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TAXONOMY AND KARYOTYPES OF LAND PULMONATE SNAILS OF THAILAND

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ชื่อโครงการวิจัย : อนุกรมวิธานและคาริโอไทป์ของหอยทากบกในประเทศไทย

TAXONOMY AND KARYOTYPE OF LAND PULMONATE SNAILS OF THAILAND

รหัสโครงการ : RSA/15/2537

เมธีวิจัย : รองศาสตราจารย์ ดร.สมศักดิ์ ปัญหา

ภาควิชาชีววิทยา คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

บทคัดย่อ (Abstract)

ได้ทำการสำรวจเอกสารและงานวิจัยที่เกี่ยวข้องกับเรื่องของหอยทากบกในประเทศไทย และได้ศึกษาจากตัวอย่างต้นแบบ (Type specimens) จากพิพิธภัณฑ์สถานธรรมชาติวิทยาที่เกี่ยวข้องทั่วโลก ทั้งในสหรัฐอเมริกา ยุโรป และเอเชีย หลังจากนั้นได้เก็บตัวอย่างของหอยทากบกจากอุทยานแห่งชาติและเขตรักษาพันธุ์สัตว์ป่า ครอบคลุมทุกบริเวณของประเทศไทย และบางส่วนของประเทศเพื่อนบ้านใกล้เคียง ตัวอย่างหอยที่ได้ส่วนหนึ่งได้นำมาศึกษาโดยกระบวนการทางอนุกรมวิธาน (Taxonomy) ได้แก่ การจัดหมวดหมู่ (Classification) การตรวจหาชื่อวิทยาศาสตร์ (Identification) และการกำหนดชื่อสปีชีส์ใหม่ตามแบบสากล (nomenclature) แล้วเก็บตัวอย่างที่ศึกษาแล้วลงทะเบียนไว้ในพิพิธภัณฑ์อย่างเป็นระบบ (Systematic Collection) ตัวอย่างอีกส่วนหนึ่งได้นำมาศึกษาโครโมโซมเพื่อช่วยในการจัดจำแนกให้มีความถูกต้องแม่นยำยิ่งขึ้น เนื่องจากการจัดจำแนกหอยในอดีตที่ผ่านมานั้นใช้วิธีศึกษาจากลักษณะวิทยาของเปลือกเป็นส่วนใหญ่ (Shell morphology)

ผลการศึกษาในระยะเวลาเกือบ 3 ปี พบว่า ชาวเยอรมันชื่อ Moellendroff และ Zilch ชาวอเมริกันชื่อ Solem ชาวอังกฤษชื่อ Tomlin และชาวญี่ปุ่นชื่อ Habe มีบทบาทสำคัญต่อการศึกษาหอยทากบกในประเทศไทยเป็นอย่างมาก นอกจากนั้นยังมีนักค้นเปลือกหอยชาวเยอรมันชื่อ Fruhstofer และชาวอเมริกันชื่อ Webb ก็มีบทบาทต่อการศึกษาเช่นกัน ทั้งในทางบวกและลบ เพื่อรวบรวมรายชื่อหอยจากงานของบุคคลดังกล่าว พบว่า ประเทศไทยมีหอยอยู่ราว 80 สปีชีส์ จากการศึกษาของผู้วิจัยตั้งแต่ ปี ค.ศ. 1994 ได้พบหอยทากบกรวมทั้งสิ้น 19 วงศ์ 72 สกุล 247 สปีชีส์ ในจำนวนทั้งหมดพบเป็นสปีชีส์ใหม่ของโลกถึง 11 สปีชีส์ และในจำนวน 17 วงศ์ พบหอยวงศ์ใหญ่ๆอยู่ 5 วงศ์ ที่มีจำนวนสปีชีส์มาก และมีบทบาทในระบบนิเวศป่าไม้อย่างสูง ได้แก่ วงศ์ Vertiginidae, Camaenidae, Ariophantidae, Streptaxidae และ Bradybaenidae

บริเวณที่พบความหลากหลายของหอยมากได้แก่ บริเวณป่าที่ประกอบด้วยเขาหินปูน ซึ่งได้พบกับความสัมพันธ์ที่หลากหลายกับสัตว์ไฟลัมอื่น ๆ ด้วย ป่าตะวันตก ได้แก่ บริเวณเขตรักษาพันธุ์สัตว์ป่าห้วยขาแข้ง อุทยานแห่งชาติแก่งกระจาน เขตรักษาพันธุ์สัตว์ป่าทุ่งใหญ่นเรศวร เขตรักษาพันธุ์สัตว์ป่าอุ้มผาง ป่าทางเหนือ ได้แก่ อุทยานแห่งชาติดอยอินทนนท์ เขตรักษาพันธุ์สัตว์ป่าดอยเชียงดาว ป่าตะวันออกได้แก่ อุทยานแห่งชาติน้ำตกพลิ้ว เขตรักษาพันธุ์สัตว์ป่าเขาสอยดาว และเขตรักษาพันธุ์สัตว์ป่าเขาช่างกุไน ป่าภาคตะวันออกเฉียงเหนือได้แก่ เขตรักษาพันธุ์สัตว์ป่าภูหลวง เขตรักษาพันธุ์สัตว์ป่าภูเขียว และเขตรักษาพันธุ์สัตว์ป่าภูวัว ป่าทางใต้ ได้แก่ เขตรักษาพันธุ์สัตว์ป่าคลองแสง เขตรักษาพันธุ์สัตว์ป่าเขาช่อง และเขตรักษาพันธุ์สัตว์ป่าฮาราบารา บริเวณป่าที่กล่าวถึงนับว่าเป็นบริเวณที่มีความหลากหลายของสปีชีส์สูงมาก โดยเฉพาะที่เขตรักษาพันธุ์สัตว์ป่าอุ้มผาง และเขตรักษาพันธุ์สัตว์ป่าคลองแสงนั้นพบหอยทากมีความหลากหลายของสปีชีส์สูงที่สุด โดยพบถึง 44 และ 43 สปีชีส์ ตามลำดับ ในจำนวนหอยทั้ง 247 สปีชีส์นั้นพบว่า 54 สปีชีส์เป็นสปีชีส์ที่พบเฉพาะประเทศไทยเท่านั้น (endemic species) คิดเป็น 21.8% นับว่าเป็นจำนวนที่สูงเมื่อเทียบกับสัตว์สะเทินน้ำสะเทินบกนั้นพบเพียง 12.1% สัตว์เลื้อยคลาน 10.4% นกมีเพียง 0.2% สัตว์เลี้ยงลูกด้วยน้ำนมมีเพียง 3% หอยยังมีอีกเกือบ 200 สปีชีส์ล้วนเป็นสปีชีส์ที่พบกระจายอยู่ในบริเวณประเทศที่มีพรมแดนติดกับประเทศไทยทุกด้าน การกระจายของหอยนั้นพบว่ามีการกระจายกระจุกตัวอยู่จำเพาะบริเวณที่ยังมีสภาพของป่าที่ค่อนข้างดีอยู่ หรือพื้นที่อนุรักษ์ชื่น ๆ ซึ่งเป็นไปตามลักษณะที่เป็นเกาะแก่งของสภาพป่าที่หลงเหลืออยู่ของประเทศ ในด้านสถานภาพของหอยในแต่ละสปีชีส์นั้นพบว่ากลุ่มหอยต้นไม้ (tree snails) หลายสปีชีส์กำลังอยู่ในสภาพที่ใกล้สูญพันธุ์ (endangered species) เช่น *Amphidromus flavus*, *A. metabletus*, *Cameena illustris* และ *Chloritis (T.) siamensis* และมีหลายสปีชีส์ที่ถูกคุกคามเนื่องจากการทำลายป่าไม้และการล่า เช่น *Amphidromus areolatus*, *A. semitesselatus*, *A. xiengensis* และกลุ่มสปีชีส์หอยบริเวณเขาหินปูน ได้แก่ หอยในวงศ์ Streptaxidae, Plectopylidae, Vertiginidae ส่วนสปีชีส์ที่พบเป็นจำนวนมากและสามารถแพร่กระจายได้ทั่วไปแม้ในถิ่นอาศัยที่มนุษย์อาศัยแม้แต่ในเมืองใหญ่ ๆ บางแห่ง เช่น *Cryptozona siamensis*, *Bulimirus siamensis*, *Succinea tenella* และ introduced species 2 สปีชีส์คือ *Achatina fulica* และ *Lamellaxis gracilis* นอกจากนั้นยังมีสกุลที่ต้องเฝ้าติดตามศึกษาอย่างละเอียด เนื่องจากมีแนวโน้มที่จะประสบปัญหาได้ ถ้าสภาพแวดล้อมถูกทำลายมากขึ้น ได้แก่ สกุล Amphidromus, Ganesella, Cameena

ในเรื่องของโครโมโซมนั้น จากการศึกษาในหอยในวงศ์ Camaenidae, Ariophantidae, Succineidae, Achatinidae และ Clausiliidae นั้น ทำให้ได้ข้อมูลที่สำคัญมาใช้ในงานอนุกรมวิธานของหอยทากบกอย่างดียิ่ง พบว่า เมื่อเทียบกับงานจากการรวบรวมของศาสตราจารย์ John Burch แห่งมหาวิทยาลัยมิชิแกน ประเทศสหรัฐอเมริกา ในปี ค.ศ. 1989 ได้ระบุจำนวนโครโมโซมของหอยหลายวงศ์ที่มีผู้ศึกษามาแล้ว การวิจัยในครั้งนี้ได้พบข้อมูลที่แตกต่างจากผลงานดังกล่าวอยู่หลายประการ กล่าวคือ โครโมโซมของหอยวงศ์หอยนกขมิ้น (Family Camaenidae) โดยเฉพาะสกุล *Amphidromus* นับได้ว่าเป็นงานวิจัยชิ้นแรกของงานวิจัยทางด้านโครโมโซมของหอยทากบก โดยเทคนิคที่แตกต่างจากเทคนิคเดิม ๆ ที่มีการวิจัยมาก่อน และเนื้อเยื่อที่นำมาใช้ศึกษาก็ต่างจากการใช้ gonad ที่มีการใช้กันมาโดยตลอด ใน Superfamily Achatinoidea ที่มีการวิจัยมาแล้วพบจำนวนแฮพพลอยด์อยู่ระหว่าง 25-31 จากการศึกษาครั้งนี้จำนวนแฮพพลอยด์ของหอยชนิด *Achatina fulica* เพียง 15 และใน Superfamily Helicarionoidea พบจำนวนแฮพพลอยด์ที่มีความหลากหลายอยู่ระหว่าง 10-36 (รายงานเดิมอยู่ระหว่าง 20-34) และเมื่อนำโครโมโซมมาจัดคาริโอไทป์สามารถนำมาใช้ในการจำแนกสปีชีส์ของหอยที่มีความสับสน ดังเช่นหอยขัดเปลือก *Macrochlamys limbata* และ *M. hepbogyra* ที่มีความคล้ายคลึงกันมากในทางสัณฐานวิทยาและมีจำนวนแฮพพลอยด์เท่ากันคือ 10 แต่เมื่อนำมาจัดคาริโอไทป์จะเห็นความแตกต่างกันอย่างชัดเจน สามารถช่วยในการจัดจำแนกได้อย่างดียิ่ง นอกจากนี้ยังสามารถจัดคาริโอไทป์เพื่อดูความแตกต่างของหอยนกขมิ้น *Amphidromus atricallosus*, *A. areolatus* และ *A. inversus*

ในด้านการเผยแพร่ผลงานวิจัย สามารถจำแนกเป็นข้อ ๆ ได้ดังนี้

1. สามารถจัด Systematic Collection ในพิพิธภัณฑ์สถานแห่งชาติวิทยาแห่งจุฬาลงกรณ์มหาวิทยาลัย ซึ่งจะใช้เป็นประโยชน์ต่อการมาทัศนศึกษาของนักเรียน นิสิต นักศึกษา ครู อาจารย์ และประชาชนผู้สนใจทั่วประเทศ และเป็น Reference Collection แก่นักวิจัยทั้งในและต่างประเทศที่จะเข้ามาศึกษาทั้งในแง่ของงานชีววิทยาพื้นฐานและการประยุกต์ทั้งทางด้านสิ่งแวดล้อม และ Biotechnology

2. ได้ตีพิมพ์เผยแพร่ผลงานวิจัยในวารสารต่างประเทศที่เป็นที่ยอมรับในทางสาขา Malacology เป็นจำนวน 4 บทความ ได้รับการตอบรับให้ลงพิมพ์แล้วอีก 3 บทความ และอยู่ในระหว่างการเตรียมต้นฉบับโดยเฉพาะงานทางด้านโครโมโซมอีก 2 บทความ

3. ได้นำเสนอผลงานในที่ประชุมระดับ International 2 ครั้ง และในระดับชาติ 3 ครั้ง และได้รับเชิญไปเป็นวิทยากรที่ประเทศญี่ปุ่น 1 ครั้ง และในประเทศไทยอีก 2 ครั้ง

4. ได้ผลิตมหาบัณฑิตที่เกี่ยวข้องกับงานทางด้านหอยพากบกไป 2 คน ขณะนี้กำลังเป็นกำลังสำคัญในการผลิตผลงานวิจัยที่สูงขึ้นต่อไป และขณะนี้สามารถรวบรวมนิสิตปริญญาโท จำนวน 3 คน และนิสิตปริญญาตรีปีที่ 4 จำนวน 3 คน ที่มีความสนใจทางด้านนี้อย่างจริงจัง ร่วมเป็นทีมงานวิจัยที่มีประสิทธิภาพยิ่งขึ้น โดยคาดว่าในระยะเวลา 3-5 ปีข้างหน้า จะสามารถผลิตนักวิจัยที่มีความสามารถมารับใช้สังคมต่อไป

Research project: TAXONOMY AND KARYOTYPE OF LAND PULMONATE SNAILS OF THAILAND

Project Code: RSA/15/1994

Research Scholar: Associate Professor Dr. Somsak Panha
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Abstract:

We have surveyed the literature regarding land pulmonate snails of Thailand and have studied type specimens from important natural history museums around the world, including the US, Europe, and Asia. After that, we collected samples of land pulmonate snails from national parks and wildlife sanctuaries throughout Thailand and in parts of neighboring countries. Some of the samples have been examined by taxonomical methods, including classification, identification, and assigning nomenclature for new species according to internationally accepted procedures. We have processed the samples that we have already examined and systematically collected them in a museum. Another portion of the samples was used for the examination of chromosomes in order to verify the accuracy of the classification, since previous classification schemes have relied mainly on shell morphology.

We now turn to a summary of our results after nearly 3 years. So far, work on land pulmonate snails in Thailand has been strongly influenced by foreign naturalists such as Moellendroff and Zilch (Germany), Solem (USA), Tomlin (UK), and Habe (Japan). In addition, shell traders such as Fruhstofer (Germany) and Webb (USA) played a role that was both positive and negative. When we list all the names of snails collected by these people, we find 80 species of Thai snails from their records. From our studies since 1994, we have found a total of 17 families, 71 genera, and 247 species. Of these, 11 species are new species that have never been found anywhere else in the world. Out of the 17 families, the following 5 families include many species and play a significant role in the forest ecosystem: Vertiginidae, Camaenidae, Ariophantidae, Streptaxidae, and Bradybaenidae. The regions where we found many snails in limestone mountain forests are as follows:

- Western Thailand:
  - Huay Kha Kang Wildlife Sanctuary
  - Kang Krajan National Park
  - Tungyai Narasuan Wildlife Sanctuary
  - Umpang Wildlife Sanctuary
- Northern Thailand:
  - Doi Inthanon National Park
  - Doi Chiang Dao Wildlife Sanctuary

- Eastern Thailand:
  - Phliu, National Park
  - Khao Soi Dao Wildlife Sanctuary
  - Khao Ang Rue Nai Wildlife Sanctuary
- Northeastern Thailand:
  - Phu Luang Wildlife Sanctuary
  - Phu Kheo Wildlife Sanctuary
  - Phu Wua Wildlife Sanctuary
- Southern Thailand:
  - Klong Sang Wildlife Sanctuary
  - Khao Chong Wildlife Sanctuary
  - Harabara Wildlife Sanctuary

All of these forests have a very high species diversity. In particular, Umpang Wildlife Sanctuary and Khlongsang Wildlife Sanctuary were found to have the highest species diversity of pulmonate snails, with 44 and 43 species, respectively.

