: 281. Fischer & Dautzenberg, 1904: 427. Solem, 1966: 11.

Material examined: Five syntypes in Haines collection, a figured specimen (fig. 12, 13) in the original description is designated here as the lectotype of "*housei*" AMNH 42923 (Fig. 5A), and paralectotype AMNH xxxx (Fig. 5B). Three syntype specimens in W.H. Blanford collection, the figured specimen (fig. 1) in the original description is designated here as lectotype of '*dalyi*' BMNH 1902.1.24.14 (Fig. 5C) and paralectotype BMNH xxxx. Boong Tuey, East Siam: RBINS 659990, 659991; Pak Chong, East Siam: RBINS 659978, 659979, 659980; Lam Ton Lang, East Siam: RBINS 659982, 659983, 659984. Doi Phunang National Park, Dok Khamtai, Prayao: 3824, 3826, 3938, 3942, 3951, 3952, 3977, 4313, 4319, 4420; Tam Pha Daeng, Chiengkam, Prayao: 4462, 4729; Tam Pha Tangyai, Doi Phunang National Park, Prayao: 3926 (Fig. 5H), 4784; Tam Air Thammachard, Long, Phare: 3979, 4451, 4762; Tam Pha Nangkoy, Rongkwang, Phare: 3884, 3924, 3943, 4726; Tam Seareethai (3 km before), Long, Phare: 4450; Ban Tha-sri, Muang, Lampang: 4728; Khao Pratu-Pha, Ngoaw, Lampang: 4463; Khao Sompod, Chaibadarn, Lopburi: 3932, 3936, 3937; Sub Lanka Forest Reserved, Lopburi: 4736; Khao Look Chang, Pakchong, Nakhonratchasrima: 3805, 3953, 3981, 4316, 4318, 4320, 4379, 4384 (Fig. 5F), 4454; Srakaerat, Pakthongchai, Nakhonratchasrima: 4391; Wat Thepphitak, Pakchong, Nakhonratchasrima: 3954, 4321, 4416; Jed Saw Noi Waterfall, Muaklek, Saraburi: 4732; Kaeng Koy, Saraburi: 4315; Muak Lek, Saraburi: 4390, 4460; Pu Kare Botanic Garden, Saraburi: 4742; Tam Dao Khaokaew, Muaklek, Saraburi: 3802, 3934, 4389, 4760; Tam Sri Wilai, Chalermprakeit, Saraburi: 3982 (Fig. 5E), 4449; Kang Kracharn National Park, Phetchaburi: 4409, 4412; Khao Nang Panthurat Nature Reserved, Cha-am, Phetchaburi: 4480; Pa La-Au Waterfall (km 30th before), Phetchaburi: 3827, 4740; Tam Na Khwang, Cha-am, Phetchaburi: 3988, 4452, 4719; Aow Noi, Prachuapkhirikhan: 3868; Bang Poo, Sam Roi Yod, Prachuapkhirikhan: 4414, 4417, 4429, 4430, 4431; Khao Lom Muak, Aow Manow, Prachuapkhirikhan:

3870, 3987, 4322; Tam Phitsadan, Pratiew, Chumporn: 3816, 3867, 4383 (Fig. 5D), 4453.

Shell: Shell medium to large, depressed, solid, and widely umbilicate. Apex acute and with dark colour; spire little elevated. Whorl 5 to 6 convex, increasing regularly; suture shallow and wide; last whorl rounded. Shell surface smooth or with thin growth lines. Periostracum thin corneous and transparent. Shell colour varying from uniform whitish or brownish to variegated with dark brown zigzag pattern, dorsal shell with darker colour than ventral side; on periphery with thin peripheral band. Collar usually with same length or shorter than aperture width. Aperture rounded; lip thickened and little expanded. Siphon short to long tubular shape, curved posteriorly and its tip usually attached to last whorl. Operculum thick calcareous, deep cup shaped and anti-clockwise multi-lamellar.

Radula: Taenioglossate arrange in v-shaped row (Fig. 9A), each transverse row contained 7 teeth (2-1-1-1-2). Central tooth with well develop central cusp and two tapered in size lateral cusps on each side. Central cusp largest with blunt tip; four lateral cusps on both side with triangular shape and pointed head. Lateral teeth with 4 cusps, central cusp largest and elongate shape with dull head, flanked with relatively small with point tip of two inner lateral cusps and one outer lateral cusp. Inner and outer marginal teeth composed of 3 cusps; largest and convex head central cusp flanked with relatively small and pointed head of inner and outer lateral cusps.

Distribution: The previous record of this species was from Thailand; Laos; Grottes de Baphnam, Phnom Rong, Cambodia; Tonkin (Haines, 1858; Ancey, 1898; Möllendorff, 1895; Solem, 1966; Fischer, 1973). The recent study is recorded from northern to central and southern peninsular Thailand. The southern most limits of this species are approximately at Isthmus of Kra (Prachuapkhirikhan Province), and the northern limited is approximately in Prayao Province.

Remarks: *Rhiostoma housei* has widest distribution among other known *Rhiostoma* species. Specimens collected from Peninsular Thailand (Chumporn, Phetchaburi and Prachuapkhirikhan Provinces) tended to have long collar and siphon, and brighter shell colour than other populations. The most peculiar variation of this species is known from Tam Pha-Tang (Fig. 5H) that exhibit smaller shell size than other populations (Table). However, with colour pattern, and collar and siphon structures are identical to the type specimens (Fig. 5A, B). Therefore, these attributed to the morphological variation among the wide distribution range species.

Rhiostoma breviocollar Tongkerd & Tumpeesuwan n.sp.

Etymology: The specific name "*breviocollar*" come from Latin words "*brevior*" meaning 'short or shorter', and "*collum*" means 'neck'. It refers to the very short to wanting of collar, a distinguished character of this species from *R. housie*.

Diagnosis: This new species differs from *R. housei* by having very short to wanting collar and incomplete tubular shape of siphon. The differences from *R. cambojense* are larger shell, flatten spire, dark brown variegated pattern, and canal shaped siphon. This species can be distinguished from *R. chupingense*, *R. samuiense* and *R. proboscidius* n. sp. by having very short to absent collar, with variegated brownish pattern, and canal shape of siphon. It differs from *R. asiphon* by having variegated brownish pattern and canal shape of siphon.

Shell: Shell medium to small, depressed, thicken, and widely umbilicate. Apex acute; spire nearly flatten to little elevated. Whorl 4 to 5 convex, increasing regularly; suture wide and shallow; last whorl rounded and stout. Shell surface with irregular growth lines. Shell colour uniform brownish or dorsal side with variegated brownish zigzag pattern on brownish or whitish background, ventral side with paler irregular pattern; on periphery with narrow and dark peripheral band. Periostracum thin, corneous and transparent. Collar extremely short to absent. Aperture rounded and whitish; lip thicken and expanded. Siphon with incomplete tubular or slit-knob shapes. Operculum thick calcareous, and cap shaped with anti-clockwise multilamellar.

Rhiostoma breviocollar breviocollar s. str.
(Figures 5I, J, 9B; Table 2)

Type material: Holotype CUMZ 4490 (Fig. 5I); type locality: Khao Smokon, Lopburi (14° 54' 25.9" N, 100° 30' 21.9" E). Paratype CUMZ 4491 (Fig. 5J), and five specimens of paratype deposited in AMNH, BMNH, MNHN, NMNH, NMW, RBINS, SMF, UMZC.

Other material examined: Phukiew Wildlife Sanctuary, Chaiyaphum: 3969; Khao Samorkhon, Thawung, Lopburi: 3927, 3975, 4366, 4490, 4491; Khao Tee Hin, Banmee, Lopburi: 4367; Wat Bandai Samsaen, Thawung, Lopburi: 3888; Wat Tam Tambon, Chaibadan, Lopburi: 3983, 4445, 4466.

Shell: Shell morphology as in species description. The distinct characters of the nominotypical subspecies are: relatively larger shell size. Shell colour usually with variegated brownish zigzag pattern on dorsal side, and ventral side with paler colour pattern. Siphon form incomplete tubular shape.

Radula: Teeth arrangement with central, lateral and marginal teeth shape almost similar to *R. housei*. Major differences: central tooth with triangular shaped central cusp (Fig. 9B). Outer marginal teeth composed of 3 cusps; largest and convex head central cusp flanked with relatively small and pointed head outer lateral cusps, inner lateral cusp usually small to nearly wanting.

Distribution: This species is recorded from several localities in Lopburi Province, central Thailand.

Remarks: With the brownish zigzag shell pattern is suggest a closely related to *R. housei*. The short to wanting collar, incomplete tubular shape of siphon, and flatten spire are the major distinguished characters. In addition, with the karyotypic and allozyme study also support these distinct species (Panha, unpublished data).

Rhiostoma breviocollar uthaiensis Tongkerd & Tumpeesuwan n. ssp.
(Figures 5K-M, 9C; Table 1)

Type material: Holotype CUMZ 4492 (Fig. 5K); type locality: Khao Patawee, Tuptan, Uthaithani (15° 28' 22.4" N, 99° 45' 29.07" E). Paratype CUMZ 3804, 3900, 3978, 4358, 4492, 4493 (Fig. 5L), 4772, and five paratype specimens deposited in AMNH, BMNH, MNHN, NMNH, NMW, RBINS, SMF, UMZC.

Other material examined: Khao Cha Ang-Oan, Borthong, Chonburi: 3809, 3818, 3861, 3972, 3984, 4363, 4364, 4377, 4448, 4461, 4475; Wat Pluang Thong, Borthong, Chonburi: 3970, 3971, 4354, 4355, 4357, 4360; Tam Neramitr, Khaochamao, Rayong: 4468; Tam Takien, Khaochamao, Rayong: 3985 (Fig. 5M), 4470; Wat Ma Diea (Tam Khao Loy), Khaochamao, Rayong: 4467, 4469;

Etymology: The subspecific name "*uthaiensis*" is derived from the name of the type locality 'Uthai Thani Province', where this new subspecies was collected.

Diagnosis: *Rhiostoma breviocollar uthaiensis* n. ssp. differs from the nominotypical subspecies by having small shell size (Table), and reduced reddish brown zigzag pattern to monochrome shell colour. It differs from *R. cambodjensis* by having slightly depressed shell, short incomplete siphon, and reddish brown shell colour. Moreover, this new subspecies is obviously differs from *R. hainesi* and *R. parahainesi* n. sp. in almost characters such as larger shell, longer collar, shape of siphon, and shell colour pattern of the latter two species.

Shell: Shell morphology as in the description of species. The major distinguish characters are: shell relatively small and depressed spire. Shell colour usually with uniform reddish brown or with zigzag pattern. Collar extremely short to absent. Siphon form short incomplete shaped.

Radula: Teeth arrangement with central, lateral and marginal teeth shape almost similar to the nominotypical subspecies (Fig. 9C).

Distribution: The new subspecies is known from an isolated limestone outcrops in Uthaithani, Chonburi and Rayong Provinces.

Remarks: The disjunct distribution of this subspecies in western (Chonburi and Rayong Provinces) and eastern (Uthaithani Province) populations is still ambiguous. The western populations perform the shell morphology clearly distinct from *R. cambodjensis*. Shell variation is recorded from Rayong populations, which showing much thicker shells than the typical specimens.

Rhiostoma hainesi Pfeiffer, 1862
(Figures 4B, 5N-R, 6A, B, 9D; Table 2)

Rhiostoma hainesi Pfeiffer, 1862: 115, pl. 12, fig. 8. Type locality: Cambodia. Martens, 1867: 64. Fischer, 1891: 101. Kobelt: 1902: 178. Fischer & Dautzenberg, 1904: 427. Kobelt, 1911: 762, pl. 113, fig. 1. Fischer, 1973: 47.
Pterocyclos hainesi Reeve, 1863: Pterocyclos pl. 4, species 19.
Pterocyclus (Rhiostoma) hainesi—Nevill, 1878: 263.
Rhiostoma smithi Bartsch, 1932: 70-71, fig. 1. Type locality: Khao Sabap, southern Siam. Abbott, 1989: 34, 2 figures (Paratype). Solem, 1966: 11. Panha & Thanamitramanee, 1997: 2.
Rhiostoma tomlini Salisbury, 1949: 41-42, pl. 3B, figs 3, 4. Type locality: Khao Sabap, Siam. Solem, 1966: 11.
Rhiostoma housei kirai Habe, 1965: 128, pl. fig. 11. Type locality: Chanthaburi, Thailand.

Material examined: Two syntypes in H. Cuming collection, a figured specimen (fig. 8) is designated here as lectotype of "*hainesi*" BMNH xxxx (Fig. 5N), and paralectotype BMNH xxxx (Fig. 5O). Holotype of '*smithi*' USNM 382943 (Fig. 5P). Paratype of "*tomlini*" BMNH 1949.6.7.1 (Fig. 5Q), J.E. Cooper coll. Acc. no. 2150 (1 shell). Holotype of "*kirai*" NSMT 52242 (Fig. 5R). Khao Yai National Park, Nakornnayok: 4458; Khao Soidao Wildlife Sanctuary, Chanthaburi: 3855, 3883, 3898, 3917, 3962, 4402 (Fig. 6B), 4406, 4423, 4457, 4743; Makok Waterfall, Chanthaburi: 3807, 3814, 3920, 3921, 4421; Plieu National Park, Chanthaburi: 3801, 3960, 3961, 3963, 3964, 3974, 4336, 4338,

4339, 4340, 4380, 4381 (Fig. 6A), 4393, 4394, 4403, 4404, 4405, 4410, 4418, 4422, 4425, 4426, 4428, 4434; Sibha Chan National Park, Chanthaburi: 4733; Trong Nong Waterfall, Chanthaburi: 4407, 4455; Wat Khao Sukim, Chanthaburi: 3803, 3815, 3828, 3918, 3919; Khao Chamao Khao Wong National Park, Rayong: 3897, 4337, 4456.

Shell: Shell large, depressed, solid and widely umbilicate. Apex acute; spire elevated. Whorl 5 to 6 convex, increasing regularly; suture shallow and wide; last whorl rounded and fairly stout. Shell surface with thin growth lines. Shell colour background uniform whitish to yellowish, and usually enclosed with thick brown periostracum. Ventral side shell often with worn out periostracum; on periphery encircled with narrow dark brown peripheral band. Collar long around same length to longer than apertural width (rarely shorter than apertural width). Aperture rounded and whitish; lip thickened and widely expanded. Siphon with short to long whitish tubular shape and curved posteriorly; some specimens with short and incomplete tube type. Operculum thick calcareous, anti-clockwise multilamellar with cap shaped.

Radula: Teeth arrangement with central and lateral teeth shape almost similar to *R. housei*. Major differences: inner marginal teeth with 4 cusps; largest and convex head central cusp flanked with relatively small and pointed head of two inner and one outer lateral cusps (Fig. 9D). Outer marginal teeth with 3 cusps; relatively large and convex head of two outer cusps flanked with small and pointed head of inner cusps.

Distribution: The previous recorded of *R. hainesi* were from vague locations in Cambodia and Thailand: Khao Sabap (=Plieu National Park, Chanthaburi) (Pfeiffer, 1862; Habe, 1965). The recent study is obtained specimens from a narrow range in Rayong and Chanthaburi Provinces, Thailand.

Remarks: *Rhiostoma hainesi* from Chanthaburi exhibit a variation in shape of siphon with canal shape (Fig. 6B) and complete siphon (Fig. 6A). These two types of shell morphs found sympatrically, which a complete siphon morph is the majority.

There are three nominal taxa have long been confusing with *R. hainesi* such as '*R. smithi*, *R. tomlini* and *R. housei kirai*' (Bartsch, 1932; Salisbury, 1949; Habe, 1965). The first two nominal names were classified based on the distinction of shell colour and shape ofsiphon. In addition, there type locality are exactly the same location (Khao Sabap, Chanthaburi), and the type specimens (Fig. 5N-Q) are identical in almost characters to *R. hainesi* and to each other. The last nominal name '*kirai*' was originally recognized as a subspecies of *R. housei* (see Habe, 1965). However, the type specimen (Fig. 5R) exhibits a long collar, complete siphon, thick periostracum with monochrome brownish shell

colour (although the periostracum is eroded), and expanded lip. These are the distinguished characters of *R. hainesi*. Therefore, we have re-arranged those three nominal names (*'smithi*, *tomlini* and *kirai'*) as a junior subjective synonym of *R. hainesi*.

Rhiostoma simplicilabre Pfeiffer, 1862
(Figure 6C, D; Table 2)

Rhiostoma simplicilabre Pfeiffer, 1862: 115, pl. 12, fig. 7. Type locality: Cambodia. Kobelt & Möllendorff, 1897: 115. Kobelt, 1902: 178, 179. Fischer & Dautzenberg, 1904: 427. Kobelt, 1911: 756, 757, pl. 110, figs, 5-7, pl. 113, fig. 3.
Pterocyclos simplicilaris—Reeve, 1863: Pterocyclos pl. 4, species 20.
Pterocyclus (Rhiostoma) simplicilabris—Nevill, 1878: 262.

Material examined: Four syntypes in H. Cuming collection, a figured specimen in the original description (fig. 7, and a label 'type' attached in umbilicus) is designated here as the lectotype of *'simplicilarbre'* BMNH xxxx (Fig. 6C), and paralectotype BMNH xxxx (Fig. 6D).

Shell: Shell medium, depressed, solid, and widely umbilicate. Apex acute and with dark colour; spire little elevated. Whorl 5 to 6 convex, increasing regularly; suture shallow and wide; last whorl rounded. Shell surface with thin regular growth lines. Shell colour with brownish zigzag pattern, ventral side with pale colour and less brownish pattern; on periphery with dark brown peripheral band. Periostracum thick corneous and transparent. Collar shorter to approximately same length to apertural width. Aperture rounded; lip little thickened and expanded. Siphon tubular shape, brownish, straight, and tip of tube usually attached to last whorl. Operculum thick calcareous and cap shaped with anti-clockwise multilamellar.

Distribution: This species were recorded manily in Cambodia (Pfeiffer, 1862) and Luang Prabang, Laos (Kobelt, 1911).

Remarks: From this study, no recent specimens are known in Thailand. Therefore, the information of this species is mainly from the type and museum specimens. This species is very closely allied to *R. housei*, the differences are straight siphon and usually perpendicular to collar, depressed spire, thick periostracum. It differs from *R. hainesi* by having variegated brownish pattern, shorter collar, and smaller shell size. However, the morphological variations and distribution ranges are still need to verify with specimens from precise locality.

Rhiostoma marioni (Ancey, 1898)

(Figures 6E, F, 9E; Table 2)

Pterocyclos marioni Ancey, 1898: 137, pl. 9, fig. F. Type locality: Luang Prabang, Laos and Mont Hou, Tonkin. Fischer & Dautzenberg, 1904: 430. Wood & Gallichan, 2008: 64, pl. 25, fig. 3 (Holotype).
Rhiostoma marioni—Dautzenber, 1900: 70.
Pterocyclus marioni—Kobelt, 1911: 757 (synonym of *R. housei*).

Material examined: Specimen in Ancey's collection (leg. H. Counillon) ex. Melvill-Tomlin collection is designated here as the lectotype of '*marioni*' NMW 1955.158.24090 (Fig. 6E). Pha Hom, Vang Vieng, LAOS: 4465, 4494 (Fig. 6F).

Shell: Shell medium, depressed, thin and widely umbilicate. Apex acute with dark colour. Whorl 5 to 6 convex, increasing regularly; suture wide and depressed; last whorl rounded and stout. Shell surface with thin growth lines. Shell covered with thick corneous to brownish periostracum; dorsal shell with thin brownish zigzag patterns; on periphery with narrow dark peripheral band. Collar short about half or less than apertural width. Aperture rounded; lip little expanded and thickened. Siphon form tubular or incomplete shape, which short and nearlt perpendicular to collar. Operculum thick calcareous and cap shaped with anti-clockwise multilamellar.

Radula: Teeth arrangement with lateral and marginal teeth shape almost similar to *R. housei*. Major differences: central tooth with well develop central cusp, which flanked with 3 tapered in size lateral cusps on each side (Fig. 9E). Central cusp largest, long and with dull tip; four lateral cusps on both side performed triangular shaped and pointed head; outer most cusp very small to nearly wanting.

Distribution: The previous records were from the type locality and from Mont Hou, Tonkin (Ancey, 1898). In this study, this species is known only from Pa Hom, Vang Vieng, Laos.

Remarks: Kobelt (1911: 757) had arranged this species as synonym of *R. housei*, but the type specimen and the recently collected specimens are clearly distinct from *R. housei*. The differences are the relatively short collar, thickened and brownish periostracum, spire depressed, and less brownish zigzag patterns.

Rhiostoma marioni was firstly nominated based on two lots of specimens (Ancey, 1898). One of these was housed in NMW, and other one may be in Dautzenberg's collection at RBINS (Wood & Gallichan, 2008). Recently, we have carefully looked for the type specimens in the RBINS type collection found no any possible specimen could be identifed as '*Pterocyclos marioni*', which is probably missing. Only a survive specimen in the NMW is qualified to be a

name-bearing function of this species (Wood & Gallichan, 2008). The shell morphology especially the cannal shaped of siphon, and long collar are indicate the characteristic of the *Rhiostoma*. Curiously that is an operculum (figure not shown), which togethered with the type specimen perform a dark-brown corneous, multispiral plate shaped and its diameter (17 mm) larger than the aperture (14 mm) of shell. This operculum is possibly from the other species; therefore, it does not include in the lectotype designation.

Rhiostoma jalorensis Sykes, 1903
(Figures 4C, 6G-I, 9F; Table 2)

Rhiostoma jalorensis Sykes, 1903: 196, pl. 20, figs 6-8. Type locality: Limestone hills and caves, Biserat, Jalor). Salisbury, 1949: pl. 3B, figs 1, 2. Laidlaw, 1928: 31.

Material examined: Holotype UMZC 1030 (Fig. 6G) and paratype NMW 2.1981.118.02760.

Klong Saeng Wildlife Sanctuary, Suratthani: 4323, 4478, 4723; Wat Nasarn, Suratthani: 4324; Koh Prao, Pangnga Bay, Pangnga: 4327; Pangnga Bay, Pangnga: 4325, 4326, 4376; Tam Khiriwong, Tubpud, Pangnga: 3822, 3823, 3832, 4484, 4485; Tam Nampud, Muang, Pangnga: 3836, 3839, 3841, 3899, 4387; Tam Suwankuha, Muang, Pangnga: 3848, 3956, 3957, 4328, 4329, 4764, 4765; Tao Thong Waterfall, Tubpud, Pangnga: 3817, 3829, 3845, 4386, 4482, 4483; Ban Sai Tai, Krabi: 4427; Behind the Tabprix Primary School, Krabi: 4487; Tam Chang Sri, Krabi: 4330; Tam Phet, Aowluk, Krabi: 3831; Tam Sra Yoong Thong, Aowluk, Krabi: 3819; Wat Tam Sue, Krabi: 3834, 3994 (Fig. 6H), 4331, 4486.

Shell: Shell small to medium, depressed, slightly thin, widely umbilicate. Apex acute; spire flat to little elevate. Whorl 5 to 6 convex, increasing regularly; suture wide and depressed; last whorl rounded. Shell surface with thin growth lines. Shell colour uniform brownish, dark brown to blackish and rarely with brownish zigzag pattern. Ventral side with paler colour than dorsally; on periphery with narrow dark peripheral band. Periostracum thin corneous and transparent or thick brown. Collar with 2 or more times longer than aperture width, curved and descending, which aperture opened ventrally. Aperture rounded and whitish; lip thickened and little expanded. Siphon tubular shape, which long, whitish and frequently tip of tube attached to last whorl. Operculum thick calcareous, cap shaped with anti-clockwise multilamellar.

Radula: Teeth arrangement with central, lateral and marginal teeth shape almost similar to *R. housei* (Fig. 9F).

Distribution: The previous recorded of *R. jalorensis* were from the type locality (Biserat, Jalor; former name of Yala Province, Thailand), and Koh Si-Hah, Singgora (=Songkhla, Province) (Sykes, 1903; Laidlaw, 1928; Salisbury, 1949). The recent collections are mainly from western part of the peninsular Thailand in Suratthani, Pangnga and Krabi Provinces.

Remarks: Shell variation is recorded in specimens from Tam Nam Pud, Pangnga (Fig. 6H) exhibit a longer collar and darker shell colour than the typical specimens (Fig. 6G, H). However, with the long complete siphon and monochrome brownish to blackish shell colour suggested the typical characteristic of *R. jalorensis*.

Rhiostoma tigris Tongkerd & Tumpeesuwan n. sp.

Etymology: The specific name "*tigris*" comes from Latin word "*tigris*" means 'tiger'. It refers to the brownish streak shell colour pattern of this new species, which is similar to the blackish streak pattern of the Bengal Tiger (*Panthera tigris tigris* (Linnaeus, 1758)).

Diagnosis: This new species differs from *R. jalorensis* and *R. chupingense* by having slender shell, with variegate brownish zigzag pattern and short to long complete siphon. It differs from *R. asiphon* and *R. samuiense* by having slender shell, relatively larger shell, longer collar, complete siphon, and performs a dark brown zigzag patterns.

Shell: Shell small to medium, depressed, slightly thin and widely umbilicate. Apex acute with dark colour; spire nearly flat. Whorl 4 to 5 convex, increasing regularly; suture wide and shallow; last whorl rounded and slender. Shell surface with thin growth lines. Shell whitish with variegated brownish to dark brown zigzag pattern, which faded in ventral side; on periphery with black peripheral band. Periostracum thin, corneous and transparent. Collar slender and around 1-2 times or more longer than aperture width, curved and descending. Aperture rounded, whitish; lip little thicken and expanded. Siphon with complete tubular with short or long and straight. Operculum thick calcareous, and cap shaped with dense or loose anti-clockwise multilamellar.

Remarks: *Rhiostoma tigris* n. sp. is superficially resembled to *R. jalorensis*, the distinguished characters other than shell morphology is an geographically separation in the north and south.

Rhiostoma tigris tigris s. str.
(Figures 6J-N, 9G)

Type material: Holotype CUMZ 4495 (Fig. 6J); type locality: Tam Phra Bampenboon, Phan, Chiengrai (19° 42' 48.8" N, 99° 45' 17.4" E). Paratype CUMZ 3914, 4495, 4496 (Fig. 6K), and two paratype specimens deposited in AMNH, BMNH, MNHN, NMNH, NMW, RBINS, SMF.

Other material examined: B. Degerbøl Coll. in ZMUC from Chieng Dao, North Thailand (1 spec. at 400 m, and 2 spec. at 1100 m). Tam Lod National Park, Maehongsorn: 4327; Tam Pang Kham, Maehongsorn: 4342; Tam Pha Daeng, Pang Mapha, Maehongsorn: 4439; Tam Pha Mon, Maehongsorn: 4343; Tam Sam-ta, Maehongsorn: 4441; Khao Tam Phra, Muang, Chiangrai: 3915; Tam Mae Suay, Mae Suy, Chiangrai: 3907, 4345; Tam Pha Cha-rui, Padad, Chiangrai: 4435; Tam Pha Chom, Maesai, Chiangrai: 3967, 4347; Tam Pum - Tam Pla, Maesai, Chiangrai: 3909, 3965, 3966; Tam Sao Hin, Maesai, Chienrai: 3906, 4442; Wat Tam Pla, Maesai, Chiangrai: 3913, 4346, 4497 (Fig. 6L); Pa Sak Ngam, Mae Tang, Chiangmai: 4754; Tam Brichinda, Inthanon National Park, Chiangmai: 4344; Tam Bua Tong, Mae Tang, Chiangmai: 4437, 4783; Tam Chiangdao, Chiangmai: 3911, 4438, 4499 (Fig. 6M); Tam Muong On, Mae On, Chiangmai: 3976, 4349, 4436, 4498 (Fig. 6N), 4731, 4763;

Shell: Shell morphology as in species description. The distinct characters are: collar slightly short slender almost same length as aperture width, little curved and not descending. Siphon complete tubular shape, straight, and tip of tube often attached to last whorl. Operculum thick calcareous, and cap shaped with dense anti-clockwise multilamellar.