Among the 247 species that were found, 54 (21.8%) are endemic species that are found only in Thailand. This is a high rate of geographic specificity compared with that for amphibians (12.1%), reptiles (10.4%), birds (only 0.2%), and mammals (only 3%). The remaining nearly 200 species are distributed among nations bordering Thailand on all sides. However, the distribution of snails is very clumpy, and mainly restricted to the few, small, isolated regions that still support a strong forest ecology.

Regarding the survival status of each species, among tree snails there are many endangered species, such as *Amphidromus flavus, A. metabletus, Camaena illustris,* and *Chloritis (T.) siamensis*. There are also many species that are threatened by deforestation and hunting, such as *Amphidromus areolatus, A. semitesselatus*, and *A. xiengensis*, and the limestone mountain species in the families Streptaxidae, Plectopylidae, and Vertiginidae. Some species are abundant and able to spread in regions inhabited by humans or even in major cities, such as *Cryptozona siamensis, Buliminus siamensis*, and *Succinea tenella*, and 2 introduced species, *Achatina fulica* and *Lamellaxis gracilis*. Other species should be carefully monitored because they may encounter problems if there is further destruction of the environment; these include members of the genera *Amphidromus, Ganesella*, and *Camaena*.

The analysis of chromosomes of snails from the families Camaenidae, Ariophantidae, Succineidae, Achatinidae, and Clausiliidae has provided very important information with regard to their classification. We compared our results with those compiled by Prof. John Burch of the University of Michigan, USA in 1989. Burch specified the number of chromosomes of several families of snails that had previously been studied at that time. Our present results differ in

several respects. Ours is the first work on snail chromosomes of the genus *Amphidromus*. The tissues that we examined are different from the gonads used previously. For Superfamiy Achatinoidea, previous studies found 25-31 haploid numbers. We found that *Achatina fulica* snails had only 15. For Superfamily Helicarionoidea, the haploid numbers were highly variable, over the range 10-36 (previous reports found 20-34). When we examined the karyotypes, we can distinguish between species that are easily confused for one another. For example, the snails *Macrochlamys limbata* and *M. Hephagyra* have very similar morphologies, and both have 10 haploid numbers, but when we examined the karyotypes we could see distinguish between them very clearly. Therefore, this technique is extremely helpful for classification. We were also able to use karyotypes to distinguish between the snails *Amphidromus atricallosus*, *A. areolatus*, and *A. inversus*.

The dissemination of our results can be summarized as follows:

1. We organized a systematic collection in the Museum of Natural History at Chulalongkorn University, which is frequently visited by school children, university students, teachers, faculty, and the general public from all over the nation. This also serves as a reference collection for researchers in Thailand and abroad to study, both in terms of basic biology and environmental applications, and for biotechnology.

2. We have published 4 articles in overseas journals that are widely accepted in the field of malacology. There are 3 more articles that have been accepted for publication, and 2 more are being prepared specifically on the topic of chromosomal studies.

3. We have produced 2 M.Sc. graduates who did their thesis work on land pulmonate snails, who will make important contributors to raise the level of research results in the future. At this point we still have 3 M.Sc. students and 3 senior B.Sc. students who are actively interested in this field. This makes for a more efficient research team, and we expect that in the next 3-5 years we will produce even more researchers to serve society in the future.

TAXONOMY AND KARYOTYPES OF LAND PULMONATE SNAILS OF THAILAND

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INTRODUCTION

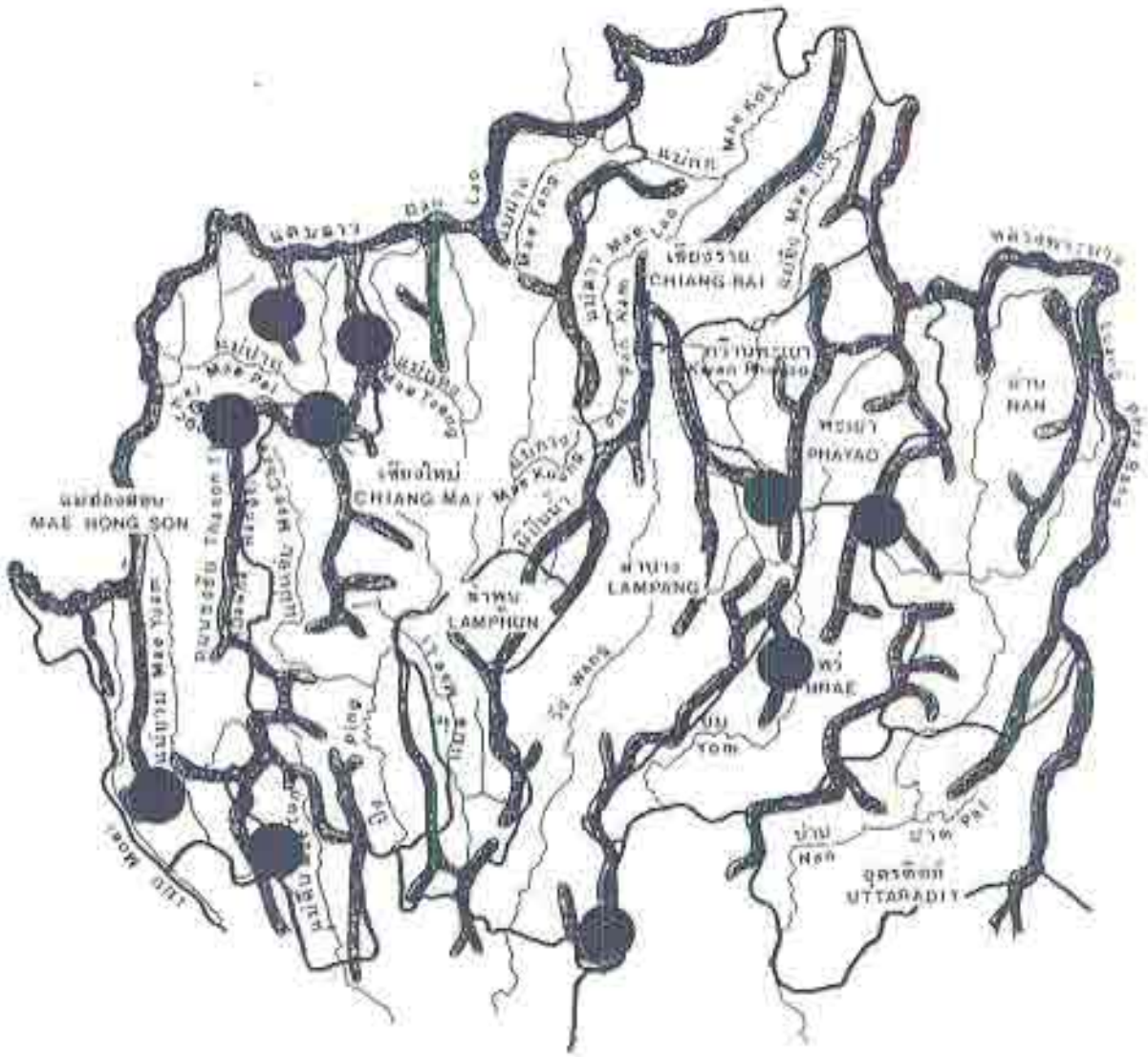
This study summarizes our present knowledge of the Thai land pulmonate snails taxonomicly and also studies chromosomes of some families and surveys the distribution patterns. The collecting has been done all over Thailand covering almost all of national parks and wildlife sanctuaries (Fig. 1). More attention has been focused on trying to determine the relationship of the Thai species. The major incentive to this study was provided by The Thailand Research Fund (TRF) (RSA/15/1994). All main collections have been started since 1994. A Checklist of the land pulmonate snails of Thailand are in press (Panha, 1997).

Attemps to identify the Thai land pulmonate snails soon involved summarization of Southeast Asian fauna, based on materials in Senckenberg Museum, Frankfurt-on-main (SMNH); Zoological Museum, Copenhagen (ZMNH); Zooligal Museum University of Amsterdam, Amsterdam; Rijksmuseum van Natuurlijke Historie, Leiden; United States National Museum, Smithsonian Institution (USNM); Michigan University Museum of Zoology, Ann Arbor (UMMZ); Field Museum of Natural History, Chicago (FMNH).

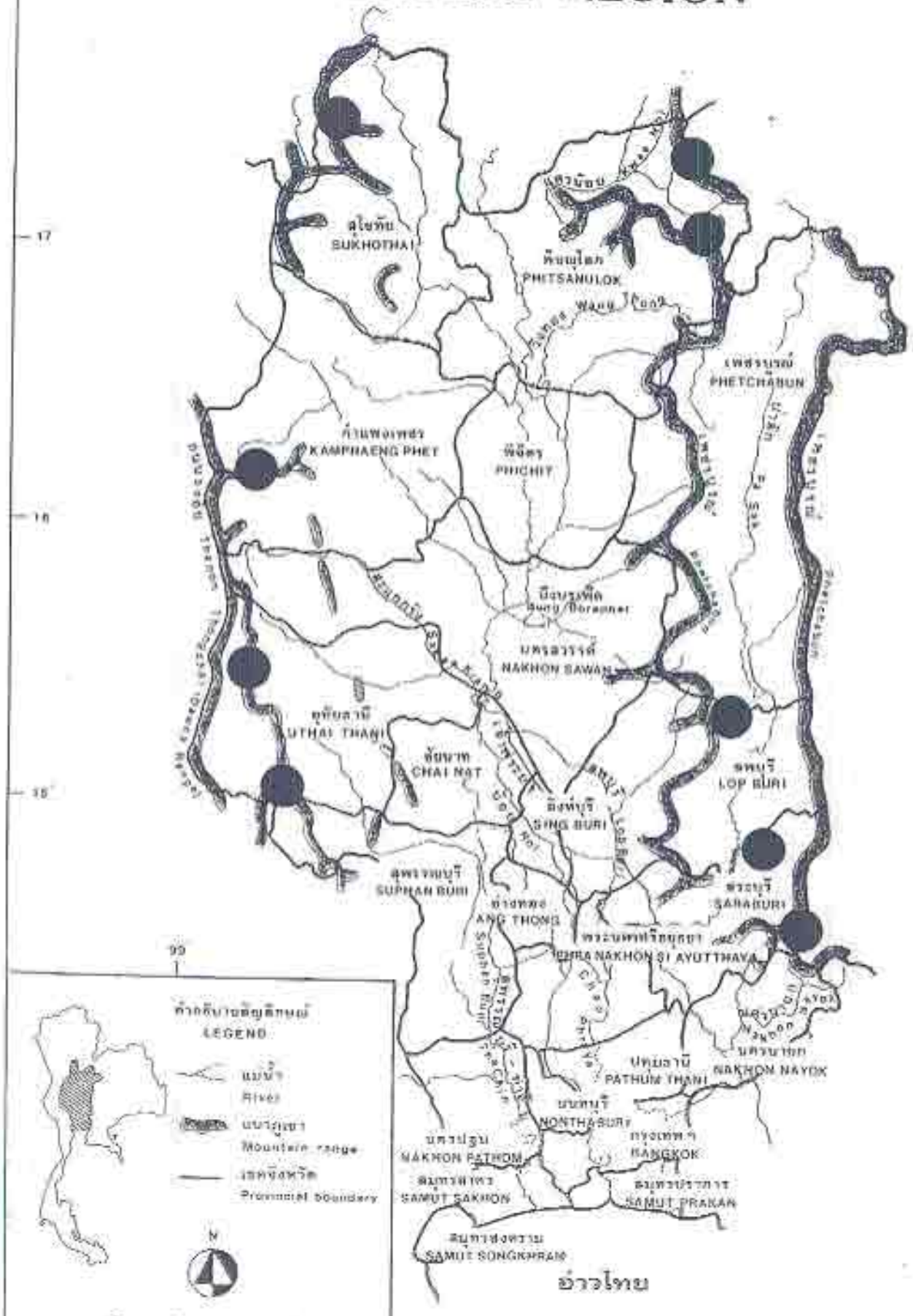
The only previous comprehensive study of Thailand non-marine mollusks is a publication from Zoological Museum, Copenhagen (Solem, 1966). Of the thirty-two species listed, eight species and two new genera were new to science. The other literature specifically concerned with Siam or Thailand is the scattered descriptions by Gould (1844); Haines (1858); Martens (1867); Morlet (1891) and Moellendorff (1894 and 1902). Very little has been published since then. Faunistic reports by Blanford (1903), Tomlin (1929 and 1932), Gude (1903) presented a check-list of the helicoid species; Suvatti (1938) summarized previously published papers in a Thai-English check-list. The most recent non marine mollusks monograph of Thailand written by Brandt (1974) however most of them are aquatic mollusks and some basommatophorans. Brandt did a big collection of Thai land snails collected from 1964 and intended to publish the next monogrph on land snails. Unfortunately he died in 1990. All of that collections are now deposited in Senckenberg Museum and I have identified all of them already in May, 1995 and included that collection in this list. Through the courtesy of Dr. Ronald Janssen, Curator of Mollusks, Senckenberg Museum, Frankfurt-on-main, it was possible to study

Fig. 1 The collecting sites from four regions of Thailand (northern, central , western, northeastern, eastern and southern), the round areas on the maps are the localities that we have collected land snails.