Radula: Teeth arrangement with lateral and marginal teeth shape almost similar to *R. housei*. Major differences: central tooth with well develop central cusp, which flanked with 3 tapered in size lateral cusps on each side (Fig. 9G). Central cusp largest and with dull tip; four lateral cusps on both side performed triangular shaped and pointed head; outer most cusp very small to nearly wanting.

Distribution: This new subspecies is mainly distributed in the northern Thailand in Chiangrai, Maehongsorn, Chiengmai, Prayao and Nan Provinces.

Remarks: The nominotypical subspecies have broad variation in the length of collar compared to the aperture width. The first form has collar longer than aperture width (Fig. 6J, K), second form has collar equivalent to aperture width (Fig. 6M, N) and third form has collar shorter than aperture width (Fig. 6N). The length of collar can be varied from short to long with in single locality. However, the slender whorls, short to long complete siphon and shell colour

with clear brownish zigzag patterns are invariable, and suggested there are closely related.

Rhiostoma tigris lannaensis Tongkerd & Tumpeesuwan n. sp.
(Figures 6O-Q, 9H; Table 2)

Type material: Holotype CUMZ 4500 (Fig. 6O); type locality: Ping Klong village, Chiengdao, Chiengmai (19° 30' 48.6" N, 99° 03' 21.1" E). Paratype CUMZ 3910, 4350, 4500, 4701 (Fig. 6P), and two paratype specimens deposited in AMNH, BMNH, MNHN, NMNH, NMW, RBINS, SMF.

Other material examined: Pang Mapha, Maehongsorn: 4341; Tam Mae Lana, Pai, Maehongsorn: 4440, 4464, 4702 (Fig. 6Q); Ban Huay Ja-karnt, Chiengdao, Chiangmai: 4737; Km 43th reach Chiengdao, Chaiprakan, Chiangmai: 4348, 4738; Tam Klapp, Chiengdao, Chiangmai: 3908; Tam Tap Tao, Chaiprakarn, Chiangmai: 3912.

Etymology: The specific name "*lannaensis*" is derived from the Thai word "*Lanna*", the name of historical empire in northern Thailand. It refers to the type locality of this new species from Chiangmai Province, where it is capital of the Lanna Empire (from 11st - 18th century).

Diagnosis: It can be distinguished from the nominotypical subspecies by having small last whorl, collar extremely long, curved and descending, and operculum having looser multi-lamellar.

Shell: Shell morphology as in species description. The distinguished characters are: medium to large shell, collar usually with two or more times longer than aperture width, slender, curved and descending, which aperture opened ventrally. Siphon usually complete tubular shape and not attached to last whorl. Operculum thick calcareous, and cap shaped with wide anti-clockwise multilamellar.

Radula: Teeth arrangement with central, lateral and marginal teeth shape almost similar to the nominotypical subspecies. The little difference is varying of 5 to 7 central tooth cusps number, which the outer most lateral cusp very small and some time wanting (Fig. 9H).

Distribution: This new subspecies has narrow range in Chiengmai, Chiengrai and Maehongsorn Provinces.

Remarks: Shell variation can be observed in this ubspecies byt the length of the siphon vary from short siphon (Fig. 6P) to long siphon (Fig. 6Q). However, with

a long and slender collar, brownish zigzag pattern of the shell, and loosed multispiral operculum are suggested that the same taxa.

Rhiostoma aquilozonatus Tongkerd & Panha n. sp.
(Figures 7A-C, 9I; Table 2)

Type material: Holotype CUMZ 4703 (Fig. 7A) from type locality: Tam Pha-Poo, Muong, Loei (17° 34' 43.2" N, 101° 42' 37.9" E). Paratype CUMZ 3886, 3887, 3916, 4704 (Fig.7B), 47663, and five paratype specimens deposited in AMNH, BMNH, MNHN, NMNH, NMW, RBINS, SMF.

Other material examined: Tam Pha Toop, Nan: 3939, 4351; Tam Kuhawaree, Nong Hin, Loei: 3925, 3940, 3946; Tam Pha Band, Chiengkan, Loei: 4444; Tam Pha Bing, Wangsapung, Loei: 3928; Wat Tam Phupha Lom, Loei: 4443; Khao Wangpha, Nawang, Nongbualumphu: 3935; Wat Suwankuha, Nongbualumphu: 3889, 3930, 3933, 4778; Tam Phraya Nakarat, Phuphaman, Khonkaen: 3929; Tam Poo-loop, Phuphaman, Khonkaen: 3931;

Etymology: The specific epithet *aquilozonatus* is derived from Latin words '*aquilus*' mean 'dark colour or blackish', and '*zona*' mean 'belt of girdle'. This name is referred to the wide and blackish peripheral band, which is the distinct character of this species.

Diagnosis: This new species is superficially similar to *R. jalorensis* and *R. tigris* n. sp., but the distinction are shorter collar, complete siphon usually attached to the last whorl, shell colour monochrome brownish to dark brown, and a wide black to dark brown peripheral band. It differs from *R. housei* and *R. marioni* by having a slender collar, without shell colour pattern (sometime with pale brownish zigzag patterns), and wide dark peripheral band on periphery.

Shell: Shell small to medium, depressed, slightly thin, widely umbilicate. Apex acute with dark colour; spire nearly flat. Whorl 4 to 5 convex, increasing regularly; suture wide and shallow; last whorl rounded. Collar short, around 1 to 2 times longer than aperture width. Shell surface with thin growth lines. Periostracum thin, corneous and transparent. Shell colour with brownish growth line or pale variegated brownish zigzag pattern, which faded in ventral shell; periphery with wide blackish peripheral band. Aperture rounded; lip little thicken and expanded. Siphon form whitish and long tubular shape, curved posteriorly and often tip of tube attached to last whorl. Operculum calcareous, thicken, with anti-clockwise, cap shaped multi-lamellar.

Radula: Teeth arrangement with central and marginal teeth shape almost similar to the nominotypical subspecies. The difference is long slender cusps on the

outer marginal teeth (Fig. 9I). Lateral teeth composed of 3 cusps, central cusp largest and elongate shape with dull head, flanked with relatively small with point tip of inner and outer lateral cusps.

Distribution: This new species is known from the limestone outcroups in Loei, Nongbualumphu, Phetchaboon and Khonkaen Provinces.

Remark: Shell variation within species is known in the specimens, which have very short collar, and stout shell (Fig. 7C) than the typical specimens. However, with the prominent wide dark peripheral band suggested to be more related to this species.

With the blackish to brownish shell colour, this new species is superficially similar to *R. tigris*. With a wide blackish peripheral band, apart of the geographic distribution between these two species suggested a clearly species separation.

Rhiostoma furfurosus Tongkerd & Panha n. sp.
(Figures 7D, E, 10A; Table 2)

Type material: Holotype CUMZ 4705 (Fig. 7D); type locality: Tam Wang Daeng, Nernmaprang, Phitsanuloke (16° 41.1' 40.1" N, 100° 40' 42.5" E). Paratype CUMZ 3901, 3903, 3904, 3905, 4447, 4705, 4706 (Fig. 7E), 4727, and five paratype specimens deposited in AMNH, BMNH, MNHN, NMNH, NMW, RBINS, SMF.

Other material examined: Tam Pha Thaphol, Nernmaprang, Phitsanuloke: 3821, 4359; Tam Tao, Nern Maprang, Phitsanuloke: 3902; Wat Pa Mamuong, Nernmaprang, Phitsanuloke: 3980, 4446, 4761.

Etymology: The specific name "*furfurosus*" come from Latin "*furfurosus*" meaning 'brownish'. It refers to the prominent character of brownish shell colour, which can be distinguished from the two peripheral species *R. housei* and *R. aquilozonatus*.

Diagnosis: This new species differs from *R. housei* by having, slender whorls, collar short, incomplete tubular or slit-knob siphon shapes, brownish to brownish-red sometime with zigzag pattern. It differs from *R. breviocollar* by having slightly long and slender collar, and reddish-brown shell colour. The distinction from *R. aquilozonatus* by slightly larger shell, incomplete tubular shaped siphon, and with narrow to absent peripheral band.

Shell: Shell medium, depressed, slightly thick and widely umbilicate. Apex acute with dark colour; spire little convex. Whorl 5 to 6 convex, increasing

regularly; suture impressed and wide; last whorl rounded and slender. Shell surface smooth or with thin growth lines. Shell colour with uniform brownish to reddish, some time with thin zigzag brownish patterns; on periphery with or without narrow blackish peripheral band. Periostracum slightly thin and corneous. Collar with usually shorter than apertureral width. Aperture rounded; lip thicken and little expanded. Siphon form incomplete tubular or slit-knob shaped. Operculum thick calcareous, and cap shaped and with anti-clockwise multilamellar.

Radula: Teeth arrangement with central and marginal teeth shape almost similar to the nominotypical subspecies. The difference is lateral teeth composed of 3 cusps, central cusp largest and elongate shape with dull head, flanked with relatively small with point tip of inner and outer lateral cusps (Fig. 10A).

Distribution: This new species are known from several localities in central Thailandin Phitsanuloke, Chaiyapoom, and Phetchaboon Provinces.

Remarks:

Rhiostoma haughtoni Benson, 1860
(Figure 7F-I; Table 2)

Rhiostoma haughtoni Benson, 1860: 96, 97. Type locality: ad cavernam Damatha, non procul ab urbe Moulmein. Stoliczka, 1871: 150. Kobelt & Möllendorff, 1897: 115. Kobelt, 1902: 177, 178, fig. 38. Kobelt, 1911: 759, 760, pl. 110, fig.14; pl. 111, figs 14-16. Gude, 1921: 128-129, fig. 22. Wenz, 1938: 462, fig. 1166. Rees, 1964: 67, pl. 4, fig. 14.
Pterocyclus (Rhiostoma) haughtoni—Henley & Theobald, 1870: 3, pl. 5, fig. 10. Nevill, 1878: 262.
Pterocyclos haughtoni—Reeve, 1863: pl. 5 species 30.

Material examined: Two specimens in the type series of W.H. Benson ex. R. MacAndrews collection (see also Naggs, 1997), the specimens with similar shape, size and colour to the original description is designated here as the lectotype of "*haughtoni*" UMZC xxxx (Fig. 7F), and paralectotype UMZC xxxx (Fig. 7G). Damaltha, Burma BMNH 88.12.4.1985-6 (marked specimen was figured in Gude, 1921, fig. 22) (Fig. 7H, I). Moulmein, Tenasserim, Burma: BMNH 75.06.5.5 (4 shells); 1566.03.VII.I (2 shells); E.R. Sykes coll., acc. 1825 (1 shell); H. Cuming coll. (1 shell); T. Oldham coll. (1 shell). Samatha, Burma: BMNH McAndrew coll. (4 shells).

Shell: Shell small depressed, thick, widely umbilicate which present all preceding whorls; apex acute. Whorl 5 to 6 convex, increasing regularly; suture

wide and depressed; last whorl rounded. Shell surface with thin growth line. Periostracum thin corneous or brownish and transparent. Shell colour with variegated dark brown zigzag streak; ventral shell with paler to whitish colour; on periphery with dark and narrow band. Collar slender and short to similar length to apertural width. Aperture rounded whitish, thickened and little expanded. Siphon short and whitish tubular shape. Operculum thick calcareous, cap shaped and with anti-clockwise multilamellar.

Distribution: None of subsequent specimens with precise locality had been records for this species. It is known from the type locality (Benson, 1860) and a few placed ranged from Moulmein to Tenasserim of Burma (Stoliczka, 1871; Gude, 1921).

Remark: Shell variation of *R. hughtoni* can vary from brownish peripheral band and variegated zigzag patterns to monochrome brownish or whitish without peripheral band (Fig. 7G, I). The major distinctive characteristic from *R. housei* and *R. tigris* n. sp. are the slightly shorter and slender collar, short tubular shaped of siphon, small shell size, and usually with out dark brownish pattern on the upper surface.

Rhiostoma strubelli Möllendorff, 1899
(Figure 7J)

Rhiostoms strubelli Möllendorff, 1899: 166. Type locality: Kalow, S-Shan States, Burma. Kobelt, 1902: 179. Kobelt, 1911: 763, pl. 113, fig. 11.

Material examined: Holotype SMF 130513 (Fig. 7H).

Shell: Shell small depressed, thin, dextral, widely umbilicate which present all preceding whorls; apex acute. Whorl 5 to 6 convex, increasing regularly; suture wide and little depressed; last whorl rounded. Shell surface with thin growth ling. Collar slender, short to similar length to apertural width. Periostracum thin corneous or brownish and transparent. Shell colour with variegated dark brown zigzag pattern, which dorsally darker colour than ventrally; with lightly dark peripheral band. Aperture rounded whitish, little expanded, thickened. Siphon long, whitish, rounded, little curved and frequently attached to penultimate whorl. Operculum calcareous, thick, cap shaped and with anti-clockwise multispiral.

Distribution: This species was known only from the type locality.

Remarks: Based on solely the type specimen, *R. strubelli* can be distinguished from *R. haughtoni* by having small shell, short collar incomplete siphon and

with brownish zigzag pattern, while the latter species perform slightly larger shell, longer collar, cannel shaped siphon, and monochrome shell colour. Because of an inadequate specimens, the specific status and distribution range of the species still hesitation. Until enough subsequent specimens with precise locality are available for clarified it taxonomic status and distribution range.

Rhiostoma samuiense Tomlin, 1932
(Figures 4D, 7K, 10B; Table 2)

Rhiostoma samuiense Tomlin, 1932: 227-228 (with 2 figures). Type locality: Samui Islands, Gulf of Thailand.

Material examined: Two lots of the syntypes in Melvill-Tomlin collection, a figured specimen in the original description (plate 26 (shell)) is designated here as lectotype of '*samuiense*' NMW 1955.158.1104 (Fig. 7K), and paralectotype NMW 1955.158.1105 (6 shells) (Fig. 7L). Fulton coll., ex. Anet, ex. T. Pain coll. from Kaw Samui NMW 2.1981.118.20704 (?syntype, 1 shell). Hin Lad Waterfall, Samui, Suratthani: 3864, 3959, 4373, 4413; Koh Samui, Suratthani: 4307, 4332, 4333, 4334, 4335, 4397; Koh Tan, Samui, Suratthani: 3863, 3890, 4382, 4415, 4432, 4707; Koh Wangnok, Khanom, Suratthani: 3885, 3891; Na Muang Waterfall, Samui, Suratthani: 3862, 3958, 3989, 4780;

Shell: Shell small, depressed, slightly thin, and widely umbilicate. Apex acute; spire little elevated. Whorl 4 to 5 convex, increasing regularly; suture wide and shallow; last whorl rounded and slender. Shell surface with thin growth lines. Shell colour uniform brownish to purplish (rarely with brownish zigzag patterns); peripheral band absent or present with narrow and thin band. Periostracum thicken with brown to blackish, ventral side usually worn out. Collar slightly long almost same length to aperture width, and little descending. Aperture rounded and whitish; lip thickened and little expanded. Siphon form small notch shape. Operculum thick calcareous, cap shaped with anti-clockwise multilamellar.

Radula: Teeth arrangement with central and marginal teeth shape almost similar to *R. housei*. Major differences: lateral teeth composed of 3 cusps; central cusp largest, elongate and convex head flanked with relatively small and pointed head of lateral cusps (Fig. 10B).

Distribution: The previous records, of the species were only form the type locality from Samui Island, Suratthani, Gulf of Thailand. *Rhiostoma samuiense* and *R. asiphon* have been reported from the same geographical area as Samui Islands, Thailand, however, our recent collection entire their range found none of these two species were sympatric. Therefore, *R. samuiense* is seemed to be

limited distribution on Samui Island and its satellite islands nearby, while *R. asiphon* were restricted on the limestone islands, northwest of Samui Island.

Remark: This species have similar morphology to *R. asiphon* and *R. chupingense*. However, it differs from the former species by having longer and curved collar, smaller shell size and dark brown periostracum, and differences from the latter species by having smaller shell size, thinner shell, thick dark brown periostracum, and short collar.

Rhiostoma chupingense Tomlin, 1938
(Figures 4E, 7O-R, 10C; Table 2)

Rhiostoma chupingense Tomlin, 1938: 73, pl. 2, figs 1, 2 (Type locality: Bukit Chuping, Perlis, Malaysia). Berry, 1963: pl. 4, fig. 28 (poor drawing shell).

Material examined: Holotype BMNH 1938.10.25.1 (Fig. 7O); paratype NMW 1955.158.0395 (3 shells), and NMW 2.1981.118.02703 (1 shell). Bukit Chuping, Perlis, MALAYSIA: 3844, 3996, 4746, 4768; Gua Kelam, Perlis, MALAYSIA: 3847; Sungi Jenis, Perlis, MALAYSIA: 3850, 3977 (Fig. 5G); Khao Ma-rong, Bang Sapan, Prachuapkhirikhan: 3865, 3874, 3986, 4477, 4720, 4739; Ban Nasarn, Suratthani: 3842, 4305, 4395; Donsak, Suratthani: 4308, 4309; Donsak Pier, Donsak, Suratthani: 3948; Khao Chang, Donsak, Suratthani: 3866; Khao Chokchae, Suratthani: 4306; Khao Pra, Donsak, Suratthani: 4777; Khao Sai, Donsak, Suratthani: 3992, 4759; Tam Kha-min, Nasarn, Suratthani: 4310; Tam Khiriwong, Donsak, Suratthani: 3811, 4776; Wat Tam Por Ngam, Donsak, Suratthani: 3873; Wat Tam Yai, Thachana, Suratthani: 3990, 4476, 4722, 4769; Samet Chunsatarn Waterfall, Nakhonsrithammarat: 4773; Tam Khao Klod, Kanom, Nakhonsrithammarat: 3944, 4000; Tam Wang Thong, Khanom, Nakhonsrithammarat: 3820, 3949, 4311, 4388, 4708, 4781; Wat Tam Khao Daeng, Ronphoboon, Nakhonsrithammarat: 3838; Khao Poo Khao Ya National Park, Patthalung: 3995, 4304, 4375, 4399; Wat Khao Huay Haeng, Huay Yod, Trang: 3840, 3846, 3945, 3993, 4774; Khao Loop Chang, Padang Bersa, Songkhla: 3849, 4479; Tam Sri Kesorn, Ratthaphum, Songkla: 4488.

Shell: Shell small to medium, depressed, thick to slightly thin, widely umbilicate. Apex acute with dark colour; spire little elevated to nearly flat. Whorl 4 to 5 convex, increasing regularly; suture wide and shallow; last whorl rounded. Shell surface with thin growth lines. Shell colour uniform brownish to purplish (rarely with brownish zigzag pattern); with narrow dark brown peripheral band. Periostracum thin, brownish and transparent. Collar longer around 1 to 2 times than aperture width, curved and little descending. Aperture rounded; lip thickened and expanded. Siphon form small notch shape. Operculum thick calcareous, cap shaped with anti-clockwise multilamellar.

Radula: Teeth arrangement with central, lateral and marginal teeth shape almost similar to *R. housei* (Fig. 10C).

Distribution: The previous records of this species were from the type locality in Malaysia, and in Songkhla Province, Thailand (Tomlin, 1938; Patamakanthin, 2001). In Thailand, *R. chupingense* has widely distributed in the eastern part of southern peninsular ranged from Suratthani to Patthalung, Trang, Nakhonsrithammarat and Songkhla Provinces. The northern limited of this species is probably at Donsak, Suratthani down south to the eastern of the peninsular Malaysia.

Remark: The lectotype of *R. chupingense* was a juvenile specimen, which apertural lip, siphonal shaped and operculum characteristic were ambiguous. This recent collection, the topotypic specimens showed that *R. chupingense* has a notch shape siphon, thicken apertural lip and calcareous, cap-shaped operculum.

Shell variations within species were detected in specimens from Thailand, which seem to have thicker and darker shell, and with narrowly dark brown peripheral band. However, a long collar, and notch shaped siphon are the typical characteristic of *R. chupingense*.

Rhiostoma parahainesi Tongkerd & Panha n. sp.
(Figures 7S, T, 8A, 10D; Table2)

Type material: Holotype CUMZ 4709 (Fig. 7S); type locality: Tam Sri-Thong, Klong Had, Chanthaburi: (13° 28' 731" N, 102° 17' 025" E). Paratype CUMZ 3858, 4710 4710 (Fig. 7T), and three paratype specimens deposited in AMNH, BMNH, MNHN, NMNH, NMW, RBINS, SMF, UMZC.

Other material examined: Khao Chakan, Srakeo: 3806, 3830, 4369, 4370, 4735; Khao Siwa, Srakeo: 4371; Tam Leaom, Klong Had, Chanthaburi: 3852;Khao Chamao Khao Wong, Kaeng Haeng Maew, Rayong: 3808, 3851, 3857, 3923, 4368, 4711, 4725;

Etymology: The specific name "*parahainesi*" come from Greek word "*para*" meaning 'beside or near', and "*hainesi*" a specific name of *Rhiostoma*. It refers to the geographic proximity of this new species and *R. hainesi*.

Diagnosis: This new species differs from *R. hainesi* and *R. simplicilabre* by having smaller shell size, slender whorls, siphon very short and form canal-like shaped, longer collar, colour light brown with zigzag pattern on periphery, periostracum corneous transparent, and lip thicken little expanded. It differs

from *R. housei* by having smaller shell, longer and descending collar, and canal shaped siphon.

Shell: Shell medium, depressed, slightly thin and widely umbilicate. Apex acute with dark colour; spire little convex. Whorl 5 to 6 convex, increasing regularly; suture impressed and wide; last whorl rounded and slender. Shell surface nearly smooth with thin growth lines. Shell colour whitish with brownish zigzag pattern or uniform brownish; ventral side with paler colour or whitish; on periphery with wide dark brown peripheral band. Periostracum thin with brownish. Collar with around 1 to 2 times longer than apertureral width. Aperture rounded; lip thicken and little expanded. Siphon form canal or notch shaped. Operculum thick calcareous, and cap shaped and with anti-clockwise multilamellar.

Radula: Teeth arrangement with central, lateral and marginal teeth shape almost similar to *R. housei*. The difference: central cusp of central teeth with curved shaped (Fig. 10D).

Distribution: This new species are known from several localities in the eastern Thailand near Cambodia border: Srakeo, Chanthaburi and Rayong Provinces.

Remark: There are 3 species, *R. hainesi*, *R. cambodjensis* and *R. parahainesi*, mainly distributed in the eastern part of Thailand. From our investigation through there distribution ranges found no sympatric populations. Except only single record of adjacent population between *R. cambodjensis* and *R. parahainesi* inhabit in lime stone outcrop in Khao Chakan, Srakeo Province. This new species are frequently occupy the northern side habitat of the mountain, while *R. cambodjensis* is commonly occurs in the southern flank of the same mountain.

Rhiostoma proboscidus Tongkerd & Panha n. sp.
(Figures 3G, 4F, 8B-E, 10E; Table 2)

Type material: Holotype CUMZ 4712 (Fig. 8B); type locality: Khao Phanomwang, Kanchanadit, Suratthani (9° 00' 44.17" N, 99° 32' 10.77" E). Paratype CUMZ 3833, 3835, 3895, 3991, 4361, 4362, 4392, 4396, 4398, 4471, 4472, 4473, 4474, 4475, 4712, 4713 (Fig. 8C-E), 4721, 4741, 4782, 4785 and five paratypes deposited in AMNH, BMNH, MNHN, NMNH, NMW, , SMF.

Other material examined: Khao Kra Dae, Sichon, Suratthani: 3869; Tam Khuha, Kanchanadit, Suratthani: 4481; Khao Chang, Sikid National Park, Nakhonsrithammarat: 3894, 3896; 3999, 4786; Khao Hu-tu, Sichon,

Nakhonsrithammarat: 3871; Khao Nam-rak, Sikid National Park, Nakhonsrithammarat: 3893, 3998, 4757.

Ethymology: The specific name "*proboscidus*" is derived the Latin word "*proboscis*" mean 'trunk of an elephant or snout'. It refers to the distinguished characters of extremely long and curved collar of this new species, which is similar to the proboscis of an elephant.

Diagnosis: This new species can be distinguished form *R. chupingense* and *R. samuiense* by having the peculiar long and descending collar, and having larger shell sized and transparent periostracum than the latter species. It differs from *R. housei* and *R. jalorensis* by having a notch shaped siphon, purplish shell colour, and proboscis like collar.

Shell: Shell small to medium, depressed, thicken, widely umbilicate. Apex acute with darker colour; spire little elevated to nearly flat. Whorl 5 to 6 convex, increasing regularly; suture wide and shallow; last whorl rounded. Shell surface with irregular growth lines. Shell colour uniform brownish to purplish (rarely with variegated pattern); narrow and thin brownish peripheral band present. Periostracum thin corneous to brownish. Collar extremely long around 3 or more times longer than apertural width, curved, descending, and twisted whose aperture turned to open posteriorly. Aperture rounded; lip thickened and little expanded. Accessory breathing pore form small notch shaped. Operculum thick calcareous and cap shaped with anti-clockwise multilamellar.

Radula: Teeth arrangement with central, lateral and marginal teeth shape almost similar to *R. housei* (Fig. 10E).

Distribution: This new species is known from several localities in Suratthani and Nakhonsrithammarat Provinces.

Remark: This new species is strikingly different from all other known species in the Southern Thailand and Peninsular Malaysia, while the monochrome brownish to purplish shell colour, notch shaped siphon and geographic adjacent are suggested a closely relationship to *R. chupingense*. However, with an extremely long, curved collar and aperture turned down to open posteriorly (like proboscis of an elephant) are garter than the shell variation. In addition, the preliminary allozyme and chromosome studies show vast difference in alles frequency and karyotypic patterns, which is the distinction between the two species (Panha, unpub. data).

Rhiostoma cambodjensis (Morelet, 1875)
(Figures 8F-I, 10F; Table 2)

Pterocyclus cambodjensis Morelet, 1875: 286, 287, pl. 13, fig. 1. Type locality: Battambang.

Opisthoporus pulchellus Morlet, 1889: 154, 188-189, pl. 6, fig. 5. Type locality Mount. Sisophon (Siam). Fischer, 1891: 100. Kobelt & Möllendorff, 1897: 119. Morlet, 1904: 376, 377, pl. 21, figs 6, 6a. Fischer & Dautzenberg, 1904: 427.

Opisthoporus cambodjensis—Fischer & Dautzenberg, 1904: 427.

Cyclotus (Siphonocyclus) pulchellus—Kobelt, 1902: 210. Kobelt, 1911: 815, pl. 121, figs 1, 2.

Rhiostoma cambodjense—Kobelt, 1902: 177. Kobelt, 1911: 763, 764, pl. 113, figs 14-16.

Material examined: Holotype of "*cambodjensis*" BMNH 93.2.4.766 (Fig. 8F); holotype of "*pulchellus*" MNHN (Fig. 8G). Khao Chakan (North), Srakeo: 3810, 3853, 3854, 3856, 3860, 4714, 4734.

Shell: Shell small, convex, thick or thin, narrow and deep umbilicus. Apex acute with dark colour; spire elevated. Whorl 4 to 5 convex, increasing regularly; suture wide, shallow and with whitish subsutural band; last whorl rounded. Shell surface nearly smooth with thin growth lines. Shell colour uniform brownish, blackish or with brownish zigzag pattern; ventral side with lighter colour; on periphery with narrow dark peripheral band. Periostracum thin, corneous and transparent. Collar absent to extremely short. Aperture rounded and whitish; lip little thickened and expanded. Siphon form canal shape. Operculum thick calcareous, and cap shaped with anti-clockwise multilamellar.

Radula: Teeth arrangement with central and marginal teeth shape almost similar to *R. housei*. Major differences: lateral teeth composed of 3 cusps; largest, elongate shape and convex head central cusp flanked with small and pointed head of lateral cusps (Fig. 10F).

Distribution: The previous records of this species were from Cambodia (Morelet, 1875; Morlet, 1889; Kobelt, 1910). The recent recorded of this species is from an isolated limestone outcrops in Srakeo Province near Thai-Cambodia border.

Remarks: The type specimen of "*Opisthophorus pulchellus* Morlet, 1889" was recorded from Mount Sisophon, Cambodia, which was very closed to the type locality of *R. cambodjensis* in Battambang, Cambodia (Morelet, 1875; Morlet, 1889). Moreover, "*O. pulchellus*" perform shell characters very resembles to that of *R. cambodjensis* as small shell size, elevated spire, very short collar, and canal shape siphon, but only brownish colour pattern is a difference character.