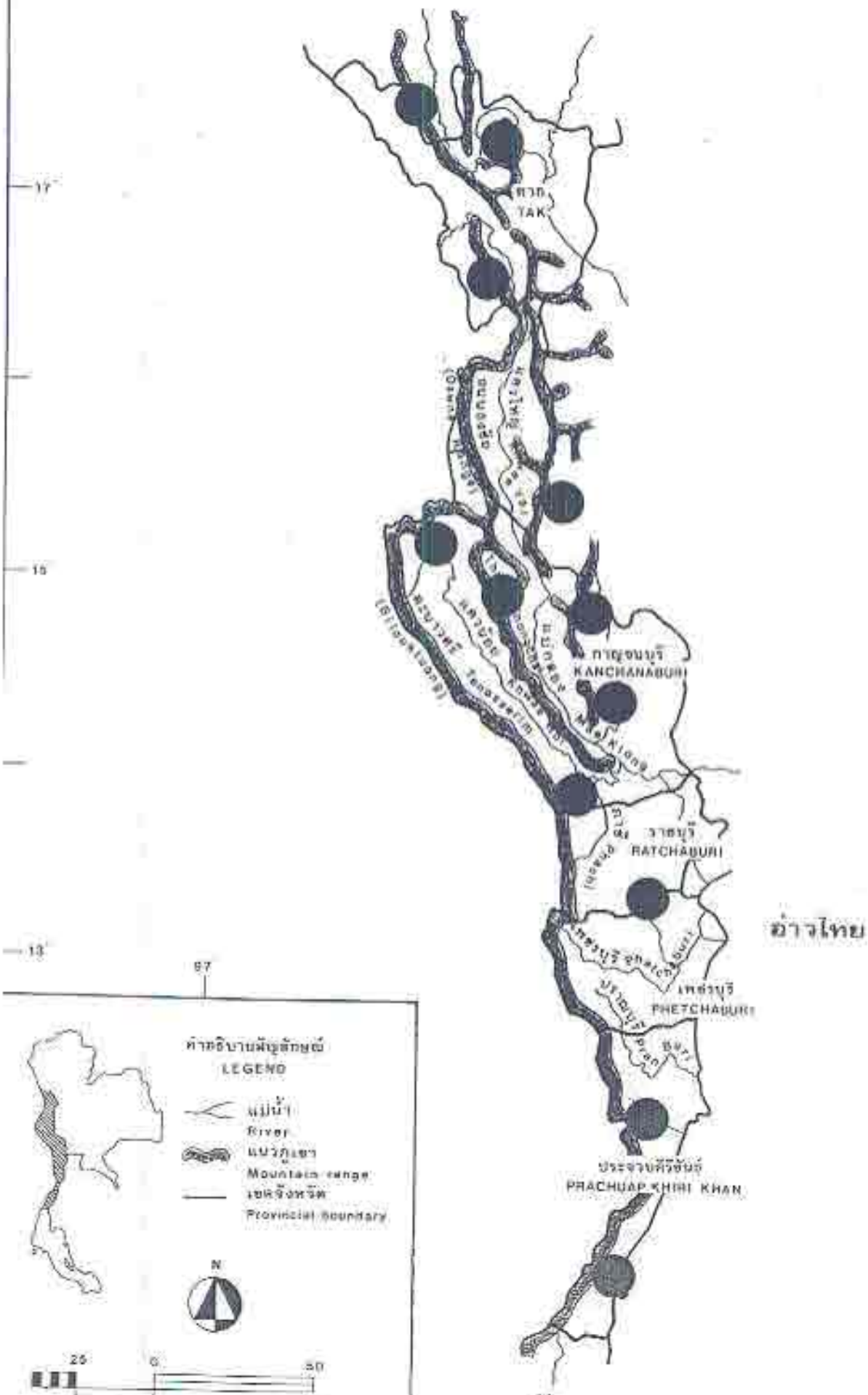
ภาคเหนือ
NORTHERN REGION



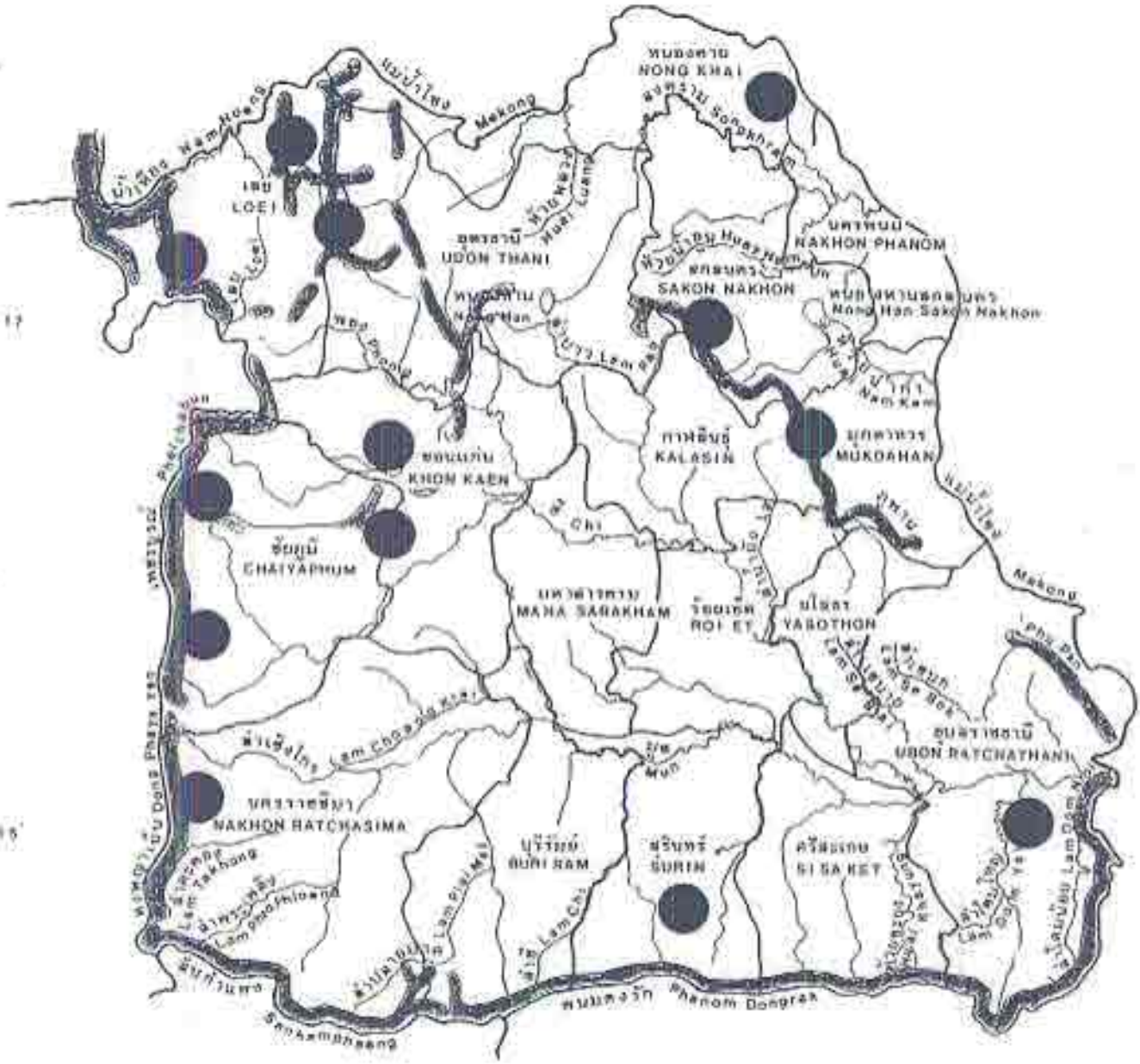
ภาคกลาง
CENTRAL REGION



ภาคตะวันตก
WESTERN REGION



ภาคตะวันออกเฉียงเหนือ
NORTHEASTERN REGION



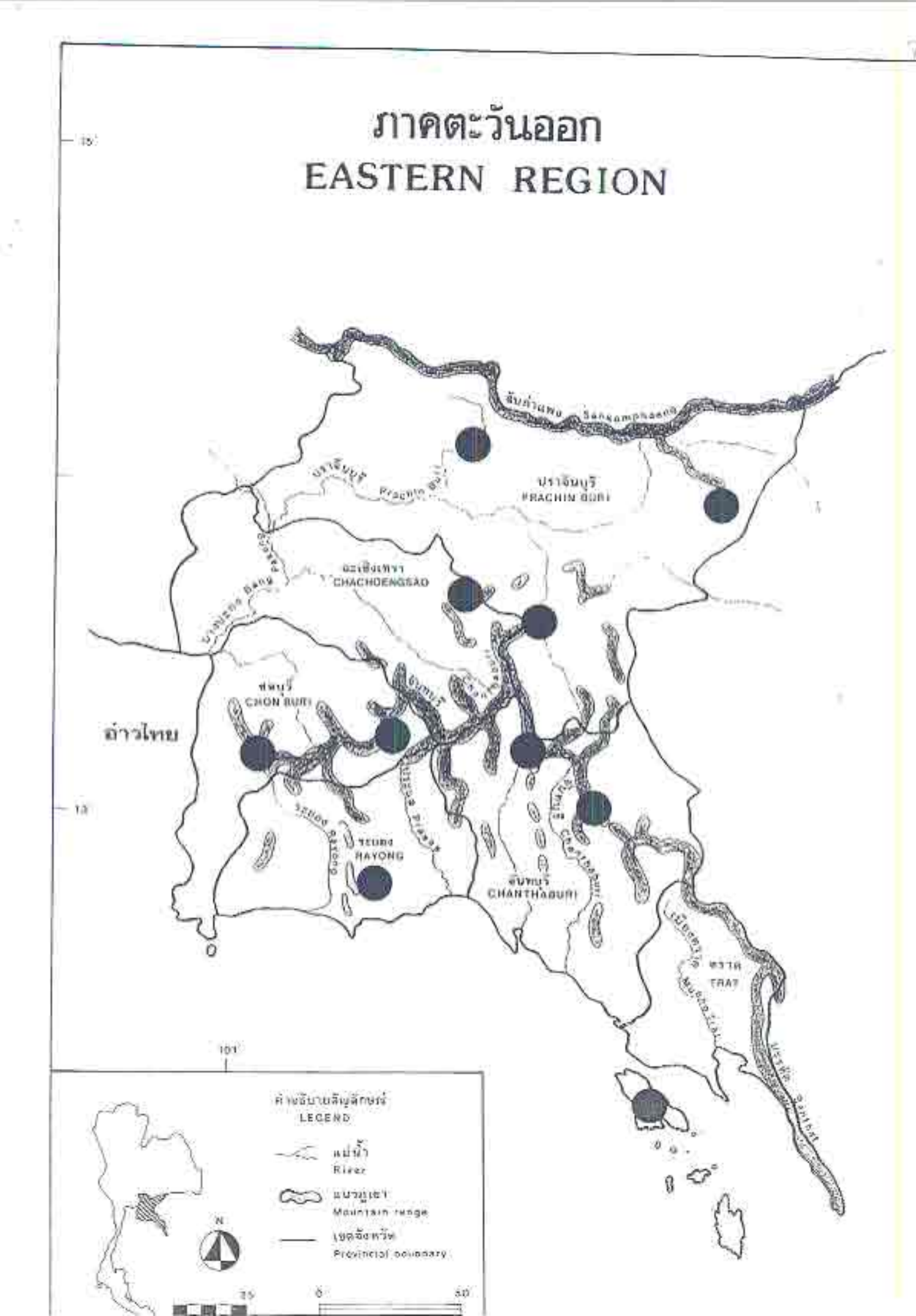
คำอธิบายสัญลักษณ์
LEGEND

- แม่น้ำ River
- แนวภูเขา Mountain range
- เขตจังหวัด Provincial boundary

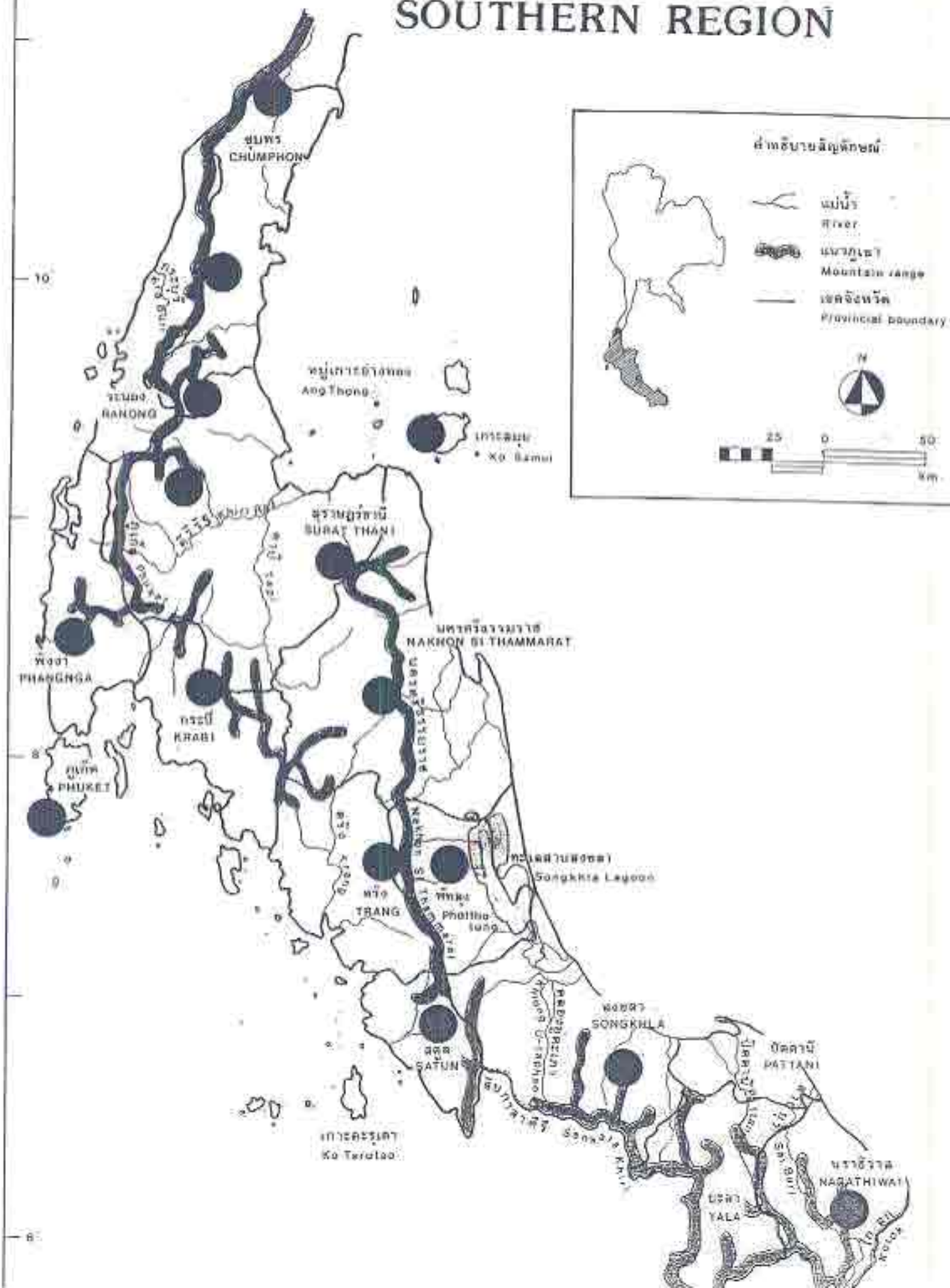
N

25 0 50
km

ภาคตะวันออก
EASTERN REGION



ภาคใต้
SOUTHERN REGION



Other authors describing or listing land pulmonate snail species from Thailand during this early period were Pfeiffer (1860, 1861a, b, 1862), Dohrn (1861), Crosse & fischer (1863), Wallace (1865), Godwin-Austen (1882, 1888, 1898) Morlet (1883, 1884, 1886, 1889, 1891a, b), Tryon (1885), Cockerell (1891), Moellendorff (1891, 1894).

During the 20th century, the number of publications dealing with land pulmonate snails found in Thailand increased, and the fauna was becoming better known. These included the works of Gude (1901, 1903 a, b, c, 1907, 1914), Blanford (1902, 1903), Sykes (1902), Pilsbry (1905), Godwin-Austen (1909, 1916, 1919), Schepman (1912), Fulton (1915), Cooke (1915), Kennard & Woodward (1923), Woodward (1924, 1925), Benthem Jutting (1929), Cockerell (1929), Laidlaw (1931), Tomlin (1929, 1932), Hass (1934, 1952), Tweedie (1947), Zilch (1953, 1961, 1966, 1984), Hubendick (1956), Solem (1965, 1966), Bruggen (1972), Loosjes & Loosjes-Van Bemmel (1973), Mead (1979) Thompson & Lee (1988) and Panha (1997). Some of these publications were faunistic surveys, and some were mainly taxonomic in nature. Some taxonomic problems still need to be resolved, and much more information is needed on the snails' ecology, ecological physiology, and responses to human modified-environments. But more details on these aspects must await further studies.

Thailand is vegetatively very diverse and presents a wide variety of terrestrial habitats (Cubit and Stewart-Cox, 1995) undoubtedly has influenced snail diversity. The present study presents the results of more comprehensive study of terrestrial snails diversity and distribution in Thailand. Detailed data were regarding some environmental factors with greatest potential influence on distribution and abundance of terrestrial snails. Both herbaceous vegetation and leaf litter provide potential food sources for terrestiral mollusks (Mason, 1970); dead leaves support fungal growth which is also a source of food for snails (Burch, 1956). Greater diversity of herbaceous vegetation and leaf litter means more diverse potential food resources, and thus leads to the potential for greater diversity of species of snails. Since snails are sensitive to dessication, moister conditions, presence of given types of surface cover, and variation in depth of the leaf litter have the potential to influence the presence and abundance of snails.

Chromosome study

The first studies in the field of molluscan cytology date from the late nineteenth century. Many of early reports have been shown to be inaccurate (Patterson & Burch, 1978). In recent years, especially since 1960, a considerable amount of information has been accumulated on variable taxa of mollusca. This recent interest may be attributed to the boom in the field of cytogenetics, in particular that of mammalian cytogenetics. In Harvey's list (1920) chromosome numbers of only 44 molluscan species were recorded, and in Makino's list (1950) those of only

127 species and subspecies. Then just two decades after Makino's work, the chromosome numbers of 622 species and subspecies were reported from 1930 to 1969 (Patterson, 1969), and karyotype of 27 species of eight archaeogastropod families were investigated (Nakamura, 1986). Chromosome numbers are now known for members of five molluscan classes, i.e., Gastropoda, Bivalvia, Polyplacophora, Cephalopoda and Scaphopoda. Most of the results have been reported from gastropods, in which only the two pulmonate orders, Basommatophora and Stylommatophora, are at all well surveyed (Burch, 1989).

The objectives of this studies were, to determine the chromosome number and describe the karyotype in detail, and to present a list to CISMOCH, Computerized Index System for Molluscan Chromosomes and present some systematic interpretations with discussing the karyological tendencies among the molluscs. Continuing the course of my study, I have several additional discussion, firstly I will discuss the technical problems, and present an applicable method to raise the level of chromosome analysis in the molluscan field; and second, I will report further information on the chromosomes of 25 species from five families particularly Family Camaenidae, which almost nobody has done it before.

MATERIALS AND METHODS

About 10,000 specimens (430 lots) of Thai land pulmonate shells (6,500) and 3,500 individuals were examined. All specimens were then systematically collected and depostied in Natural History Museum of Chulalongkorn University, Phyathai Road, Bangkok by running number of CUMZ 001 - 653 for shell collection and CUMZ 001 - 846. About 3,000 shells collection of Brandt deposting in Senckenberg Museum, Frankfurt were also examined and excluded that above records.