However, the types specimens of *R. cambodjensis* seem to be a worn out and erodes prismatic shell layer, where only pale traces of shell pattern remained on the dorsal shell. Therefore, we concluded that "*O. pulchellus*" is an intact form of *R. cambodjensis*.

This species are mainly distributed in the eastern Thailand and in Cambodia. However, the peculiar disjunct distribution in Tam Phra Sabai, Phare (CUMZ , 3 shells) are still curious. For primarly, identification with the shell characteristic suggested this population belong to this species.

Rhiostoma asiphon Möllendorff, 1893
(Figures 8J, K, 10G; Table 2)

Rhiostoma asiphon Möllendorff, 1893: 142. Type locality: Insel Samui, Golf von Siam. Möllendorff, 1894: 152, 153, pl. 16, figs 16, 17. Fischer & Dautzenberg, 1904: 427. Kobelt, 1902: 176. Kobelt, 1911: 760, 761, pl. 111, figs 4-8. Benthem Jutting, 1960: 11.

Material examined: Lectotype SMF 130509 (Fig. 8J), paralectotype SMF 130510, 130511, 130512 (designated by Zilch (1956: 174)). Koh Wua Talup, Angthong National Park, Suratthani: 3872, 4365, 4400, 4715, 4730, 4767; Koh Sam Sao, Angthong National Park, Suratthani: 3892, 4756.

Shell: Shell medium to small, depressed, thicken, widely umbilicate. Apex acute with dark colour; spire nearly flat to little elevate. Whorl 4 to 5 convex, increasing regularly; suture wide and very shallow; last whorl rounded and stout. Shell surface with thin growth lines. Shell colour uniform brownish to purplish, ventral shell with lighter colour than dorsally; peripheral band sometime absent or present with thin and narrow band. Periostracum corneous to brownish and translucent. Collar extremely short to absent. Aperture rounded; lip thickened and expanded. Siphon form triangular notch shape, which appeared near suture. Operculum thick calcareous, cap shaped with anti-clockwise multilamellar.

Radula: Teeth arrangement with lateral and marginal teeth shape almost similar to *R. housei*. Major differences: central tooth with well develop central cusp, which flanked with 3 tapered in size lateral cusps on each side (Fig. 10G). Central cusp large, long and with blunt tip; six lateral cusps on both side perform triangular shaped with pointed head.

Distribution: Rhiostoma asiphon tended to have limited distribution from the type locality (Möllendorff, 1894), and on the limestone islands, Northwest of Samui Island, Suratthani, Thailand.

Remarks: Under the nominal species name '*Rhiostoma asiphon* [not Möllendorff, 1894]' have been reported from many localities on the Peninsular Malaysia (Benthem Jutting, 1960; Berry, 1963; Chang, 1997). However, we have revisited all placed, and found no specimens could be strictly identified as *R. asiphon* Möllendorff, 1894. Conversely a number of *Pterocyclus* sp., commonly snail in those all localities, are collected, and there shell morphology are superficially similar to the *R. asiphon* s.s. However, this species exhibit an expanded wing at siphonal area and with groove inside shell closed to apertural lip, and with plate-like operculum. These contrasted to the characteristic of *Rhiostoma* (Table 1) and the type specimens of *R. asiphon* (Fig. 8J). Therefore, we supposed that '*R. asiphon* [not Möllendorff, 1894]', which reported by Benthem Jutting (1960), Berry (1963) and Chang (1997) were an erroneous identified specis and confused with the species of *Pterocyclus* sp. These *Pterocyclus* specimens seem to be an undescribed species, because it has long been recognize as '*R. asiphon* [not Möllendorff, 1894]'.

The topotypic specimens can vary from an absent to short collar, and uniform purplis to light brownis shell colour. Although, *R. asiphon* is similar to *R. chupingense*, *R. proboscidius* n. sp. and *R. samuiense* with uniform purplish shell colour, and notch shape siphon. It still differs from the first two species by very short to absent collar compared among them. In addition, *R. samiense* perform a long collar, smaller shell size and thicken periostracum, which contratst to R. siphon.

Rhiostoma morleti Dautzenberg & Fischer, 1906 [1905]
(Figure 8L-M)

Pterocyclus planorbulus Morlet, 1891: 247 (not Lamarck). Locality: Long-son.
Rhiostoma morleti Dautzenberg & Fischer, 1905: 429-431, pl. 10, figs 1-4. Type locality: Luang Prabang, Laos; Ha Giang, Tonkin. Kobelt, 1911: 755, 756, pl. 110, fig. 1-4.

Material examined: The figured specimen in Dautzenberg & Fischer (1905: figs 1-2) is designated here as the lectotype of '*morleti*' MNHN (Fig. 8L), and 2 shells in Dautzenberg coll. RBINS 658845 (Fig. 8M) as the paralectotype. Phong-Tho, Tonkin: SMF 130576

Shell: Shell medium to large, depressed, thicken, widely umbilicate. Apex acute with white or dark colour; spire mostly flat or little elevate. Whorl 4 to 5 convex, increasing regularly; suture wide and slightly deep; last whorl rounded and stout. Shell surface with thin growth lines. Shell colour varying from uniform whitish to brownish, or with variegated brownish pattern; ventral shell whitish and without pattern; peripheral band usually present with thick or thin dark brown band. Periostracum thick with corneous to brownish and translucent.

Collar short to absent. Aperture rounded with little projection at suture; lip thickened and little expanded. Siphon form cannel or incomplete shape with expanded at base near suture. Operculum thick calcareous, cap shaped with anti-clockwise multilamellar.

Distribution: This species has many recorded ranged in in Laos, Vietnam and Cambodia (Morlet, 1891; Dautzenberg & Fischer, 1905). In this study, Dautzenberg's collection at RBINS were collected from southern Laos, Cambodia and Vietnam. The ranged of this specie maybe restricted in the right bank of Mae Klong River.

Remarks: This species can be distinguished from *R. simplicilarbre*, and *R. marioni* by having more depressed to flatten spire, wider umbilicus, very short collar, and with incomplete siphon. While, the formers species perform and elevated spire, longer collar, and complete siphon. Rhiostoma morleti differs from R. cambodjensis by the latter species having smaller shell size, elevated spire, canal shped siphon, blackish apex, and collar usually absent.

Rhiostoma prestoni (Bavay & Dautzenberg, 1908)
(Figure 8N-P)

Pterocyclus prestoni Bavay & Dautzenberg, 1908: 248, 249. (Type locality: Binh-Lu, Tonkin). Bavay & Dautzenberg, 1909: 283, 284, pl. 11, figs 1-3. Kobelt, 1913: 969, 970, pl. 112, figs 5-7. Zilch, 1956: 172.
Pterocyclus prestoni var. *depicta* Bavay & Dautzenberg, 1908: 249. (Type locality: Phong-Tho, Tonkin). Bavay & Dautzenberg, 1909: 284, pl. 11, fig. 4. Zilch, 1956: 173. Kobelt, 1913: 970, pl. 112, figs 8-9.
Pterocyclus fruhstorferi Kobelt, 1909: 82. (Type locality: Chiem-hoa, Tonkin). Kobelt, 1911: 739, 740, pl. 107, figs 7-9. Zilch, 1956: 172.

Material examined: Holotype of '*prestoni*' MNHN (Fig. 8N), paratype RBINS 525354 (1 shell). Holotype of '*depicta*' MNHN (Fig. 8O), paratype RBINS 525355 (3 shells). Lectotype of '*fruhstorferi*' SMF 130353 (Fig. 8P), paralectotype SMF 130354 (designated by Zilch, 1956: 172). Trinh-Loung, Tonkin: SMF 130356; Muong-Hum, Tonkin: SMF 130357, 130358.

Shell: Shell medium to small, depressed, thicken, widely umbilicate. Apex acute with white or dark colour; spire mostly flat or little elevate. Whorl 4 to 5 convex, increasing regularly; suture wide and slightly deep; last whorl rounded and stout. Shell surface with thin growth lines. Shell colour varying from uniform brownish, or with variegated brownish pattern; ventral shell with paler colour; peripheral band usually absent or present with thin brownish band. Periostracum thick corneous to brownish. Collar absent. Aperture rounded; lip

thickened and little expanded. Siphon form cannel shaped and with expanded at base near suture. Operculum thick calcareous, cap shaped with anti-clockwise multilamellar.

Destribution: The precvious record of this species was mainly in Tonkin, Northern of Vietnam (Bavay & Dautzenberg, 1909; Kobelt, 1909, 1911)

Remark: This species has long been classified as member of the *Pterocyclus* (Kobelt, 1911; Zilch, 1956). However, the type specimens having anticlockwise muitispiral and calcareous cup-shape operculum, and apertural lip not expanded or perform wing shaped. These are the distinguished charactes of the *Rhiostoma* (Table 1).

Rhiostoma prestoni is very closely related to *R. morleti.* The differences between them are slightly smaller shell and cannal shaped siphon which attached to the last whorl of R. prestoni, while *R. morleti* having a lager shell, incomplete siphon and with very short collar.

However, most of the museum speciems are mostly from first half of 20th centuary and with imprecise localities. Pleanty of specimens in Dautzenberg Coll. (RBINS) are indicated that the canal shaped siphon and expanded siphoal area are strictly conserved. However, shell variation can be observed in the shell colour from monochrome writish, to with variegated brownish pattern, some are with narrow to wide blackish peripheral band.Therefore we recognized this species as separate species, until the newly additional specimens are available to clarify the systematics relationship of thses two species.

Rhiostoma pygmaeus Tongkerd & Panha n. sp.
(Figures 8Q-S, 10H; Table 2)

Type material: Holotype CUMZ 4716 (Fig. 8Q); type locality: Pha Chuu, Sri Nan National Park, Nan (18° 22' 4.6" N, 100° 50' 23.4" E). Paratype CUMZ 3922, 4716, 4717(Fig. 8R), 4718 (Fig. 8S), and three paratype specimens deposited in AMNH, BMNH, MNHN, NMNH, NMW, SMF.

Other material examined:

Etymology: The specific name "*pygmaeus*" come from Latin word "*pygmaeus*" mean 'dwarf'. It refers to the smallest shell size of the new species with in the genus.

Diagnosis: *Rhiostoma pygmaeus* n. sp. differs from all other recognized species by having smallest (Table). The distinction from *R. cambodjensis* other than shell sized are uniform shell colour with brownish pattern or monochrome whitish; while the latter species perform blackish upper spire.

Shell: Shell small, thin and widely umbilicus. Apex acute with dark colour; spire elevated. Whorl 4 to 5 convex, increasing regularly; suture wide and deep; last whorl rounded. Shell surface with thin parallel growth lines. Shell colour usually uniform whitish or brownish, or rarely with thin brownish pattern on dorsal side; on periphery with thin peripheral band or absent. Periostricum thick corneous or brownish. Collar very short to absent. Aperture rounded and whitish; lip little thickened. Siphon form canal shape. Operculum calcareous, and low-cap shaped with anti-clockwise multilamellar.

Radula: Teeth arrangement with central and marginal teeth shape almost similar to *R. housei*. Major differences: lateral teeth composed of 3 cusp, largest, elongate shape and pointed head central cusp flanked two tapered in size and pointed head of inner lateral cusps (Fig. 10H)

Distribution: This new species in known only from the type locality at base of limestone cleft in Pha Chuu, Srinan National Park, Nan, northern Thailand near Thai-Laos border.

Remarks: Although, this species having a shell form closed to the members of the *Cyclotus*, however, with a multispiral low-concaved operculum, and canal shaped of sphon located on apertural lip are the distinguished characters of the *Rhiostoma* s. str (see also Table 1 for comparison). Shell variation is observed, Two forms, of which with brownish pattern form (Fig. 8Q, R), and a monochrome whitish shell form (Fig. 8S) are the variation observed in this species.

CONCLUSION

Taxonomic remark: The higher classifications of *Rhiostoma* are almost no variable through the time. Kobelt (1902) and Gude (1921) placed it's in the section Pterocycleae of the subfamily Cyclophorinae, which equivalent to subfamily Pterocyclinae by Vaught (1989). However, the recent classification of gastropods (Bouchet & Rocroi, 2005) has recognized the tribe Pterocyclini under the subfamily Cyclophorinae. Both in Kobelt (1902) and Gude (1921) have been recognized 4 genera under tribe Pterocyclini, there were *Pterocyclus* Benson, 1832, *Rhiostoma* Benson, 1860, *Platyphaphe* Möllendorff, 1890, and *Pearsonia* Kobelt, 1902. The diagnostic shell characters among these genera are given in Table 1.

Benson (1860) included 3 nominal species in his new genus. Long collar and cap shaped operculum were conchological characters considered distinctive of the genus. After that, there were 23 nominal taxa were subsequently introduced to the genus *Rhiostoma* (e.g. Pfeiffer, 1862; Möllendorff, 1894;

Tomlin, 1932; Dautzenberg & Fischer, 1908; Laidlaw, 1932; Salisbury, 1949). However, in this study only 12 nominal species (Table 1) were strictly recognized and the type specimens are provided. The comparative shell characteristics of *Rhitostoma* among other related genera known in the region: *Cyclotus* Swainson, 1832, *Pterocyclus*, *Pearsoni* and *Theobaldius* Nevill, 1878 are given in Table 2. The remained taxa are reclassified, and several of them are considered into different genus such as *Cyclotus* and *Pterocyclus*. Firstly, of these *R. cavernae* Godwin-Austen, 1889, *R. gwendolenae* Godwin-Austen, 1889, *R. hungerfordi* Godwin-Austen, 1889, *R. iris* Godwin-Austen, 1889, and *R. boxalli* Godwin-Austen, 1893 from Borneo should be excluded from *Rhiostoma*, because their shell morphology without breathing tube and disconnected part of last whorl, apertural lip greatly expanded and corneous operculum. These characters represent *Pterocyclus* species, which superficially resemblance to *Rhiostoma*. Second, originally designed, *R. bernardii* Pfeiffer, 1862, *R. jousseaumei* Morgan, 1885 and *R. macalpinewoodsi* Laidlaw, 1939 should be referred to the genus *Cyclotus* because they represent a small shell, dark hirsute periostracum and plate like operculum, which are the distinctive shell morphology of the *Cyclotys*. In addition, *R. spelaeotes* Tomlin, 1931, also should be referred to *Pterocyclus spelaeotes*, although there shell morphology was look alike to *Rhiostoma*. However, the major distinctive characters such as plate-like clalcareous operculum and perforem radial grove in the aperture near apertural lip indicated the characters of *Pterocyclus*. Third, we examined the type specimens of *R. tomlini* Salisbury, 1949 and *R. smithi* Bartsch, 1932 and '*R. housei kirai* Habe, 1962' and considered that these three nominal species-group names are synonymy of *R. hainesi* Pfeiffer, 1862. For the reason, they were collected from the same small mountain namely Khoa Sabap, Chanthaburi; every morphological character among the type specimens of each nominal species-group names are exactly resemblance to the type specimens of *R. hainesi*. But only the name "*kirai*" appear to be based on old specimens, which the periostracum was worn out. Therefore, it is virtually distinct from *R. hainesi*. Forth, *R. dalyi* Blanford, 1902 the type material indicated the shell morphology, breathing tube formation and shell colour pattern are strictly resemble to the *R. housei*, therefore we decided this "*dalyi*" as synonym of *R. housei*. The last, there were 5 nominal species, which not at first classified as the *Rhiostoma*: *Pterocyclus cambodjensis* Morelet, 1875, *P. marioni* Ancey, 1897, *P. morleti* Dautzenberg & Fischer, 1905, and *Opisthoporus pulchellus* Morlet, 1889 are considered to be the member of the genus *Rhiostoma*, base on the type materials and the recent collection, and museum collections. These 4 species exhibit several distinct characters of *Rhiostoma* such as cap-shaped calcareous operculum, breathing tube formation and lip without expanded wing.

ACKNOWLEDGEMENTS

We are grateful to
M. Siddal and S. Watson (AMNH, New York);
P. Bouchet and V. Héros (MNHN, Paris);
P. Greenhall and R. Hershler (NMNH, Washington D.C.);
J. Abblet and H. Taylor (NHM, London);
H. Wood (NMW, Cardiff);
(NSMT, Tokyo);
T. Backeljau (RBINS, Brussel);
R. Janssen (SMF, Frankfurt);
R.C. Preece (UMCZ, Cambridge);
R.G. Moolenbeek (ZMA, Amsterdam);
H. Enghoff (ZMUC, Copenhagen) f

or their kindly having permitted and helped our study of type material. We are also indebted to B. Kongim, C. Tumpeesuwan, N. Tandavanitja, P. Pimwichai, P. Prasarnkok, R. Chanaboon, R. Promdam, S. Pholkoksung for field assistance. We also thank anonymous reviewers for providing helpful suggestions. This project was funded by an award from the BRT (BRT T_144019), CU Graduate School Thesis Granted to ST., and the Darwin Initiative Project (no. 14-653).

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Table 1. Comparative morphological difference among 5 closely related genera.
The supperscript number indicate the references: [1]Kobelt (1910), [2]Gude (1921), [3]Benson (1860), [4]Möllendorff, (1885), [5]Yen (1939), [6]Naggs & Rhaheem (1999)

Characters	*Pterocyclus* Benson, 1832[1,2]	*Cyclotus* Swainson, 1840[1,2]	*Rhiostoma* Benson, 1860[1,2,3]	*Theobaldius* Nevill, 1878[1,2]	*Platyrhaphe* Möllendorff, 1890[1,2,4,5]	*Pearsoni* Kobelt, 1902[1,2,6]
Type species	*Pterocyclus rupestris* Benson, 1832	*Cyclotus variegatus* Pearson, 1833	*Rhiostoma hughtoni* Benson, 1860	*Cyclophorus annulatus* Pfeiffer, 1847	*Cyclophorus chinensis* Möllendorff, 1875	*Spiraculum hispidum* Pearson, 1833
Shell size	medium to large (width 25-40 mm)	small, (width 10-30 mm)	medium to large, (width 25-40 mm)	medium to large (width 25-40 mm)	medium to large (width 25-40 mm)	medium to large (width 25-40 mm)
Operculum	calcareous, plate or concave shaped	corneous or thin calcareous, plate-shape	calcareous, cap-shaped	corneous		calcareous, plate-shaped
Breathing accessory tube (siphon)	apertural tube, short and with unique shaped	absent or short sutural tube	apertural tube, with short to long	absent	absent	absent or with short sutural tube
Aperture, lip free or attached	rounded, lip free or attached and widely expanded	rounded, lip free or attached and little expanded	rounded, lip always free and expanded	rounded, lip attached and little expanded	rounded, lip attached and little expanded	rounded, lip attached and expanded
Disconnected part of last whorl	absent to short	absent to short	short to extremely long, curved and descending	absent	absent	absent to short
Shell sculpture	smooth	smooth or with radial ribbed	smooth	smooth	smooth	smooth
Periostracum	thick to thin	thicken or hairy and dark colour	usually thin, transparent	thick corneous and dark colour	thicken corneous and dark colour	thicken or hairy and dark colour
Distribution	India, southern China, Indochina	Asia and Australia	principally in Indochina	primarily in India and Sri Lanka	China	principally in India

Table 2. Species included in the genus *Rhiostoma* by this study with the type specimens and type localities.

	Species/Subspecies	Type materials	Type locality
1.	*Rhiostoma housei* (Haines, 1855)	Lectotype AMNH 42923 (Fig. 5A)	Siam
2.	*Rhiostoma hughtoni* Benson, 1860	Lectotype UMZC xxxx (Fig. 7F)	Damotha, N.E. of Moulmein, Burma
3.	*Rhiostoma hainesi* Pfeiffer, 1862	Lectotype BMNH xxxx (Fig. 5N)	Cambodia
4.	*Rhiostoma simplicilabre* Pfeiffer, 1862	Lectotype BMNH xxxx (Fig. 6C)	Cambodia
5.	*Rhiostoma cambodjense* (Morelet, 1875)	Holotype BMNH 93.2.4.766 (Fig. 8E)	Battambang, Cambodia
6.	*Rhiostoma asiphon* Möllendorff, 1894	Lectotype SMF 130509 (Fig. 8I)	Samui Island, Gulf of Thailand
7.	*Rhiostoma marioni* (Ancey, 1897)	Lectotype NMW 1995.158.24090 (Fig. 6E)	Luang Prabang, Laos; Mount Hou, Tonkin
8.	*Rhiostoma strubelli* Möllendorff, 1899	Holotype SMF 130513 (Fig. 7H).	Kalow, Shan States, Burma
9.	*Rhiostoma jalorensis* Sykes, 1903	Holotype UMZC 1030 (Fig. 6G)	Limestone hills and caves, Biserat, Jalor
10.	*Rhiostoma morleti* Dautzenberg & Fischer, 1905	Lectotype NMNH (Fig. 8K)	Luang Prabang, Laos; Ha-Giana, Tonkin
11.	*Rhiostoma prestoni* (Bavay & Dautzenberg, 1908)	Holotype NMNH (Fig. 8N)	Binh-Lu, Tonkin
12.	*Rhiostoma samuiense* Tomlin, 1931	Lectotype NMW 1995.158.1104 (Fig. 7I)	Kaw Samui Island, Gulf of Thailand
13.	*Rhiostoma chupingense* Tomlin, 1939	Lectotype BMNH 1938.10.25.1 (Fig. 7L)	Bukit Chuping, Perlis, Malaysia
14.	*Rhiostoma breviocollar breviocollar* Tongkerd & Tumpeesuwan, n. sp.	Holotype CUMZ 4490 (Fig. 5I)	Khao Samorkorn, Ban-Mee, Lopburi, Thailand
15.	*Rhiostoma breviocollar uthaiensis* Tongkerd & Tumpeesuwan, n. sp.	Holotype CUMZ 4492 (Fig. 5K)	Khao Patawee, Tabtun, Uthaithani, Thailand
16.	*Rhiostoma tigris tigris* Tongkerd & Tumpeesuwan, n. sp.	Holotype CUMZ 4495 (Fig. 6J)	Tam Phra Bampenboon, Pan, Chiengrai, Thaialnd
17.	*Rhiostoma tigris lannaensis* Tongkerd & Tumpeesuwan, n. sp.	Holotype CUMZ 4500 (Fig. 6O)	Ping-Klong, Chiengdao, Chiengmai, Thailand
18.	*Rhiostoma aquilozonatus* Tongkerd & Panha, n. sp.	Holotype CUMZ 4703 (Fig. 7A)	Tam Pha Poo, Muong, Loei, Thailand
19.	*Rhiostoma furfurosus* Tonkerd & Panha, n. sp.	Holotype CUMZ 4705 (Fig. 7D)	Tam Wang Daeng, Nernmaprang, Phitsanulok, Thialand
20.	*Rhiostoma parahainesi* n. sp. Tongkerd & Panha, n. sp.	Holotype CUMZ 4709 (Fig. 7Q)	Tam Srithong, Klonghad, Srakeo, Thaialnd
21.	*Rhiostoma proboscidius* Tongkerd & Panha, n. sp.	Holotype CUMZ 4712 (Fig. 8A)	Khao Phanomwang, Kanchanadit, Suratthani, Thaialnd
22.	*Rhiostoma pygmaeus* Tongkerd & Panha, n. sp.	Holotype CUMZ 4716 (Fig. 8Q)	Sri-Nan National Park, Nanoi, Nan, Thailand

Figure 1.
A. Shell morphology of *Rhiostoma* spp. with measurement and shell terminology.
B. Typical characteristic of operculum of the *Rhiostoma* showing top, side and cross section views.
C. Typical characteristic of operculum of the *Cyclotus* showing top, side and cross section views. Abbreviation: H; height, MJD; major diameter, MND; minor diameter, Collar; disconnected part of last whorl, Siphon; small tube near aperture

Figure 2. Apertural view and siphon formation of the Pterocyclinae.
A. Apertural view of *Pterocyclus* sp. showing an expanded and wing shaped lip.
B. Apertural view of *Cyclotus setosus* showing an expanded lip.
C-F. Aperture and siphon shaped variation with in the *Rhisotoma*; **C.** Notch shaped siphon, **D.** Canal shaped siphon, **E.** Incomplete siphon, and **F.** Completed siphon and the apertural groove shown in crossection.

Figure 3. **A-F.** General anatomy of *Rhiostoma housei* from Tam Dao Khaokaew, Muklek, Saraburi (CUMZ).
A. Right side of female snail showing ovary and vaginal groove.
B. Right side of male snail showing the testis and external penis.
C. Arrangement of kidney, heart and circulatory system in pulmonary cavity.
D. Left side of snail showing the digestive tract and mantle.
E. Male genitalia.
F. Female genitalia.
G. Spermatophore of *Rhiostoma proboscidius* n. sp. from the type locality with its cross sections showing spermatophore shaped in each section.

Figure 4. Live snails.
A. *Rhiostoma housei* from Aow Manow, Prachuapkhirakhan.
B. *Rhiostoma hainesi* from Kao Soidao Waterfall, Chanthaburi.
C. *Rhiostoma jalorensis* from Wat Tam Sue, Krabi.
D. *Rhiostoma samuiense* from Hin Lad Waterfall, Samui, Suratthani.
E. *Rhiostoma chupingense* from Bukit Chuping, Perlis, Malaysia.
F. Copulation pari, unsuccessful transferring spermatophore, of *Rhiostoma proboscidius* n. sp. from the type locality. Female on left, male on right, and the red arrow indicate a spermatophore.

Figure 5. Shell morphology of *Rhiostoma* spp.

A-H. *Rhiostoma housei*; **A.** lectotype of "*housei*" AMNH 42923, **B.** paralectotype AMNH xxxx, **C.** lectotype of "*dalyi*" BMNH 1902.1.24.14, **D.** specimen from Tam Phitsadan, Chumporn (4383), **E.** specimen from Tam Sriwilai, Saraburi (3982), **F.** specimen from Khao Look Chang, Pakchong, Nakhonratchasrima CUMZ, **G.** specimen from Phu Nang National Park, Prayao (3977), and **H.** specimen from Tam Phatang Yai, Phu Nang National Park, Prayao (3926).

I, J. *Rhiostoma breviocollar breviocollar* n. ssp., **I.** holotype CUMZ 4490, and **J.** paratype CUMZ 4491.

K-M. *Rhiostoma breviocollar uthaiensis* n. ssp., **K.** holotype CUMZ 4492, **L.** paratype CUMZ 4493, and **M.** specimen from Tam Takien, Khaochmao, Rayong, CUMZ 3985.

N-R. *Rhiostoma hainesi*, **N.** lectotype of "*hainesi*" BMNH xxxx, **O.** paralectotype BMNH xxxxx, **P.** holotype of "*smithi*" USNM 382943, **Q.** paratype of "*tomlini*" BMNH xxx, and **R.** holotype of "*kirai*" NSMT 52242.

Figure 6. Shell morphology of *Rhiostoma* spp.

A, B. *Rhiostoma hainesi*, **A.** specimens from Plieu National Park, Chanthaburi (4381), and **B.** specimen from Khao Soidao Waterfall, Chanthaburi (4402).

C, D. *Rhiostoma simplicilarbre*, **C.** lectotype BMNH xxxx, and **D.** paralectotype BMNH xxxx.

E, F. *Rhiostoma marioni*, **E.** lectotype NMW 1955.158.24090, and **F.** specimen from Pa Hom, Vang Vieng, Laos (4494).

G-I. *Rhiostoma jalorensis*, **G.** holotype UMCZ 1030, **H.** specimen from Wat Tam Sue, Krabi (3994), and **I.** specimen from Tam Nam Pud, Tubpud, Pangnga (4387).

J-N. *Rhiostoma tigris tigris* n. ssp. **J.** holotype CUMZ 4495, **K.** paratype CUMZ 4496, **L.** specimen from Tam Pla, Maesai, Chiengrai (4497), **M.** specimen from Tam Chiengdao, Chiengmai (4499), and **N.** specimen from Tam Muong Oon, Mae-Oon, Chiengmai (4498).

O-Q. *Rhiostoma tigris lannaensis* n. ssp. **O.** holotype CUMZ 4500, **P.** paratype CUMZ 4710, and **Q.** specimen from Tam Mae-lana, Pai, Maehongsorn (4702).