During the summer of 1994, 1995 and 1996, four museums in Europe and three in the United States were visited and their mollusk collections searched for Thailand and adjacent countries materials as well as natural history on the collection of land snails in this region. The relevant specimens were borrowed and studied over the period of the next two years. The institutions visited and the number of lots from each are:

SMNH	Senckenberg Museum (78 lots)
ZMNH	Zoological Museum, Copenhagen (46 lots)
RNHL	Rijksmuseum, Leiden (64 lots)
ZMA	Zoological Museum Amsterdam (57 lots)
USNM	United Sates National Museum (61 lots)
UMMZ	University of Michigan Museum of Zoology (38 lots)
FMNH	Field Museum of Natural History, Chicago (102 lots)

Geography of Thailand

Thailand is the third largest country in Southeast Asia, after Indonesia and Myanmar, with a land area of 513,115 square kilometres. As the crow flies it is roughly 1,650 kilometres from north to south and 800 kilometres from east to west, but only 11 kilometres wide at its narrowest part in the peninsula. It is bordered by Myanmar to the west, Laos to the north and east, Cambodia to the southeast and Malaysia in the south. Most of Thailand's 5,326 kilometres land boundary is marked by natural features, usually rivers or mountain ridges. However, its 2,815 kilometres coastline is also important. The country is positioned at a unique biological crossroads where the continent's southern mountain complexes sweep down to the plains and sea. Equatorial animals found in Malaysia and Indonesia inhabit Thai forests of the southern peninsula. More than 1,500 kilometres away, the northern provinces are home to temperate zone creatures found otherwise only in China and Laos. Its vegetation is likewise varied, ranging from mangrove swamps to the soaring canopies of tropical rain forests to pine trees in cool, misty height.

In Thailand's cornucopia of wildlife are bird species which exceed all those found in Europe or North America. Reefs along 3,000 kilometres of coastline are heaven for a dense marine life. Amphibians, reptiles, moths and butterflies continue to be discovered in fields and streams. Among the mammals is Asia's largest, the

elephant, and the world smallest, the hog-nosed bat (Gray, Piprell and Graham, 1994; Graham and Round, 1994).

SYSTEMATICS

The species are listed in phylogenic order, utilizing a classification adopted from Solem, Burch and Vaught. Since this collection contained many specimens of each species, comparable material from adjacent areas was possible, however no modern systematic studies have been published on the mollusks of Southeast Asia, little information could be contributed towards speciation and distributional problems.

Despite the limited data on distribution and generally inadequate descriptions found in much of the previous literature, many times it proved possible to suggest that typological species from neighboring areas might be synonymous with, or at most subspecifically distinct from, the Thailand material. Although available sets were inadequate to propose new synonymies, even simple collation of the very widely scattered literature serves a useful function.

Fortunately, a large percentage of the collection had been preserved in alcohol. This allowed preparation of several comments about generic and family classification, particulary concerning Camaenidae, Helicarionidae, Ariophantidae and Zonitidae.

The list below contains 15 families, 59 genera and 136 species (Panha, 1997a). However the most recent investigation is now in preparation for publication, contains 19 families, 72 genera 247 species. Vertiginidae, Ariophantidae and Camaenidae are the big families which contain 35, 60 and 45 species respectively (Fig. 2).

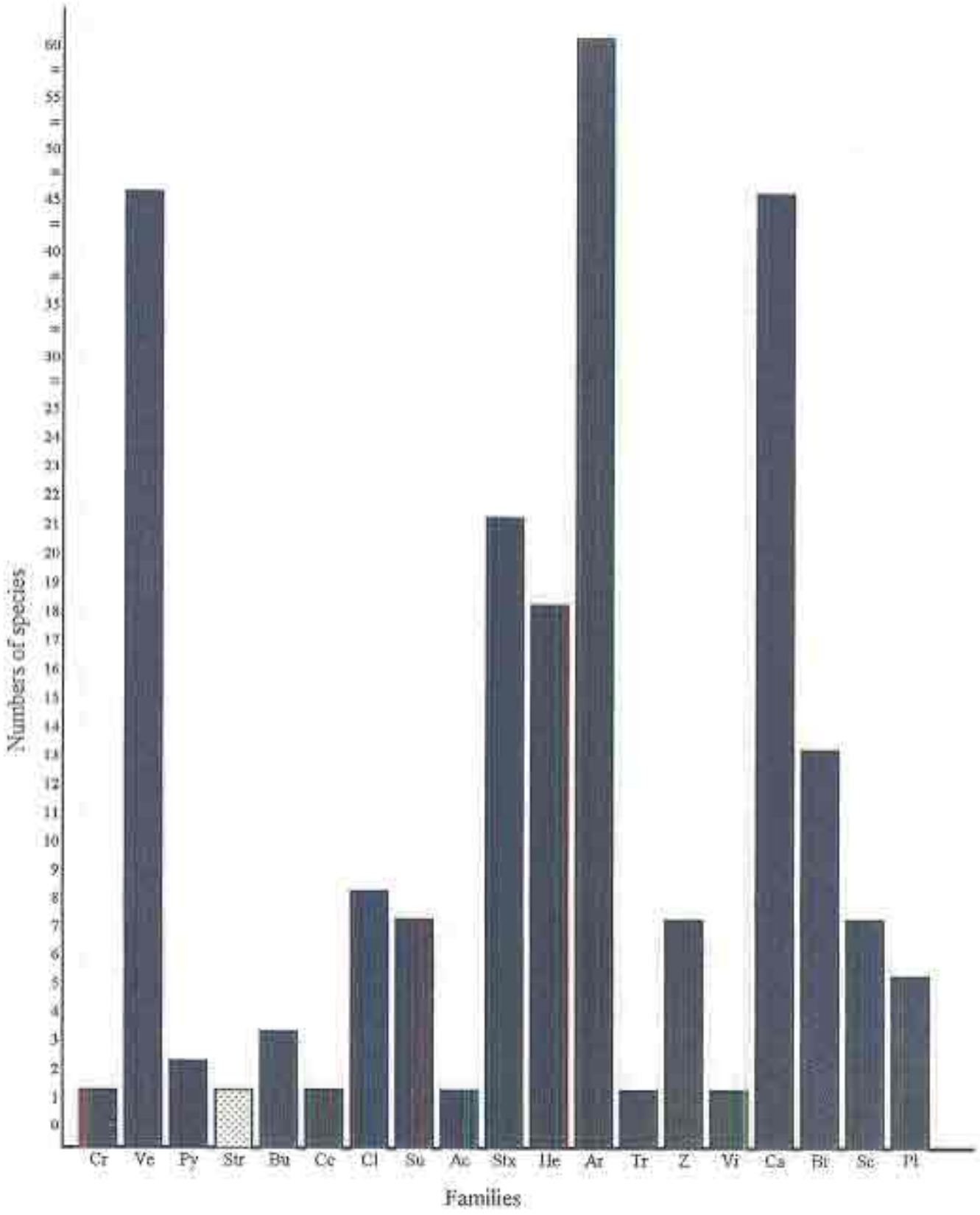


Fig. 2 The nineteenth families of Thai land pulmonate snails collected during this study.

OUTLINE OF CLASSIFICATION AND LIST SPECIES

The records below come mostly from our own collecting in the area and the specimens housed in the Museum of Natural History, Chulalongkorn University.

Subclass Pulmonata Cuvier
- Order Stylommatophora Schmidt
- Superfamily Pupilloidea
- Family Vertiginidae
  - Genus *Hypselostoma* Benson
    - *H. holimanae* Thompson & Lee
  - Genus Gyliotrachela Tomlin
    - *G. transitans* (Moellendorff)

Superfamily Buliminoidea
- Family Buliminidae
  - Genus *Buliminus* Beck
    - *B. siamensis* Redfield
  - Genus *Coccoderma* Moellendorff
    - *C. ceratina* (Reeve)
- Family Cerastuidae
  - Genus *Cerastua* Strand
    - *C. siamensis* (Redfield)

Superfamily Clausilioidea
- Family Clausiliidae
  - Genus *Formosana* Boettger
    - *F. cambodjensis* (Pfeiffer)
  - Genus *Clausilia* Draparnaud
    - *C. (Pseudonenia) kelantanese* Sykes

Superfamily Achatinoidea
- Family Subulinidae
  - Genus *Curvella* Chaper
    - *C. puta* (Benson)
  - Genus *Glessula* Van Martens
    - *G. latestriata* Moellendorff
  - Genus *Lamellaxis* Strebel & Pfeiffer
    - *L. gracilis* (Hutton) [introduced]
  - Genus *Prosopeas* Morch
    - *P. filiforme* Moellendorff
    - *P. walkeri* (Benson)
  - Genus *Plicaxis* Sykes
    - *P. mirabilis* Sykes

Genus *Stenogyra* Shuttleworth
S. erecta (Benson)
Family Achatinidae
Genus *Achatina* Lamarck
A. fulica (Ferussac) [introduced]

Superfamily Streptaxoidea
Family Streptaxidae
Genus *Streptaxis* Gray
S. depressa Moellendorff
S. mouhoti Pfeiffer
S. pelluceus Pfeiffer
S. porrectus Pfeiffer
S. siamensis Pfeiffer
Genus *Discartemon* Pfeiffer
D. roebeleni (Moellendorff)
Genus *Haploptychius* Moellendorff
H. mirificus (Moellendorff)
Genus *Euplecta* Semper
E. bijuga (Stoliczka)
E. dichromatica Morlet
E. pataniensis de Morgan
Genus *Hemiplecta* Alber
H. crossei Pfeiffer
H. danae (Pfeiffer)
H. distincta (Pfeiffer)
H. hugonis Pfeiffer
H. neptunus (Pfeiffer)
H. siamensis (Pfeiffer)
H. weinkauffiana Crosse & Fischer
H. zimmayensis Godwin-Austen
Genus *Dyakia* Godwin-Austen
D. hugonis Pfeiffer
D. salangana (Martens)
D. striata (Gray)
Genus *Parmarion* Fischer
P. setchaunensis Heude
Genus *Austenia* Nevill
A. doisutepensis Solem
Genus *Cryptaustenia* Cockerell
C. gadinodromica Solem
Genus *Cryptogirasia* Godwin-Austen
C. rubra (Godwin-Austen)
Genus *Macrochlamys* Benson
M. anceps (Gould)

M. asamurai Panha
M. dugasti Morlet
M. limbata Moellendorff
M. molecula Benson
M. pumicatal (Morlet)
M. resplendens (Phillippi)
Genus *Megaustenia* Cockerell
M. siamensis (Haines)
Genus *Muangnua* Solem
M. limax Solem
Genus *Sarika* Godwin-Austen
S. hainesii (Pfeiffer)
S. kautaoensis Tomlin
S. obesior (Martens)
Genus *Teraia* Solem
T. crenulata (Yen)
T. thailandica Solem
Genus *Durgella* Blanford
D. libas Solem
Genus *Naninia* Sowerby
N. benoiti Crosse & Fischer
N. mouhoti Pfeiffer
N. pedina Benson
N. subcornea Pfeiffer
Genus *Minyongia* Godwin-Austen
M. kempi Godwin-Austen
Genus *Myotesta* Collinge
M. fruhstorferi Collinge
M. punctata Collinge
Genus *Sitala* Adams
S. trochulus (Moellendorff)
Genus *Ariophanta* Desmoulins
A. laevis Muller
Genus *Ibycus* Heynemann
I. perakensis Godwin-Austen
Genus *Trochomorpha* Alber
T. capitium Benson
Family Zonitidae
Genus *Bertia* Ancey
B. cambodjensis Reeve

Superfamily Vitrinoidea
Family Vitrinidae
Genus *Vitrina* Draparnaud
V. cochinchinensis Morlet

Superfamily Camaenoidea
Family Camaenidae
Genus *Camaena* Alber
C. illustris (Pfeiffer)
Genus *Amphidromus* Alber
A. areolatus (Pfeiffer)
A. atricallosus (Gould)
A. dohrni (Pfeiffer)
A. fultoni Ancey
A. glaucolarynx (Dohrn)
A. hemicyclus Rockebr
A. inversus annamiticus (Crosse & Fischer)
A. leucoxanthus Martens
A. metabletus Moellendorff
A. moellendorfi Haas
A. tanyai Panha
A. perversus Linnaeus
A. rhombostomus Pfeiffer
A. schomburgki (Pfeiffer)
A. semitesselatus (Morlet)
A. sinensis indistinctus Pilsbry
A. xiengensis Morlet
Genus *Chloritis* Beck
C. breviseta Pfeiffer
C. (T.) deliciosa (Pfeiffer)
C. (T.) diplochone Moellendorff
C. (T.) fouresi Morlet
C. (T.) insularis Moellendorff
C. (Trichochloritis) siamensis Moellendorff
C. platytropis Moellendorff
C. platytropis samuiana Moellendorff
C. platytropis siamensis Moellendorff
C. tenella Pfeiffer
Genus *Ganesella* Blanford
G. capitium Benson
G. coudeini (Bavay and Dautzenberg)
G. dipplogramme Moellendorff
G. hariola carinella Moellendorff
G. perakensis Crossei
G. perakensis Grossei
G. ptychostyla Martens
Genus *Trachia* Alber
T. gabata Gould

Superfamily Helicoidea
Family Bradybaenidae
Genus *Bradybaena* Beck
B. (Acusta) brevispira Morlet
B. fouresi Morlet
B. norodomiana Morlet
Genus *Aegista* Alber
A. (Plectotropis) emensa (Godwin-Austen)
A. (P.) goniochila Pfeiffer
A. (P.) oldhami Pfeiffer
A. (P.) orthocheilis Heude
A. (P.) trichotropis Pfeiffer
A. (P.) winteriana Pfeiffer
Genus *Cathaica* Moellendorff
C. brevispira Haines

Superfamily Succinoidea
Family Succineidae
Genus *Succinea* Draparnaud
S. cochinchinensis Pfeiffer
S. tenella Morlet

Superfamily Plectopylidoidea
Family Plectopylidae (Corillidae)
Genus *Plectopylis* Benson
P. (Chersaecia) degerbolae Solem
P. (C.) simplex Solem

The division of the Pulmonata into Stylommatophora (land snails) and Basommatophora (freshwater snails) recognizes basic adaptive radiations and is supported by morphological and physiological characters. The most comprehensive classification of the Stylommatophara has been developed by Pilsbry (1919, 1948) and H. B. Baker (1955, 1956 a, b). Based on the structure of the pallial region, five orders-Heterurethra, Tracheopulmonata, Orthurethara Mesurethra, and Sigmurethra - have been recognized. The "key character" used in separating the various orders is the relationship of the ureter to the kidney and other pallial organs. The five orders are characterized as follows:

Tracheopulmonata: Ureter multi-looped, opening into respiratory pore or directly to exterior (Fig. 3 b).

Orthurethra: Ureter remote from hindgut, running from tapered anterior end of kidney to anterior border of lung (Fig. 3 c).

Mesurethra: Ureter represented mainly by lateral opening of the relatively short kidney (Fig. 3 d).

Sigmurethra: Ureter abruptly reflexed, passing to posterior end of lung cavity, then turning across to the last fold of the gut and following it forward to the mantle edge (Fig. 3 e).

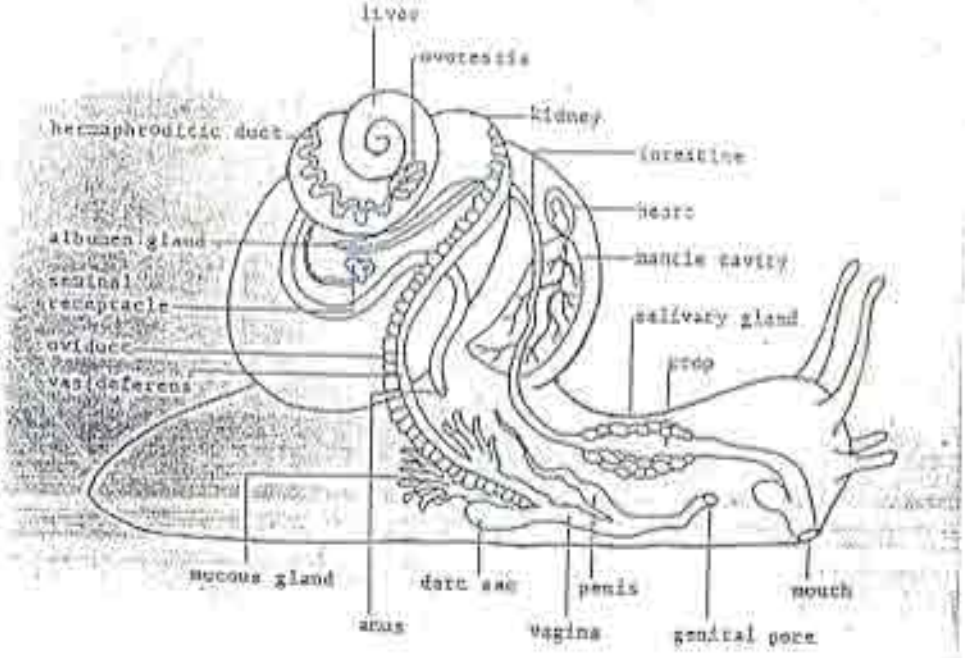


Fig. 4. Anatomy of land pulmonate snail (Hegner, 1961)

Order ORTHURETHRA Pilsbry, 1900
Family Vertiginidae

Shell small, in most cases elongated oval; aperture with or without folds; lower tentacles occasionally absent, but as a rule are present; radula regular; lateral plates usually with an outer cusp.

Key to genera of Thailand

1. Shell cone-shaped widely umbilicate 2
   shell cone-schaped narrowly umbilicate ..... *Boysidia*
2. There is one lamella on the penultimate whorl apertural margin broadened ..... *Hypselostoma*
   There are two lamellae on the penultimate whorl separated: the apertural folds and lamellae finely spinulose; apertural margin broadened ..... *Gyliotrachela*

Genus *Hypselostoma* Benson 1856
Hypselostoma holimanae Thompson & Lee 1988

Hypselostoma holimanae Thompson & Lee 1988, Nautilus, 1988: 102(2): 78-81.

Shell small, about 2.6-2.9 mm wide and 2.3-2.6 mm high; about 0.85-0.95 times as high as wide. Shell turban shaped with a moderately long conical spire. Last whorl conspicuously enlarged, and with a distinct peripheral angle and a basal angle. Last whorl ascending at about 10° to longitudinal axis of spire. Whorls 4.6-4.9. Protoconch consisting of about 1.5 whorls that appear smooth under light microscopy; at higher magnifications the whorls are sculptured with a dense mesh of fine reticulating threads that have an underlying spiral arrangement. Peristome broadly expanded and nearly uniformly wide around aperture. Aperture barrier with four teeth located on inner rim of the aperture just behind expanding peristome and arranged opposite each other in a cross configuration.

Distribution: Thailand, Kanchanaburi Province.

Genus *Gyliotrachela* Tomlin 1930
Gyliotrachela transitans (Moellendorff 1894)

Hypselostoma transitans Moellendorff, 1894, Proc. Zool. Soc. Lond., 1894: 146-156.
Gyliotrachela transitans (Moellendorff 1894), Nach. der Deutch. Malak. Gesel. 1897, 6: 57-103.

Shell small 2.75 mm wide and 2.66 mm high, with quadrangular shape of the last whorl and the dentition of the aperture in common, widely umbilicate. Aperture oblique with expanding peristome, apertural dentition consisting pacietal lamella, one basal tooth and one columella tooth.

Distribution: Samui-Island, Surat-thani Province.

Family Buliminidae

Shell small, dextral, seldom sinistral, oval to tower shaped; aperture generally toothless, sometimes with one or a few denticles; columellar margin as a rule without, seldom with one fold. Radula with transverse rows of plates, in most cases with one outer cusp which is cleft on the marginal plates. Genitalia with a tube-shaped spermatophore sack on the sometime very long stalk of the receptaculum seminis.

Genus *Buliminus* Beck 1837

Petraeus siamensis Redfield 1853, Ann. Lyc. N., 1853: 15.

Buliminus siamensis (Redfield 1853), J. De Conchyl., 1889, 37: 128.

Shell medium 0.4 cm wide 1.6 mm high, sinistral with cylindrical shape without dentition of the aperture, aperture round, shell brown color. The snail lives under leaves litter.

Distribution: Eastern and Southern Thailand and Cambodia

Genus *Coccoderma* Moellendorff 1907

Coccoderma ceratina (Reeve 1849)

Buliminus ceratinus Reeve 1849, Conch. Icon, pl. 77, fig 569.

Coccoderma ceratina (Reeve 1849), Gude, 1914. Fauna Brit. India, Moll. 2, pp. 230-231.

Shell 6.9 mm wide, 13.3 mm high, with 7 whorls, compared to *C. milagerica* (Pfeiffer 1846) of Burma in FMNH, the Thai land shell is less elongated and has a distinctly greater angle to the spire.

Distribution: Chieng Dao at 1,800 meters, Chieng Mai Province

Family Cerastuidae

Shell medium with dextral and sinistral chirality, high cone-shaped. Aperture of the shell toothless, sometimes with a columellar fold; radular plates in most cases with distinct outer cusps; penis with an appendix; receptaculum seminis without spermatophore sack.

Genus *Cerastus* Martens 1860

Cerastus siamensis (Redfield 1903)

Cerastua siamensis Redfield 1903, Proc. Malac. Soc. Long. 5: 284-286.

Cerastus siamensis (Redfield 1903),

Shell medium with sinistral chirality, brown color, umbilicus closed. Columellar margin without fold. Whorl large, rounded, aperture oval; apertural margin widened, reflected. Shell 0.5-0.6 wide 1.5-17 high.

Distribution: Eastern Thailand and Cambodia.

Order Sigmurethra Pilsbry 1900
Family Subulinidae

Shell turreted to cylinder-shaped, more seldom elongated oval, as a rule unicolored, without inner lamellae; axis thin columella truncated or passing into the lower margin. Central plate of radula narrow; lateral plates with outer cusp, frequently also with inner cusp.

Key to genera of Thailand

1. Shell perforate of scarely perforate 2
   Shell imperforate 4
2. Lateral plates of radula possess outer cusps ..... *Stenogyra*
   Lateral plates of radula possess long cusps 3
3. Lateral plates of with prolonged cusps ..... *Curvella*
   Lateral plates with long pointed median cusps ..... *Prosopeas*
4. Lateralplates possess inner and outer cusps ..... *Lamellaxis*
   Lateral plates possess outer cusps 5
5. Shell possess callous columella ..... *Plicaxis*
   Shell possess columella ..... *Glessula*

Genus *Lamellaxis* Strebel 1882

Lamellaxis (*Allopeas*) gracile (Hutton 1834)

Bulimus gracilis Hutton 1834. J. Asiatic Soc. Bengal 3, p. 93.
Lamellaxis (Allopeas) *gracile* (Hutton 1834). Spolia. Zool. Mus. haun. 1966, 24: 94.

This is an introduced species. Shell turreted; apex smooth, without parietal lamella; lateral plates of the radula with inner and outer cusp; eggs with calcareous shell. Shell small 1-2 mm wide 0.8-1 cm high, yellowish. Many of *L.* (*A.*) *gracile* have been accidentally imported on plants into the country.

Distribution: Circumtropical.

Genus *Prosopeas* Morch 1876

Prosopeas walkeri (Benson 1863)

Spiraxis walkeri Benson 1863. Ann. Mag. Nat. Hist. (3) 11, p. 90.
Prosopeas walkeri (Benson 1863). Spolia. Zool. Mus. haun. 1966, 24: 94.

Shell turreted, scarcely perforate with 9 3/8 whorls. Shell 15.8 mm high, having a shallower suture and more heavily callused columella region. Eggs spherical, with calcareous shwll. Lateral plates possess long pointed median cusps. Shell has olive green periostracum.

Distribution: Northern Thailand and Myanmar.

Genus *Curvella* Chaper 1885

Curvella puta (Benson 1856)

Bulinus puta Benson 1857. Ann. Mag. Nat. Hist. (2) 19, p. 330.
Curvella puta (Benson 1857). Spolia Zool. Mus. haun. 1966, 24: 94.

Shell 4.25 mm wide, 6.73 mm high with whorls 5 1/2. Shell ovate cone-shaped, perforate, apex rounded, smooth; growth line arched; apertural margin roundly projecting; columella straight. The cutting edges of the lateral plates of the radula prolonged.

Distribution: Western Thailand and Myanmar.

Genus *Glessula* Martens 1860

Glessula latestriata Moellendorff 1889

Glessula latestriata Moelendorff 1899. Nachrb. d. Malak. Gesell. 31, p. 166.

Shell imperforate, ovate cone-shaped, brownish, smooth and shing; apex blunt; aperture oval; apertural margin blunt; columella concave, 7.9-11.2 mm high with 6 to 6 5/8 whorls. Foot without lateral furrow; jaw finely striated; central plate of the radula with lateral cusps on the cutting edge; lateral plates with outer cusp; marginal plates tricuspid.

Distribution: Northern Thailand (Doi Inthanon, Doi Suthep, Doi Chiang Dao) and Myanmar.

Genus *Stenogyra* Shuttleworth 1854

Stenogyra erecta (Benson 1849)

Stenogyra erecta Benson 1849 (Achatina). Ann. Mag. Nat. Hist. 9: 487.
Stenogyra erecta (Benson 1849). Conch. Icon. 1860, 16: 69.

Shell 2.4-2.5 cm high, 0.8-0.9 cm wide, apertural 8 mm high 5 mm wide, turreted, apex obtuse, perforate. Lateral plates of radula posses outer cusps. Shell brownish color; eggs with calcareous shell.

Distribution: Eastern Thailand, Laos and Cambodia.

Order Mesurethra Pilsbry, 1900
Family Clausiliidae

Shell nearly always sinistral, turreted, with several whorls; aperture small with internal lamellae; on the upper margin and on the columella with an upper lamella and a lower lamella seperated by the interlamellar; adjoining the inner end of the upper lamella is the spiral lamella lying parallel to the suture; extending beside the lower lamella is the columellar lamella which diverges from it downward, between these lies the "clausilium" a plate joined with the columella by an elastic stalk, this plate forms a closing device when the animal withdraws into the shell.

Key to genera of Thailand

1. Shell palatal fold weakly developed 2
   Shell palatal fold strongly developed ..... *Formosana*
2. Shell palatal fold weakly developed ..... *Phaedusa*
   Shell palatal fold rudimentary ..... *Clausilia*

Genus *Formosana* O. Boettger 1877

Formosana cambodjensis (Pfeiffer 1861)

Formosana cambodjensis (Pfeiffer 1861), Arch. Naturgesch., Berlin, 1925, 91: 1-18.

Shell sinistral, 0.6-0.8 cm wide and 1.6-2.2 cm high. The decollated shell consists of 5 to 6 rather convex whorls, sculptured with fine iregular striae (5-8 per mm on the whorl above the aperture). These striae are hardly coarser on the neck. Suture rather deep, without a thread. The neck has no crest. The aperture is pear-shaped, whitish within; the sinulus is high.

Distribution: Eastern Thailand and Cambodia.

Genus *Clausilia* Draparnaud 1805

Clausilia (*Pseudonenia*) kalantanense Sykes

Clausilia (*Pseudonenia*) *kalantanense* Sykes 1902, J. Malac. 1902: 22, 61.

Shell small, dextral, 03-0.5 cm wide and 1.2-1.4 cm high, with rib-like striae, spindle-shaped, with neck fold, crecentic fold present, palatal fold rudimentary, clausilium narrow. Behind the short penis the weak retractor attaches to a small loop; the sperm duct is thick; the process of the stalk of the receptaculum seminis arises close to its base.

Distribution: Southern Thailand and Malaysia.

Family Streptaxidae

Shell helicoid, turriform or pupiform, the last whorls usually deviating obliquely from the others. Animal has long neck and short tail; has simple undivided foot, a large pharynx, no jaw; a long and narrow radula and is carnivorus. The shell is colorless to transparent, sometimes quite distorted. There is a long spermatheeal duct, a short vagina and frequently a muscular or sheated armed penis.

Key to genera of Thailand

1. Shell possess apertural dentition 2
   Shell possess without apertural dentition ..... *Steptaxis*
2. Shell possess 1 parietal and 1 basal tooth 3
   Shell possess 2 parietal and other teeth 4
   Shell possess only on parietal tooth ..... *Haploptychius*
3. Shell widely umbilicate ..... *Discartemon*
   Shell narrowly umbilicate ..... *Micrartemon*
4. Behind the apertural margin with a few small pits, corresponding interal denticles ..... *Perottetia*
   Behind the apertural margin without any small pits ..... *Oophana*

Genus *Streptaxis* Gray 1837

Streptaxis depressa Moellendorff 1894

Streptaxis depressa Moellendorff 1894, Proc. Zool. Soc. p. 146.

Shell widely umbilicate, solide, opaque, grayish white; whorls 6 1/2, closely arcuately ribbed-striate; without apertural dentition; lip thickened, reflected, its extremities joined by a shining callus.

Distribution: Southern Thailand and Malaysia.

Streptaxis mouhoti Pfeiffer 1848

Streptaxis mouhoti Pfeiffer 1848, Proc. Zool. Soc. p. 108.

Shell perviously umbilicated, thinnish, closely oblique ribbed-striate, whitish, suture impressed, submarginate; whorls 6 1/2, the last whorl becoming smooth and flattened below; aperture with an entering parietal lamella and three minute lip teeth; peristome white, narrowly reflected, slightly arculate above.

Distribution: Southern Thailand and Malaysia.

Streptaxis pellucens Pfeifer 1862
Streptaxis pellucens Pfeiffer 1862, Proc. Zool. Soc. p. 273.

Shell narrowly umbilicated, thin, shining, hyaline, suture impressed, submarginate; whorls 6 1/2, arcuately ribbed-striate, becoming smooth on the body-whorl; parietal lamella small, compressed, lip somewhat thickened and reflected, thinner and arcuate above.

Distribution: Northeastern Thailand, Laos and Cambodia.

Streptaxis porrectus Pfeiffer 1862
Streptaxis porrectus Pfeiffer 1862, Proc. Zool. Soc. p. 273.

Shell narrowly umbilicated, thin, greenish white, whorls 7, closely ribbed-striate, the last whorl smooth on the base, the penultimate whorl subangulate; parietal lamella moderate; compressed entering: lip widely expanded, reflected, the margin sub-parallel

Distribution: Northeastern Thailand, Laos and Cambodia.

Genus *Discartemon* Pfeiffer 1856

Discartemon roebeleni (Moellendorff)
Steptaxis roebeleni Moellendorff 1894, Proc. Zool. Soc. p. 147.
Discartemon roebeleni (Moellendorff 1894), Arch. Moll. 90(1/3); p. 82.

Shell discoidal, openly umbilicated; aperture transverse, outer lip reflected, thickened and together with parietal wall, and one big parietal tooth and one basal tooth.

Distribution: Southern Thailand and Malaysia.

Genus *Haploptychius* Moellendorff 1905

Haploptychius mirificus (Moellendorff 1894)
Steptaxis mirificus Moellendorff 1894, Proc. Zool. Soc. Lond. p. 147.
Haploptychius mirificus (Moellendorff 1894), M. CH., I. 12b p. 140.

Shell distorted, openly umbilicated, aperture transverse outer lip reflected, apex flatened, parietal tooth transverse with indistict basal tooth.

Distribution: Southern Thailand and Malaysia.

Genus *Micratemon* (Moellendorff 1890)

Micratemon prestoni (Gude 1903)
Haploptychius prestoni Gude 1903, Proc. Mal. Soc. Lond. 5: 322.
Micratemon prestoni (Gude 1903), Bull. Raffles Mus. 1954: 96.

Shell very small, narrowly umbilicate, weakly bulging above, smooth, regulary coiled; apeture half-moon-shaped, with a lamella on the penultimate whorl and a transverse thickening of the lower margin.

Distribution: Southern Thailand and Malaysia.

Genus *Oophana* Ancey 1884

Oophana strangulatus (Moellendorff 1894)
Streptaxis (Oophana) strangulatus Moellendorff 1894, Proc. Zool. Soc. Lond. p. 148.
Oophana strangulatus (Moelendorff 1894), Arch Moll., 90(1/3), p. 85.

Shell oval with 4 3/4 whorls, gray color, aperture with one parietal tooth, 3 palatal teeth and one columella tooth. Shell higher than wide.

Distribution: Ko-Samui Thailand.

Oophana strangulatus (Moellendorff 1902)
Streptaxis siamensis subbulbulus Moellendorff 1902, N. Bl., 34(9/10): 154.
Oophana subbulbulus (Moellendorff 1902), Arch Moll., 90(1/3), p. 85.

Shell almost oval with 4 3/4 whorls, whitish color, wider than high, aperture with one parietal tooth and three short dentition on apertural reflected rib.

Distribution: Central Thailand.

Genus *Perrottetia* Kobelt 1905

Perrottetia siamensis depressa (Moellendorff 1894)
Streptaxis siamensis depressa Moellendorff 1894, Proc. Zool. Soc. Lond. p. 146.
Perrottetia siamensis depressa (Moellendorff 1894), Arch. Moll. 90 (1/3), p. 86.