Figure 7. Shell morphology of *Rhiostoma* spp.

A-C. *Rhiostoma aquilozonatue* n. sp. **A.** holotype CUMZ 4703, B. paratype CUMZ 4704, and **C.** specimen from Wat Suwankuha, Nongbualumphu (3889).

D, E. *Rhiostoma furfurosus* n. sp. **D.** holotype CUMZ 4705, and **E.** paratype CUMZ 4706.

F-I. *Rhiostoma haughtoni*, **F.** lectotype UMZC xxxx and **G.** paralectotype UMZC xxxx, and **H** and **I.** specimens from Damaltha, Burma BMNH 88.12.4.1985-6 (**H:** specimens examined in Gude (1921, fig. 22)).

J. holotype of *Rhiostoma strubelli* SMF 130513.

K-N. *Rhiostoma samuiense*, K. lectotype NMW 1955.158.1104, **L.** prarlectotype NMW xxxx, **M.** specimen from Hin Lad Waterfall, Samui, Suratthani (3989), and **N.** specimen from Koh Tan, Samui, Suratthani (4797).

O-R. *Rhiostoma chupingense*, **O.** lectotype BMNH 1938.10.25.1, **P.** topotypic specimen (3996), **Q.** specimen from Khao Mar-Rong, Bangsaphan, Prachuapkhirikhan (3986), and **R.** specimen from Tam Wang Thong, Kanom, Nakhonsrithammarat (4708).

S-T. *Rhiostoma parahainesi* n. sp. **S.** holotype CUMZ 4709, and **T.** paratype CUMZ 4710.

Figure 8. Shell morphology of *Rhiostoma* spp.

A. *Rhiostoma parahainesi* n. sp. from Khao Chamao, Kaeng Hang Meaw, Chanthaburi (4711).

B-E. *Rhiostoma proboscidus* n. sp., **B.** holotype CUMZ 4712, and **C-E.** paratypes CUMZ 4713.

F-I. *Rhiostoma cambodjensis*, **F.** holotype of "*cambodjensis*" BMNH 93.2.4.776, **G.** holotype of "*pulchellus*" MNHN, and **H-I.** specimens from Khao Chakan, Srakeow (4714).

J, K. *Rhiostoma asiphon*, **J.** lectotype SMF 130509, and **K.** specimen from Koh Wua Talup, Angthong National Park, Suratthani (4715).

L-M. *Rhiostoma morleti*, **L.** lectotype MNHN, and **M.** paralectotype RBINS 658845.

N-P. *Rhiostoma prestoni*, **N.** lectotype of "*prestoni*" MNHN, **O.** lectotype of "*depicta*" MNHN, and **P.** lectotype of "*fruhstorferi*" SMF 130353.

Q-S. *Rhiostoma pygmaeus* n. sp. **Q.** holotype CUMZ 4716, **R.** paratype CUMZ 4717, and **S.** paratype CUMZ 4718.

Figure 9. Radula morphology of *Rhiostoma* spp.

A. *Rhiostoma housei* from Saraburi (CUMZ).

B. *Rhiostoma breviocollar breviocollar* n. ssp. from Lopburi (paratype CUMZ).

C. *Rhiostoma breviocollar uthaiensis* n. ssp. from Uthiathani (paratype CUMZ).

D. *Rhiostoma hainesi* from Chanthaburi (CUMZ).
E. *Rhiostoma marioni* from Laos (CUMZ).
F. *Rhiostoma jalorensis* from Krabi (CUMZ).
G. *Rhiostoma tigris tigris* n. ssp. from Chiengrai (CUMZ).
H. *Rhiostoma tigris lannaensis* n. ssp. from Maehongsorn (paratype CUMZ).
I. *Rhiostoma tigris lannaensis* n. ssp. from Maehongsorn (paratype CUMZ).

Figure 10. Radula morphology of *Rhiostoma* spp.
A. *Rhiostoma furfurosus* n. sp. from Phitsanuloke (paratype CUMZ).
B. *Rhiostoma samuiense* from Suratthani (CUMZ).
C. *Rhiostoma chupingense* from Bukit Chuping, Malaysia (CUMZ).
D. *Rhiostoma parahainesi* n. sp. from Srakeo (paratype CUMZ).
F. *Rhiostoma proboscidus* n. sp. from Suratthani(paratype CUMZ).
G. *Rhiostoma cambodjensis* from Srakeo (CUMZ).
H. *Rhiostoma asiphon* from Suratthani (CUMZ).
I. *Rhiostoma pygmaeus* n. sp. from Nan (paratype CUMZ).

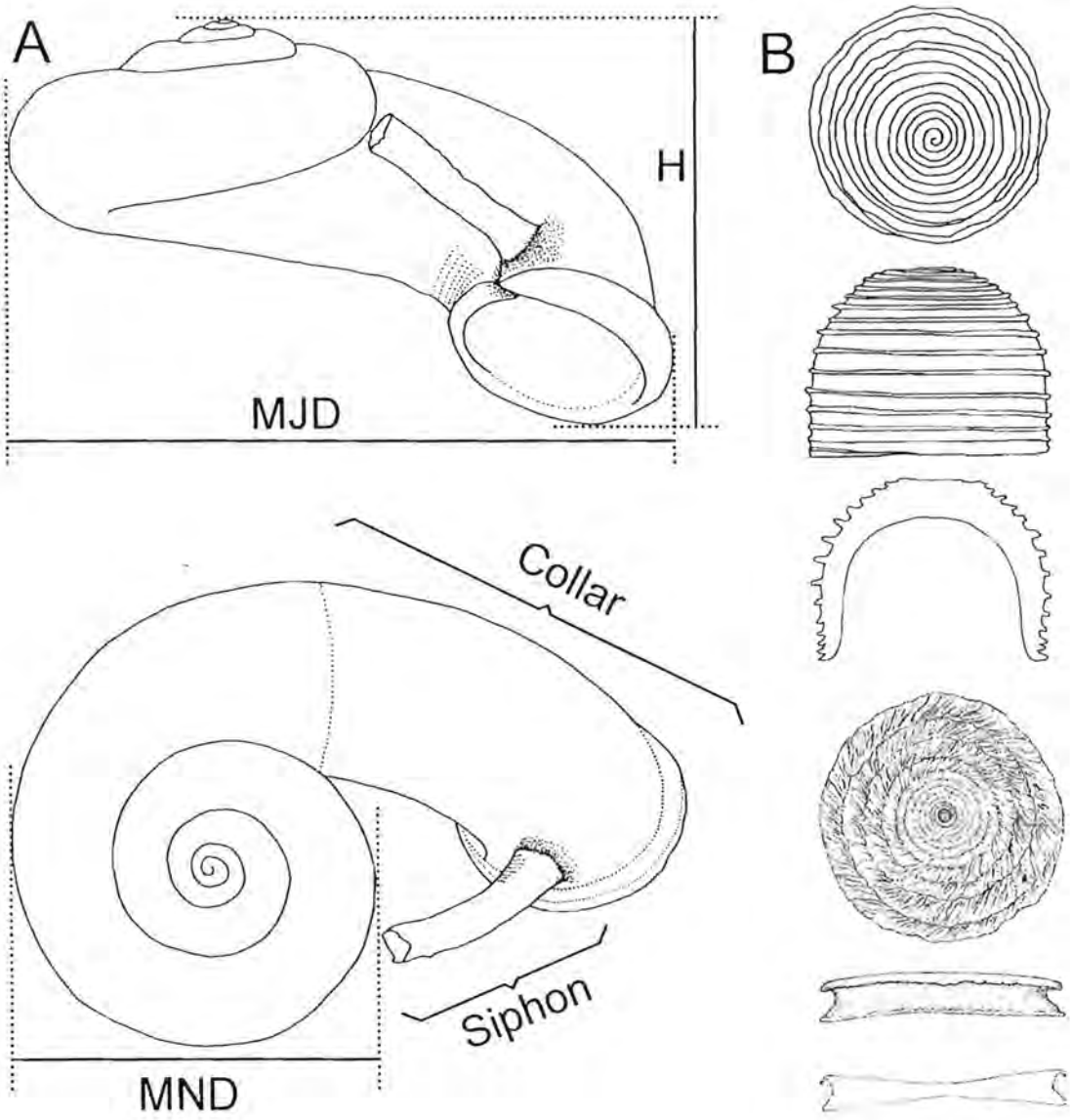

FIG.1

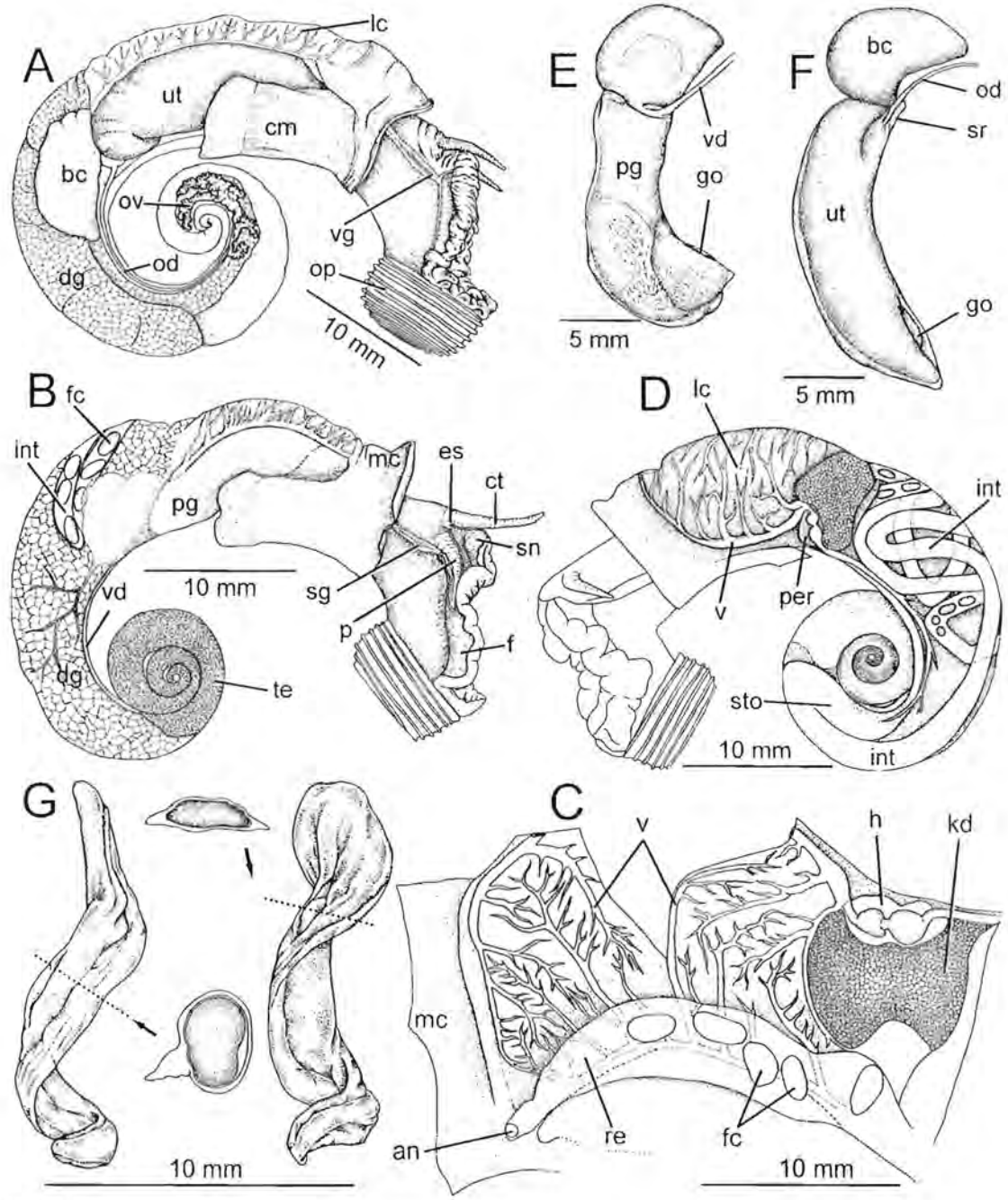
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FIG.2