Shell distorted, behind the apertural margin with a few small pits and corresponding internal denticles; parietal lamella doubled with two palatal dentition.

Distribution: Ko-Samui Thailand.

Perrottetia siamensis expansilabris (Moellendorff 1902)
Streptaxis siamensis expansilabris Moellendorff 1902, N. Bl., 34: 154.
Perrottetia siamensis expansilabris (Moellendorff 1902), Arch. Moll. 90 (1/3), p. 86.

Shell distorted, behind the apertural margin with a few small pits and corresponding internal denticles; parietal lamella doubled with short one palatal tooth.

Distribution: Ko-Srichang Thailand.

Perrottetia siamensis subglobosus (Moellendorff 1902)

Streptaxis siamensis subglobosus Moellendorff 1902, N. Bl., 34: 154.

Perrottetia siamensis subglobosus (Moellendorff 1902), Arch. Moll. 90 (1/3), p. 87.

Shell distorted, behind the apertural margin with a few small pits and corresponding internal denticles; parietal lamella doubled without palatal tooth.

Distribution: Ko-Samui Thailand.

Family Helicariondiae

Dart apparatus absent; epiphallus slender with lime-sac at apex, a small knob to long sinuated appendage; penial retractor inserting much further down epiphallus and at most having a small retractor caecum.

Key to genera of Thailand.

1. Shell umbilicate 2
   Shell non-umbilicate 3
2. Shell narrowly umbilicate ..... *Hemiglypta*
   Shell widely umbilicate ..... *Sivella*
3. Shell cone-shaped 4
   Shell round-shaped ..... *Helixarion*
4. Shell cone-shaped with keeled 5
   Shell cone-shaped without keeled ..... *Sexara*
5. Shell cone-shaped with angulate body whorl ..... *Kaliella*
   Shell cone-shaped with spiral threads above ..... *Geotrochus*

Genus *Helixarion* Ferussac 1821

Helixarion siamensis Haines 1882

Helixarion siamensis Haines 1882, Coch. Indica, p. 14.

Shell nonumbilicate, thin, roundish, with small spire and 3 - 3 1/2 rapidly increasing whorls, the last one large, with wide aperture. Mantle with shell lobes; lateral plates of the radula with outer cusp, sometimes also with small inner cusp; marginal plates bicuspid; penis thin; epiphallus with long process; receptaculum seminis club-shaped.

Distribution: northern Thailand and Myanmar.

Genus *Geotrochus* Hasselt 1823

Geotrochus perakensis Crosse 1879

Geotrochus perakensis Crosse 1879, J. de Conchyl., 27, p. 199.

Shell nonumbilicate, cone-shaped, with spiral threads above. Apex elevated dome-shaped, smooth. Foot with small caudal pit; central and lateral plates of the radula with small outer cusps; marginal plates bicuspid; penis without appendage, with short retractor; receptaculum seminis fairly small, club-shaped.

Distribution: eastern Thailand and Cambodia.

Sesara parva Solem 1966

Sesara parva Solem 1966, Spolia Zool. Mus. Haun., 24, pp. 30-36.

Shell small 6.01-7.52 mm wide, depressed-conoid with two palatal teeth, the upper much larger, and only 5 1/2 - 6 1/4 whorls. Body and tail short, retracted within shell. Pedal grooves high on sides of foot, meeting above caudal horn. Sole of foot tripartite, central portion less than half width of each side when contracted.

Distribution: Chiang Mai Thailand

Genus *Sivella* Blanford 1863

Sivella castra (Benson 1852)

Helix castra Benson 1852. Ann Mag. Nat. Hist. 2(10), p. 349.

Sivella castra (Benson 1852). Fauna Brit. India, Moll. 2, pp. 3-4.

Shell 11.5 mm wide, 5.7 mm high with 6 1/2 whorls, lens-shaped; penis and stalk of the receptaculum seminis long. Foot without caudal pit and sole furrows, central and lateral plates of the radula sometimes with small outer cusps; marginal plates bicuspid.

Distribution: Chiang Mai Thailand.

Genus *Kaliella* Blanford 1863

Kaliella subsculpta Moellendorff 1901

Kaliella subsculpta Moellendorff 1901, J. Mal. p. 30.

Shell subperforate, elongately pyramidal, horny, smooth, apex yellow, rather acute, the base subimpressed in the umbilical region; whorls 8, flattened, suture impressed; aperture quadrate, right margin thin, columellar sub-reflexed.

Distribution: Karnchanaburi Thailand and Myanmar.

Genus *Sesara* Albers 1860

Sesara megalodon Blandford 1902

Sesara megalodon Blanford, 1902, J. Proc. Malac. Soc., 5, p. 35.

Shell imperforated, depressed similar to *S. infrendens* (Gould), the distinguish is the different aperture with four teeth instead of three. The large outer tooth in the basal margin represents the two outer teeth of *S. infrendens*. Shell 9.25-10 mm wide and 6 mm wide.

Distribution: Pitsanuloke Thailand.

Family Camaenidae

Shell variable, with or without umbilicus, len-shaped to elongated oval or turreted; aperture sometimes with teeth or folds; apertural margin as a rule widened or refected. Jaw ribbed or smooth; the form of radular plates is also variable; central and lateral plates sometimes with, sometimes without lateral cusps; marginal plates with 2 or mor cusps. Kidney band-shaped, long and narrow. The penis is continous with the epiphallus and flagellum. The spermathecal duct is not branch.

Key to genera of Thailand

1. Shell trochiform ..... *Ganesella*
   Shell long ovate ..... *Amphidromus*
   Shell depressed 2
2. Shell highly depresed ..... *Trachia*
   Shell moderately depressed 3
3. Shell depressed globose ..... *Camaena*
   Shell depressed helices ..... *Chloritis*

Amphidromus dohrni (Pfeiffer 1863)

Bulimus dohrni Pfeiffer 1863, Proc. Zool. Soc. Lond., p. 525.
Amphidromus dohrni (Pfeiffer 1863), Fieldiana Zool., 41(4), p. 530.

Shell slender, less swollen with proportionately smaller aperture, and the lip is narrowly expanded with the rolled edge adnate to the body whorl. It has a rather intense yellow base color, a brown or black line behind the lip that sometimes ascend partly up the parietal callus with the base of the shell green.

Distribution: Poulo-Condor, Cambodia and Thailand.

Amphidromus fultoni Ancey 1897

Amphidromus fultoni Ancey 1897, Natilus, 11, pp. 62-63.

Shell much more obese shell with a few dots on the third whorl, two very narrow basal bands, and a subsutural whitish band.

Distribution: Southern Thailand and Cambodia.

Amphidromus glaucolarynx (Dohrn 1861)

Bulimus glaucolarynx Dohrn 1861, Proc. Zool. Soc. Lond. p. 207.
Amphidromus glaucolarynx (Dohrn 1861), Fieldiana, Zool., 41(4), pp. 524.

Shell violet-purple aperture, slender shape, and broad vertical purple-brown streaks separate from others. Shell has both sinistral and dextral with 32-39 mm high, 6 to 6 7/8 whorls.

Distribution: Thailand and Cambodia

Amphidromus inversus annamiticus (Crosse & Fischer 1863)

Bulimus annamiticus Crosse and Fischer 1863, J. de Conch. 11, pp. 357-359.
Amphidromus inversus annamiticus (Crosse & Fischer 1863), Fieldiana, Zool., 41(4), p. 561.

The ground color is pale brown and the dark zone of the body whorl is paler than in typicus *inversus*. Shell moderately large (50 mm high), amphidromine, whitish, surface dull with brown streaks and zones or varices. Lip strong and reflexed, often appressed to the preceding whorl.

Distribution: Thailand and Cambodia.

Amphidromus sinensis indistinctus Plisbry 1900

Amphidromus sinensis indistinctus Pilsbry 1900, Man. Conch., 13, p. 192.

Shell 35-37 mm high, with 6 1/2 - 7 whorls, with reddish-brown spiral bands on the basal portion of the body whorl are diagnostic. Lip and aperture are white, lower whorls yellow.

Distribution: Western Thailand and Myanmar.

Amphidromus xiengensis Morlet 1891

Amphidromus xiengensis Morlet 1891, J. de Conch. 39, pp. 27.

Shell has the radial streaks interrupted by a single spiral yellow zone and has the streaking continued to the aperture. Shell has 37-38 mm high with 7 whorls. Five color forms could be distinguished.

Distribution: Thailand, Laos and Cambodia.

Species Diversity

From our studies since 1994, we have found a total of 17 families, 71 genera, and 247 species. Of these, 11 species are new species that have never been found anywhere else in the world. Out of the 17 families, the following 5 families include many species and play a significant role in the forest ecosystem: Vertiginidae, Camaenidae, Ariophantidae, Streptaxidae, and Bradybaenidae. The regions where we found many snails in limestone mountain forests are as follows:

- Western Thailand:
  - Huay Kha Kang Wildlife Sanctuary
  - Kang Krajan National Park
  - Tungyai Narasuan Wildlife Sanctuary
  - Umpang Wildlife Sanctuary
- Northern Thailand:
  - Doi Inthanon National Park
  - Doi Chiang Dao Wildlife Sanctuary

- Eastern Thailand:
  - Phliu, National Park
  - Khao Soi Dao Wildlife Sanctuary
  - Khao Ang Rue Nai Wildlife Sanctuary
- Northeastern Thailand:
  - Phu Luang Wildlife Sanctuary
  - Phu Kheo Wildlife Sanctuary
  - Phu Wua Wildlife Sanctuary

- Southern Thailand:
  - Klong Sang Wildlife Sanctuary
  - Khao Chong Wildlife Sanctuary
  - Harabara Wildlife Sanctuary

All of these forests have a very high species diversity. In particular, Umpang Wildlife Sanctuary and Khlongsang Wildlife Sanctuary were found to have the highest species diversity of pulmonate snails, with 44 and 43 species, respectively.

Among the 247 species that were found, 54 (21.8%) are endemic species that are found only in Thailand. This is a high rate of geographic specificity compared with that for amphibians (12.1%), reptiles (10.4%), birds (only 0.2%), and mammals (only 3%). The remaining nearly 200 species are distributed among nations bordering Thailand on all sides. However, the distribution of snails is very clumpy, and mainly restricted to the few, small, isolated regions that still support a strong forest ecology.

Regarding the survival status of each species, among tree snails there are many endangered species, such as *Amphidromus flavus, A. metabletus, Camaena illustris*, and *Chloritis (T.) siamensis*. There are also many species that are threatened by deforestation and hunting, such as *Amphidromus areolatus, A. semitesselatus*, and *A. xiengensis*, and the limestone mountain species in the families Streptaxidae, Plectopylidae, and Vertiginidae. Some species are abundant and able to spread in regions inhabited by humans or even in major cities, such as *Cryptozona siamensis, Bulimonus siamensis*, and *Succinea tenella*, and 2 introduced species, *Achatina fulica* and *Lamellaxis gracilis*. Other species should be carefully monitored because they may encounter problems if there is further destruction of the environment; these include members of the genera *Amphidromus, Ganesella*, and *Camaena*.

Species diversity was highest in the western forest with limestone areas, 222 species were recorded (Fig. 5), in particular 183, 179, 171 species were collected from around the areas of Kang Krajan National Park, Huay Kha Kang Wildlife Sanctuary, and Tungyai Narastuan Wildlife Sanctuary (Fig. 6). In very particular, just only small areas around d the offices of Umpang Wildlife Sanctuary and Klongsang Wildlife Sanctuary were found to have the highest species diversity of land pulmonate snails, with 44 and 43 species, respectively.

Species diversity was positively correlated with tree leaf litter diversity ($r = 0.76$, $p < 0.01$) (Fig. 7). Although there was no overall significant correlation of species diversity with elevation ($R = -0.41$) (Fig. 8).

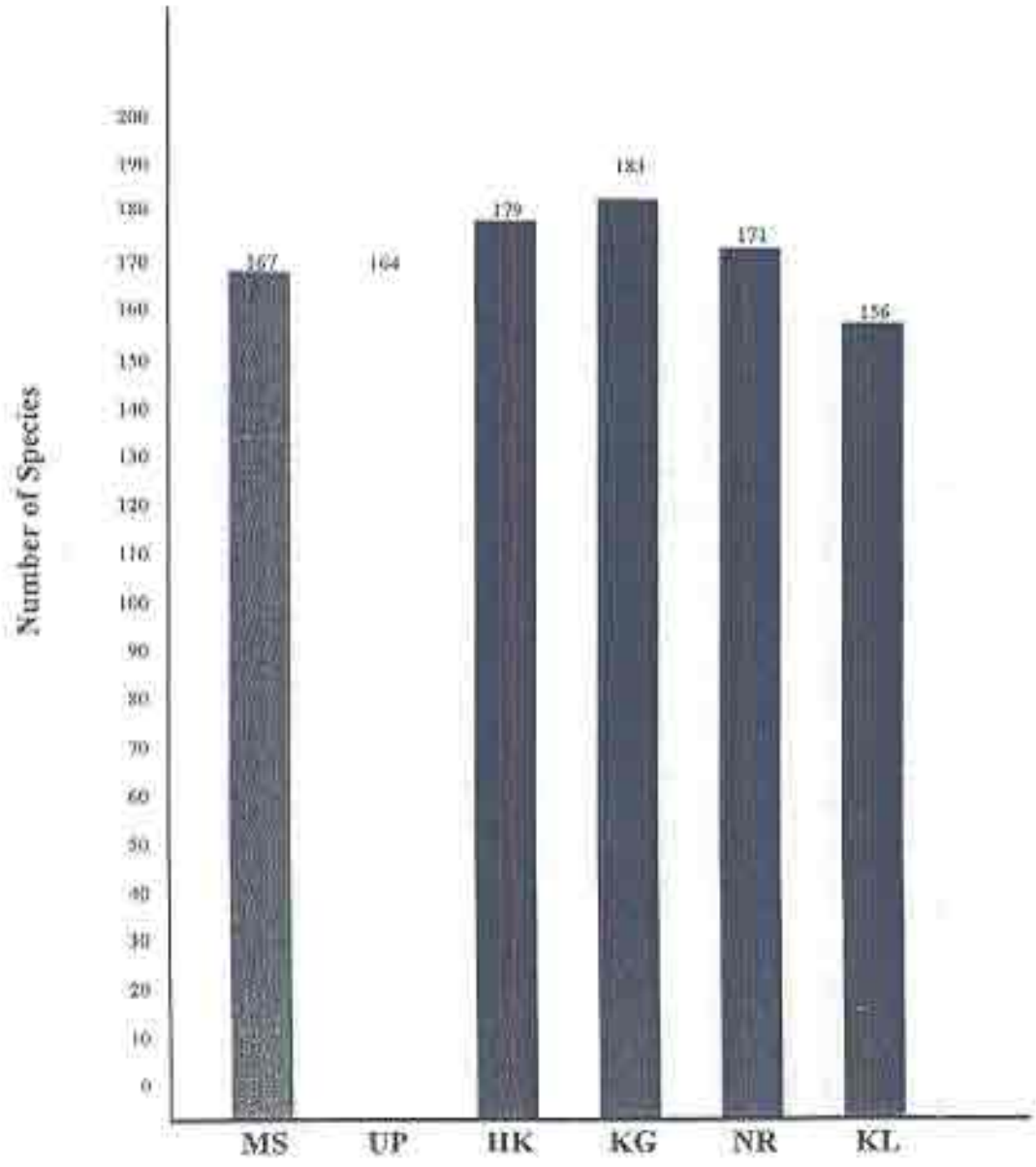


fig. 6 Species richness of Thai land pulmonate snails in western region.