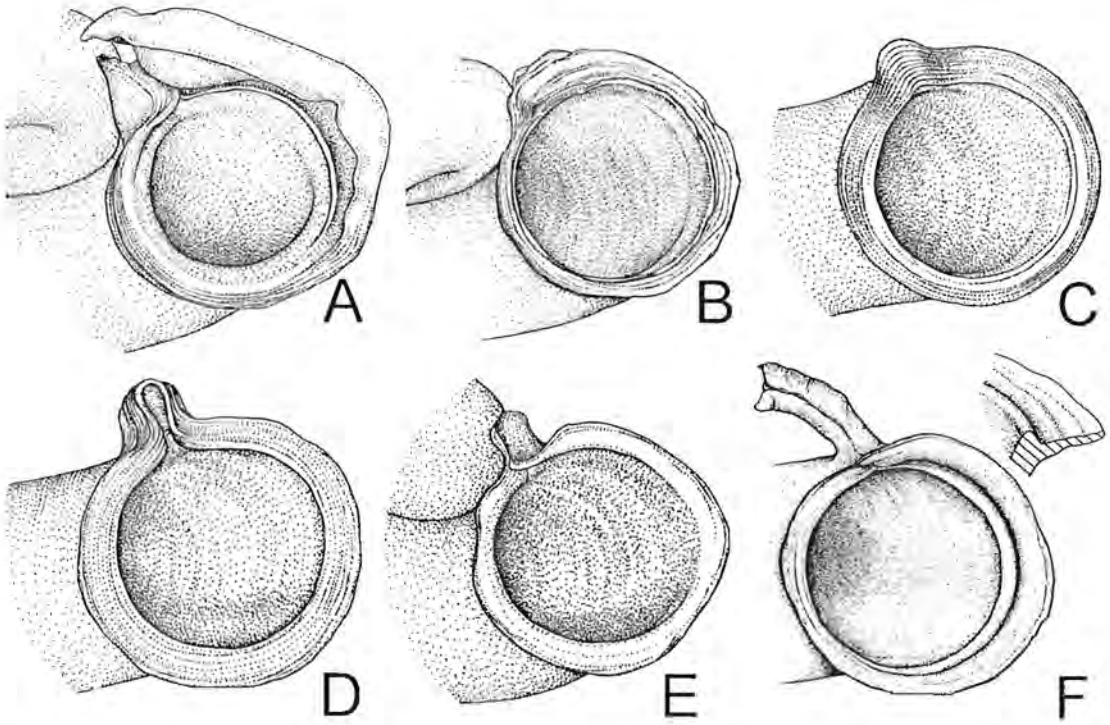

FIG.3

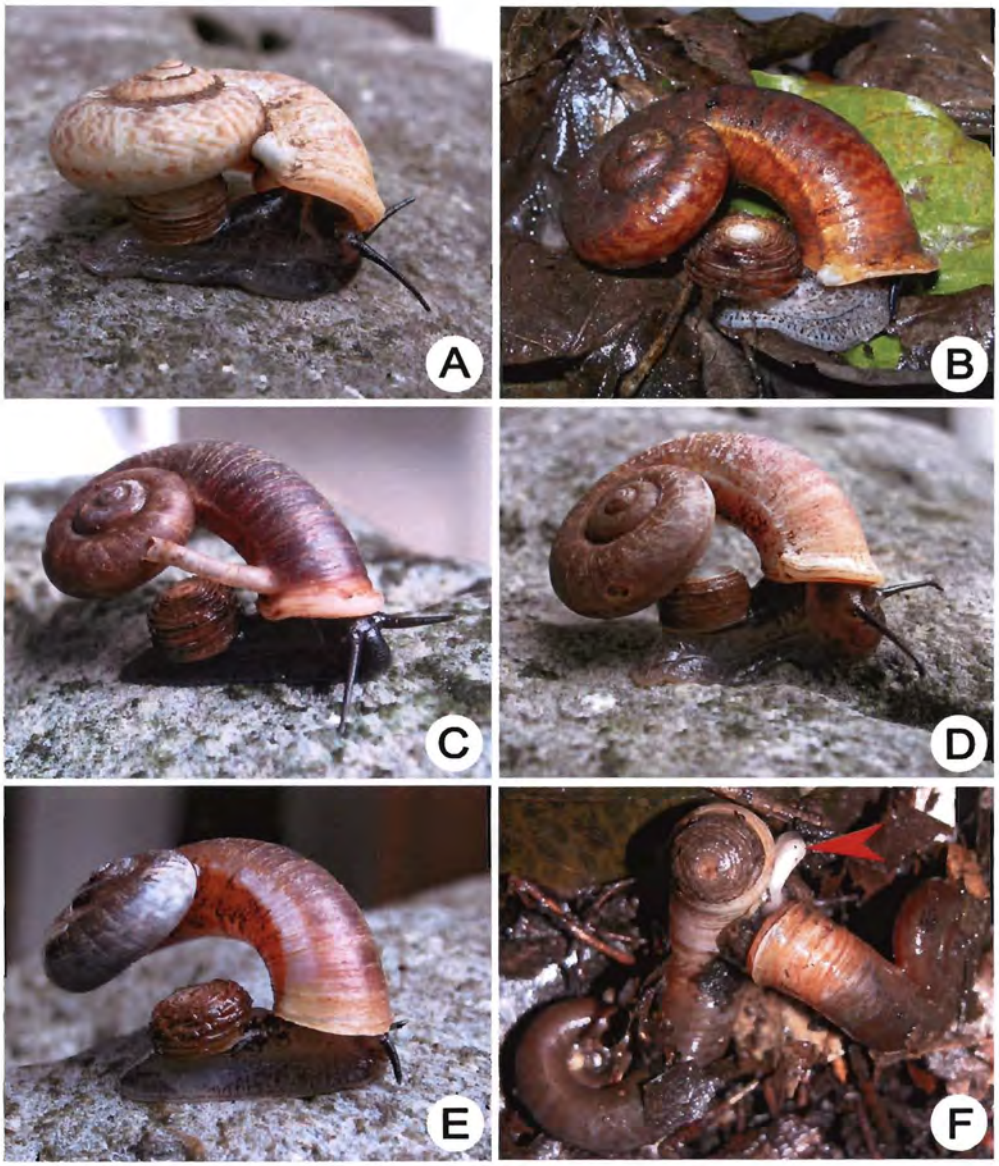

FIG.4

FIG.5

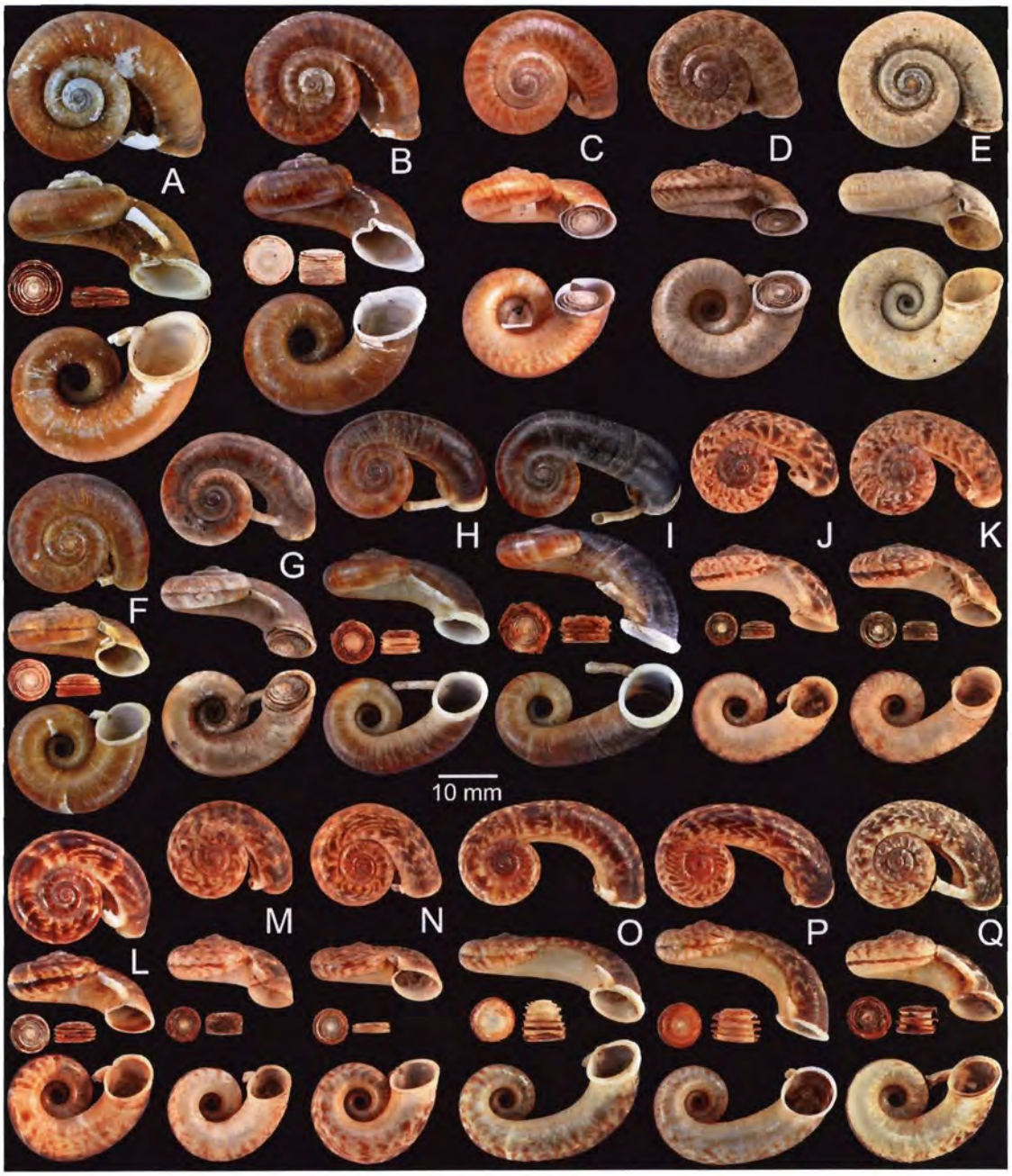

FIG.6

FIG.7

FIG.8

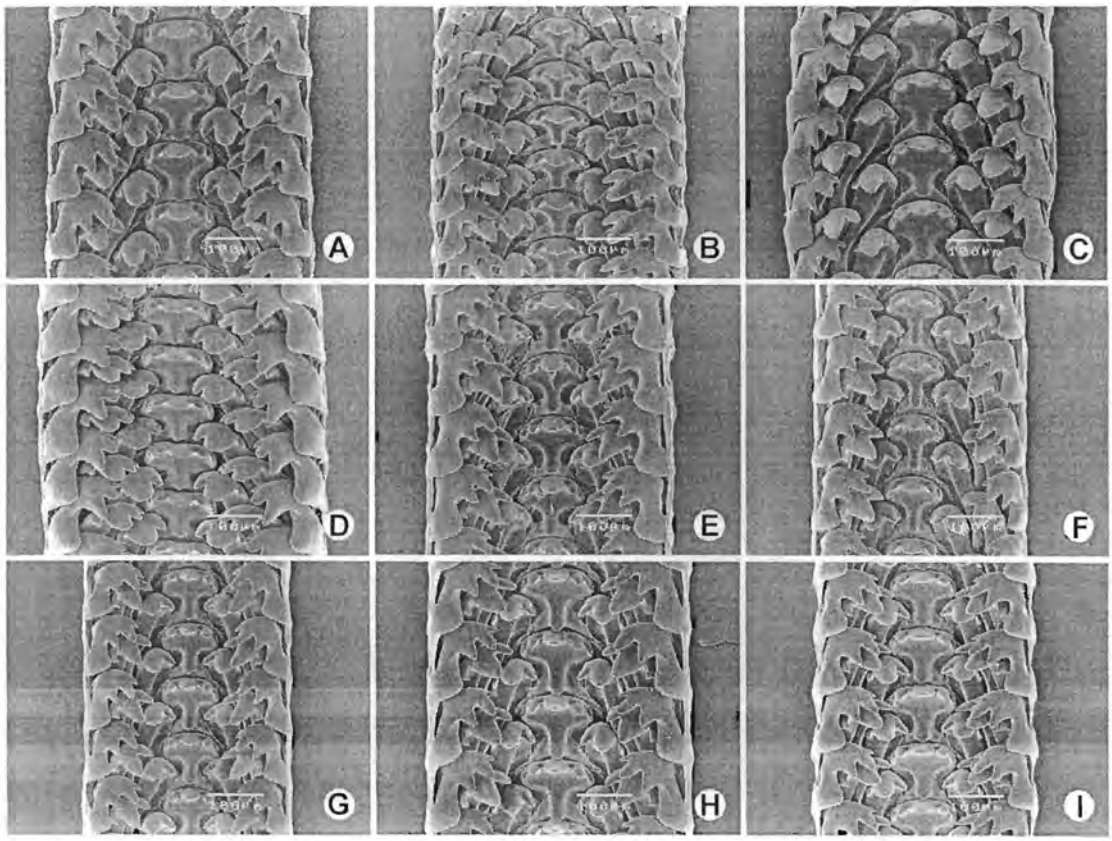

FIG.9

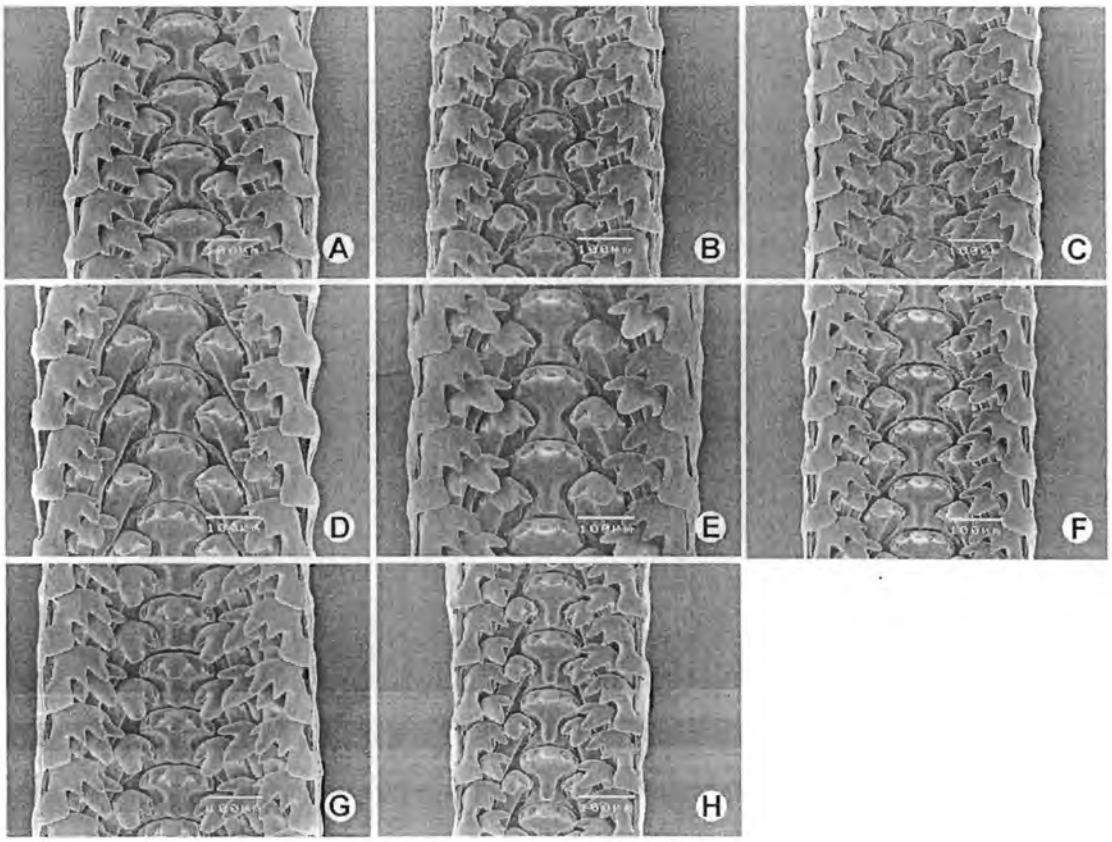

FIG.10