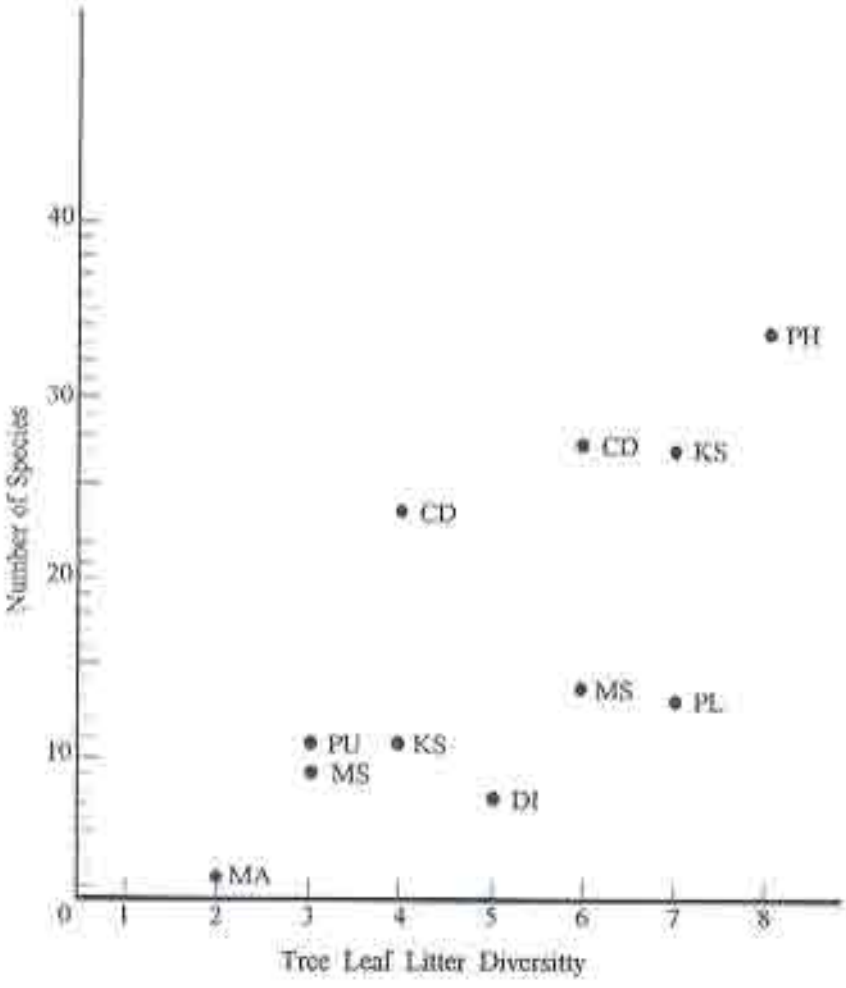


Fig. 7 Species richness (number of species) of snails in relation to tree leaf litter diversity.

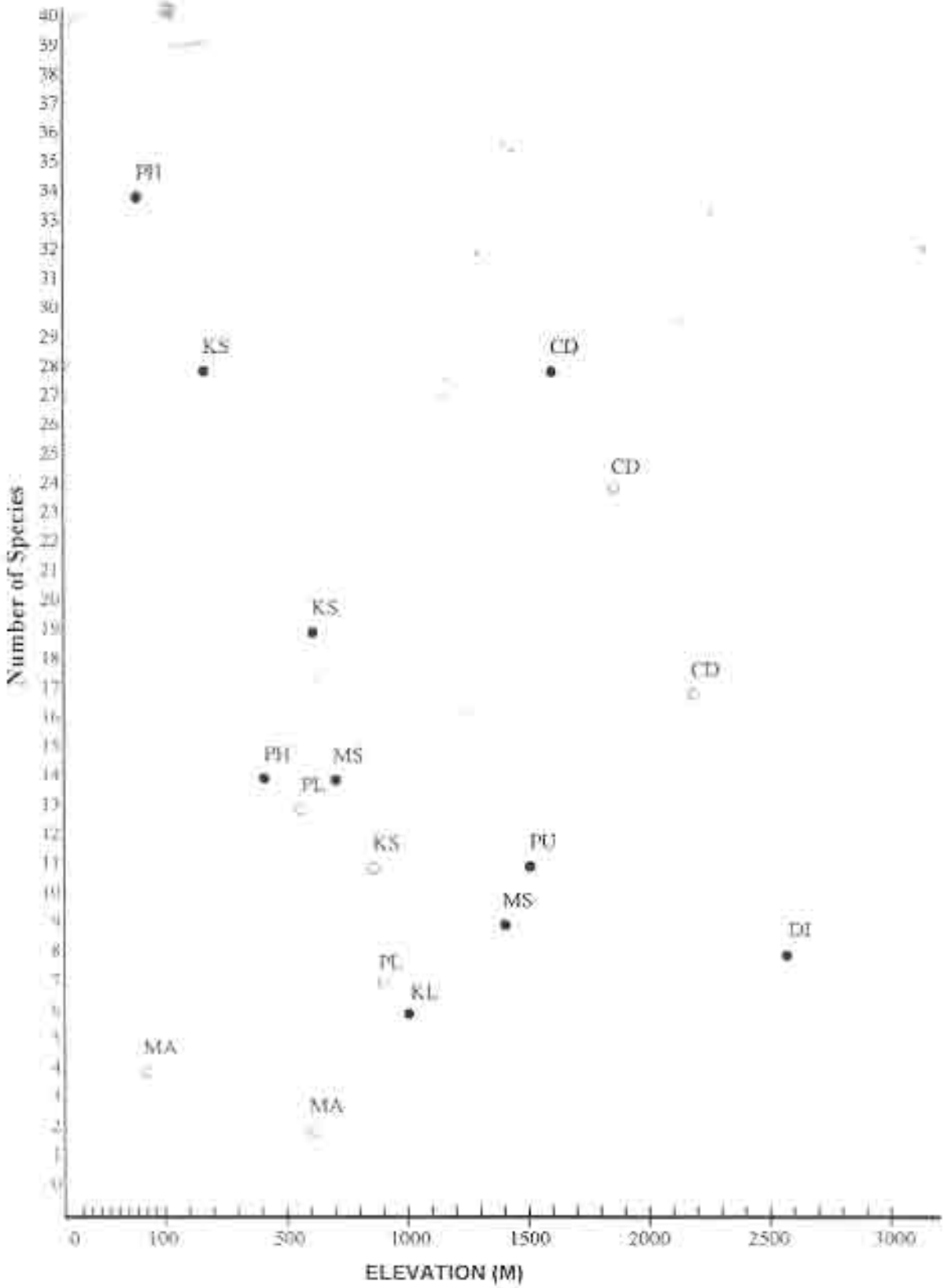


Fig. 8 Species richness (number of species) of Thai land pulmonate snails in relation to elevation.

Chromosome study

The analysis of chromosomes of snails from the families Ariophantidae Camaenidae, succineidae, Achatinidae and Clausiliidae has provided very important information with regard to their classification. We compared our results with those compiled by Prof. John Burch of the University of Michigan, U.S.A. in 1989 (Fig. 9). Burch specified the number of chromosomes of several families of snails that had previously been studied at that time. Our present results differ in several respects. Ours is the first work on snail chromosomes of the genus *Amphidromus*. The tissue that we examined are different from the gonads used previously. Livers and pedal glands were used in this study to prepare mitotic chromosome.

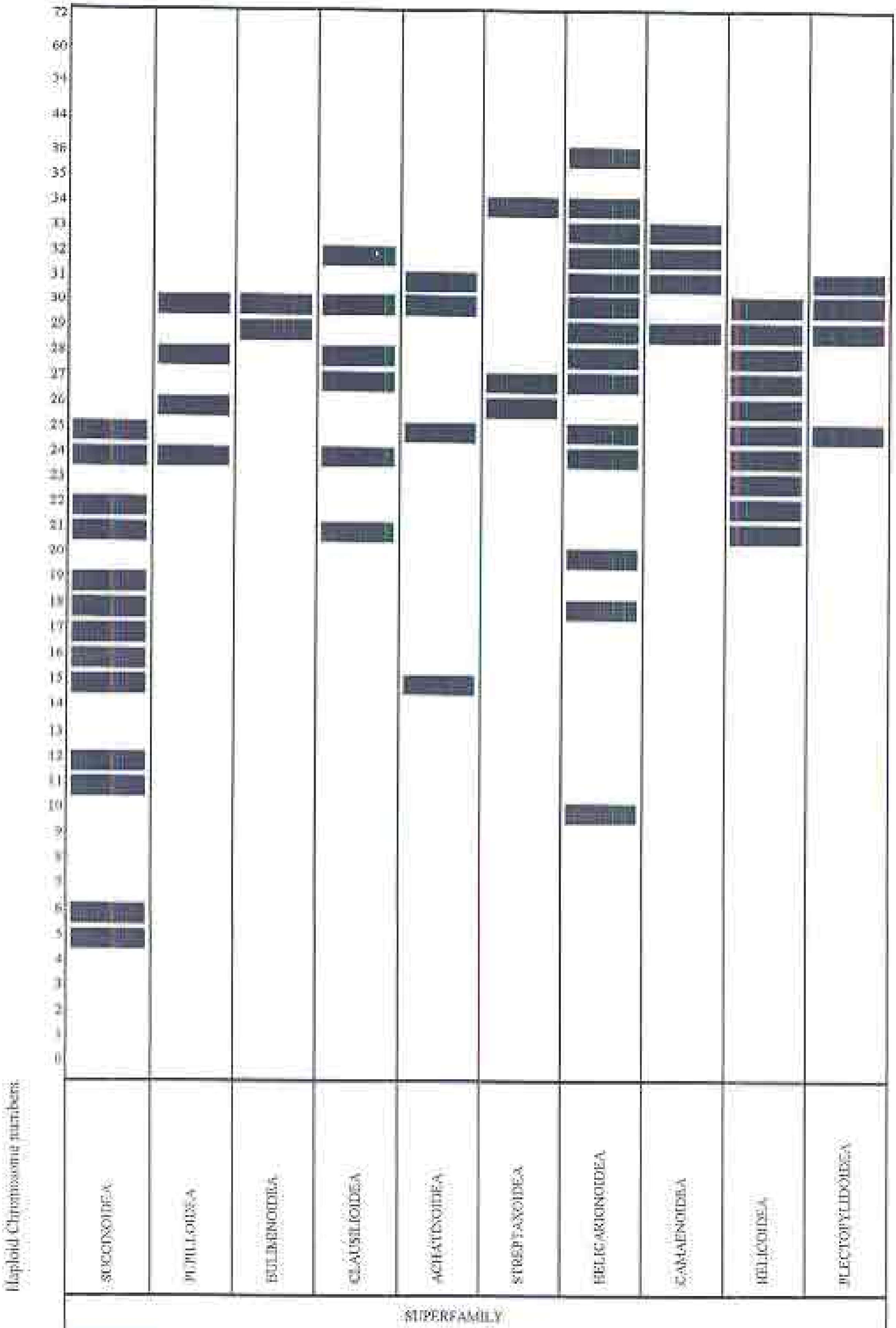


Fig. 9 Haploid chromosome numbers in the land Pulmonata. (blue are the reviews of Burch, 1989; Red are the results of this study)

ARIOPHANTIDAE

1. *Macrochlamys hepbagyra* Moellendorff 1894

Chromosome numbers of 2N = 20 from 15 metaphases were counted (Fig. 10). The karyotype of the pedal gland metaphase chromosomes consisted of 6 pairs of the large metacentric and 4 pairs of the smaller chromosomes. Two of the smaller pairs were subtelocentric and submetacentric chromosomes. The smallest two pairs were probably metacentric for No. 9 and telocentric for No. 10 pair. Only one set of the chromosomes could be measured and the result are shown in idiogram in Fig. 11.

2. *Macrochlamys limbata* Moellendorff 1894

Chromosome number of 2n = 20 (Fig. 12). The karyotype of the pedal gland metaphase chromosomes were all metacentric. They gradually decreased in size from 1 pair to No. 10 pair. The measurement and the result are shown in idiogram in Fig. 13.

From the above 2 species, have very similar morphologies, and both have 10 haploid numbers, but when we examined the karyotypes, we could discriminate between them very clearly. Therefore this technique is extremely helpful for classification.

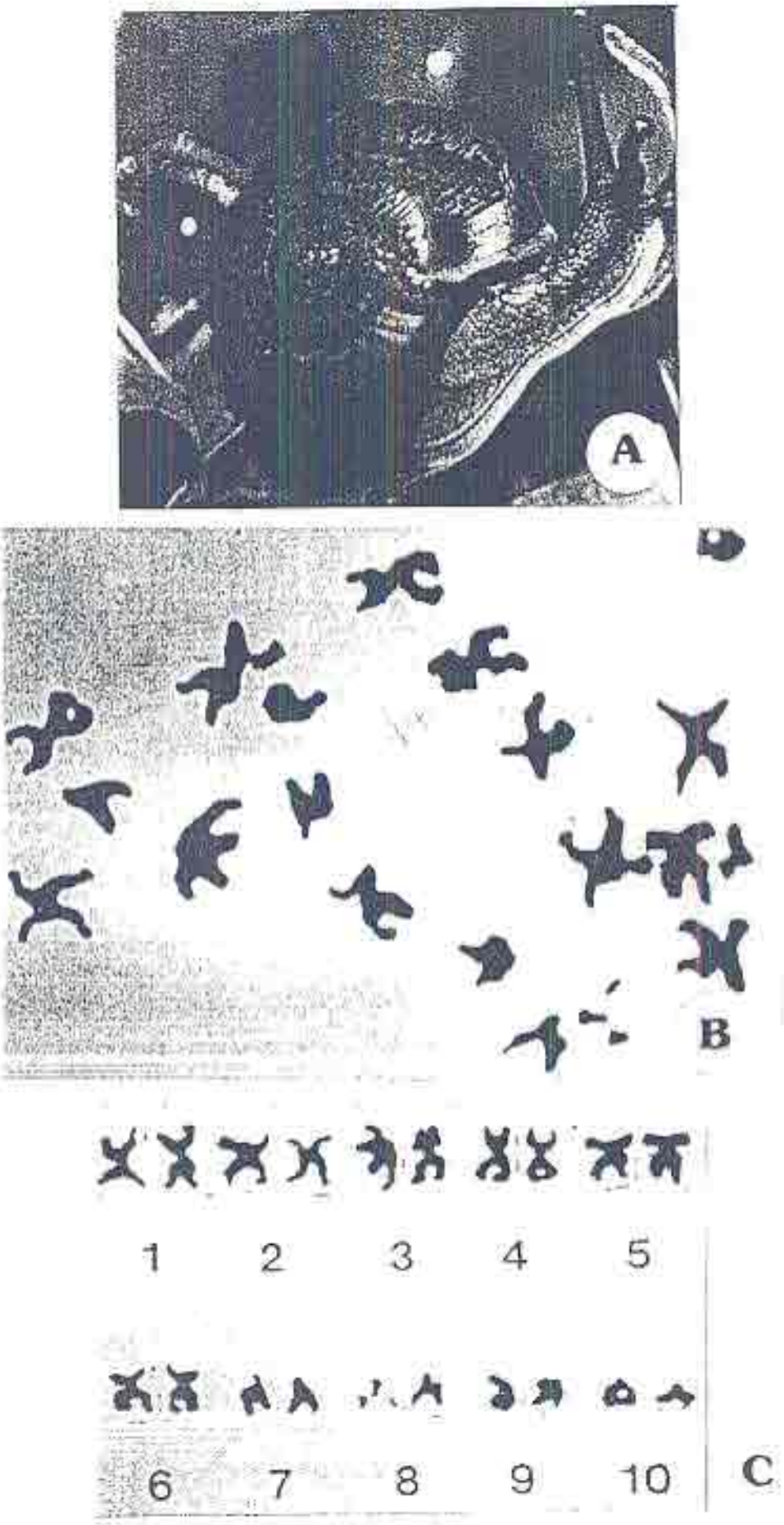


Fig. 10 The snail, *Macrochlamys hephagyra* (A); metaphase chromosome (B); and karyotype constructed from metaphase chromosome (C).

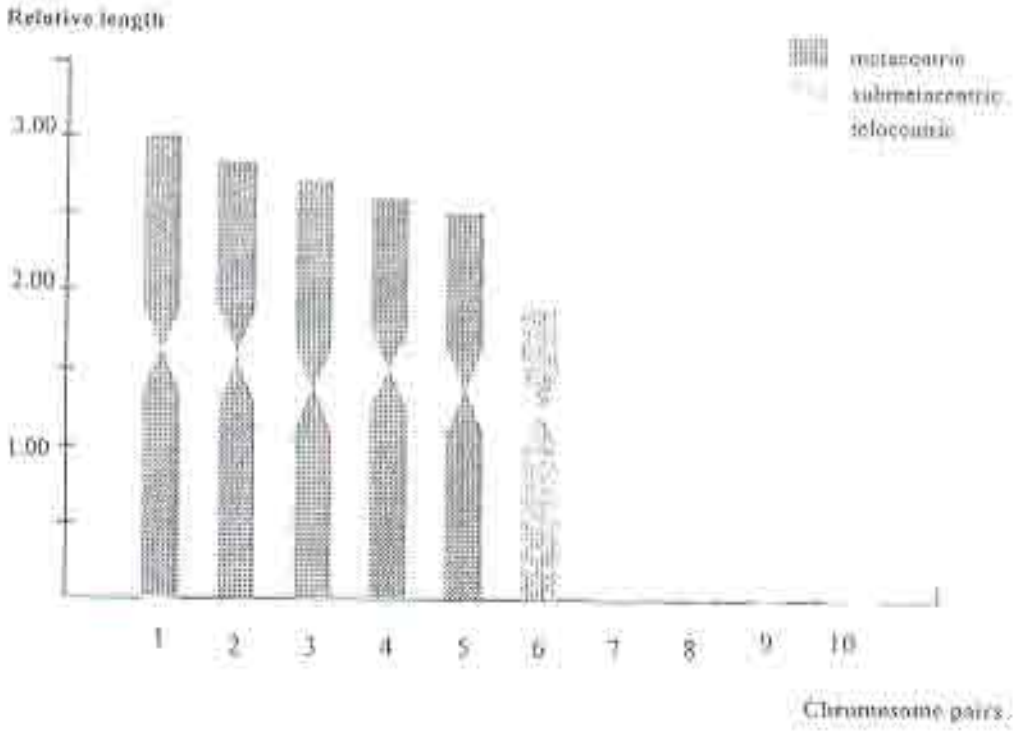


Fig. 11 Idiogram from metaphase chromosome of the snail, *Macrochlamys hephagyra*

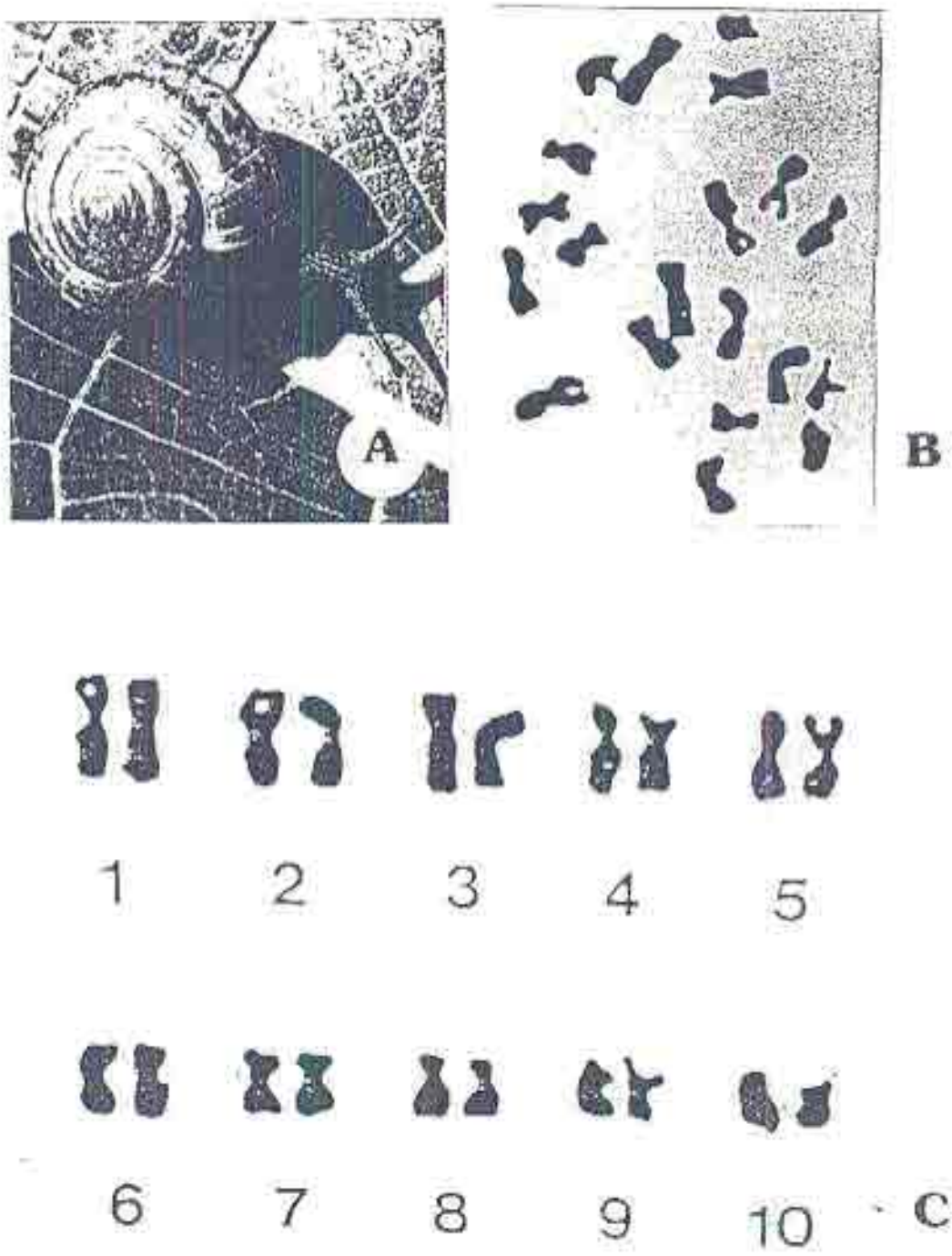


Fig. 12 The snail, *Macrochlamys limbata* (A); metaphase chromosome (B); and karyotype constructed from metaphase chromosome.

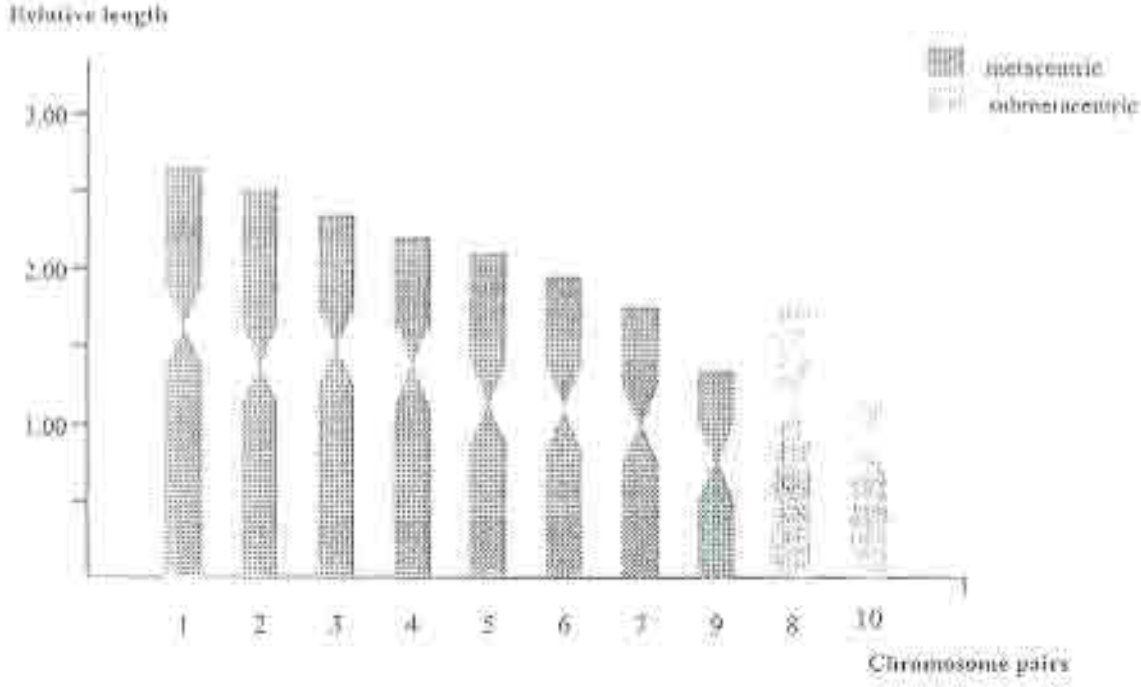


Fig. 13 Idiogram from metaphase chromosome of the snail, *Macrochlamys limbata*.

3. *Macrochlamys resplendens* (Phillippi 1863)

Chromosome number of 2N = 30 (Fig. 14). Fifteen bivalent were observed at the mataphase. All the chromosomes were metacentric or submetacentric.

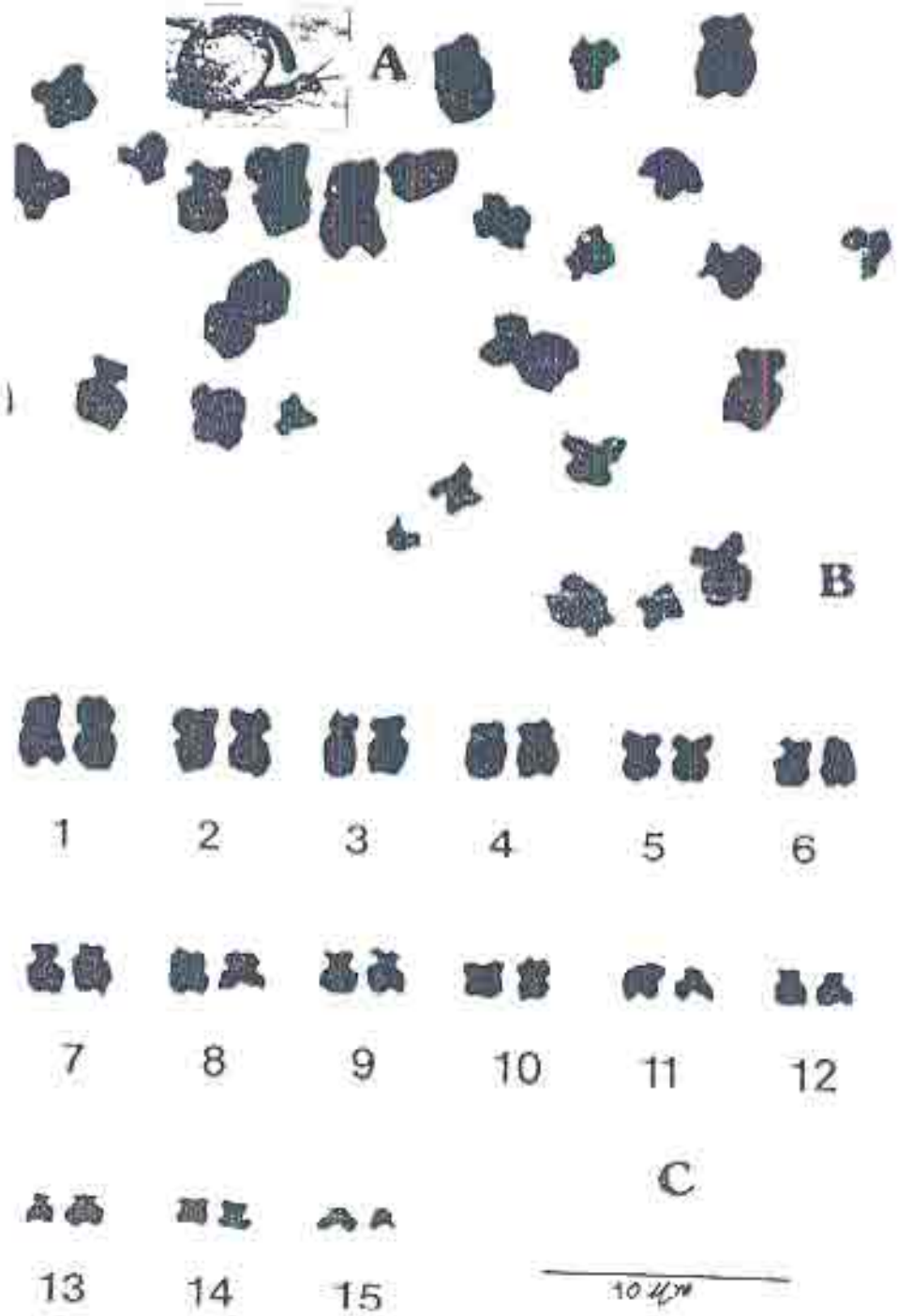


Fig. 14 The snail *Macrochlamys resplendens* (A); metaphase chromosome (B); and karyotype constructed from metaphase chromosome (C).

4. *Hemiplecta distincta* (Pfeiffer 1850)

Chromosome number of 2N = 60 (Fig. 15). The ovotestis chromosomes were larger chromosomes of No. 1-9 and smaller chromosomes of No. 10-30. The measurements are shown in idiogram in Fig. 16.

5. *Hemiplecta weinkauffiana* (Crosse & Fischer 1894)

Chromosome number of 2N = 58 (Fig. 17). The karyotype of the ovotestis diakinesis chromosomes only shown from large to smallest size.

6. *Dyakia salangana* (Martens 1856)

Chromosome number of 2N = 36 (Fig. 18). The karyotype of the pedal gland metaphase chromosomes consisted of 14 pairs of metacentric and 4 pairs of submetacentric chromosomes.

7. *Cryptozona siamensis* (Pfeiffer 1856)

Chromosome number of 2N = 16 (Fig. 19). The karyotype of the pedal gland metaphase chromosomes consisted of 6 pairs of metacentric, 2 pairs of telocentric. We can produce C-banding from one metaphase chromosome. The C-bands are localized only on pericentromeric regions of all chromosomes and in the short arm of chromosome No. 4.

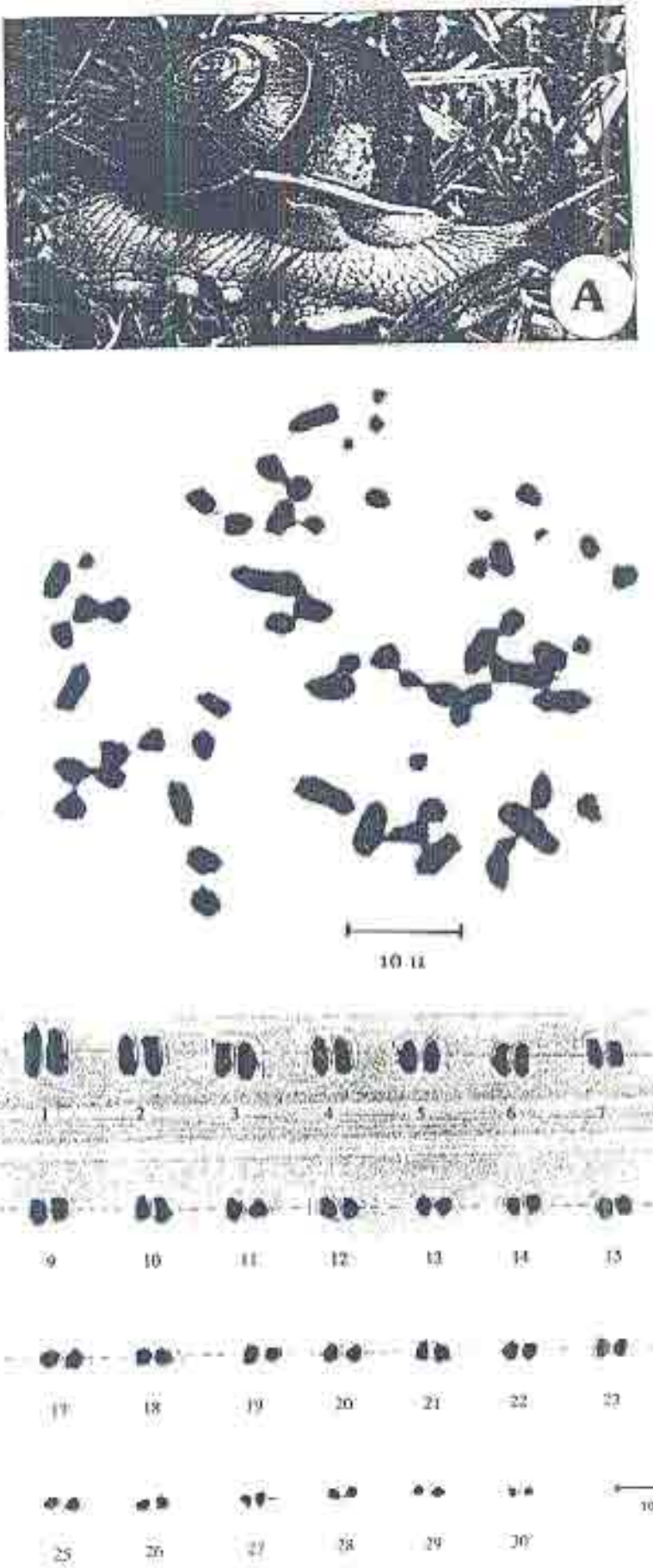


Fig. 15 The snail *Hemiplecta distincta* (A); metaphase chromosome (B); and karyotype constructed from metaphase chromosome (C).

Fig. 16 Idiogram from metaphase chromosome of the snail, *Hemiplecta distincta*

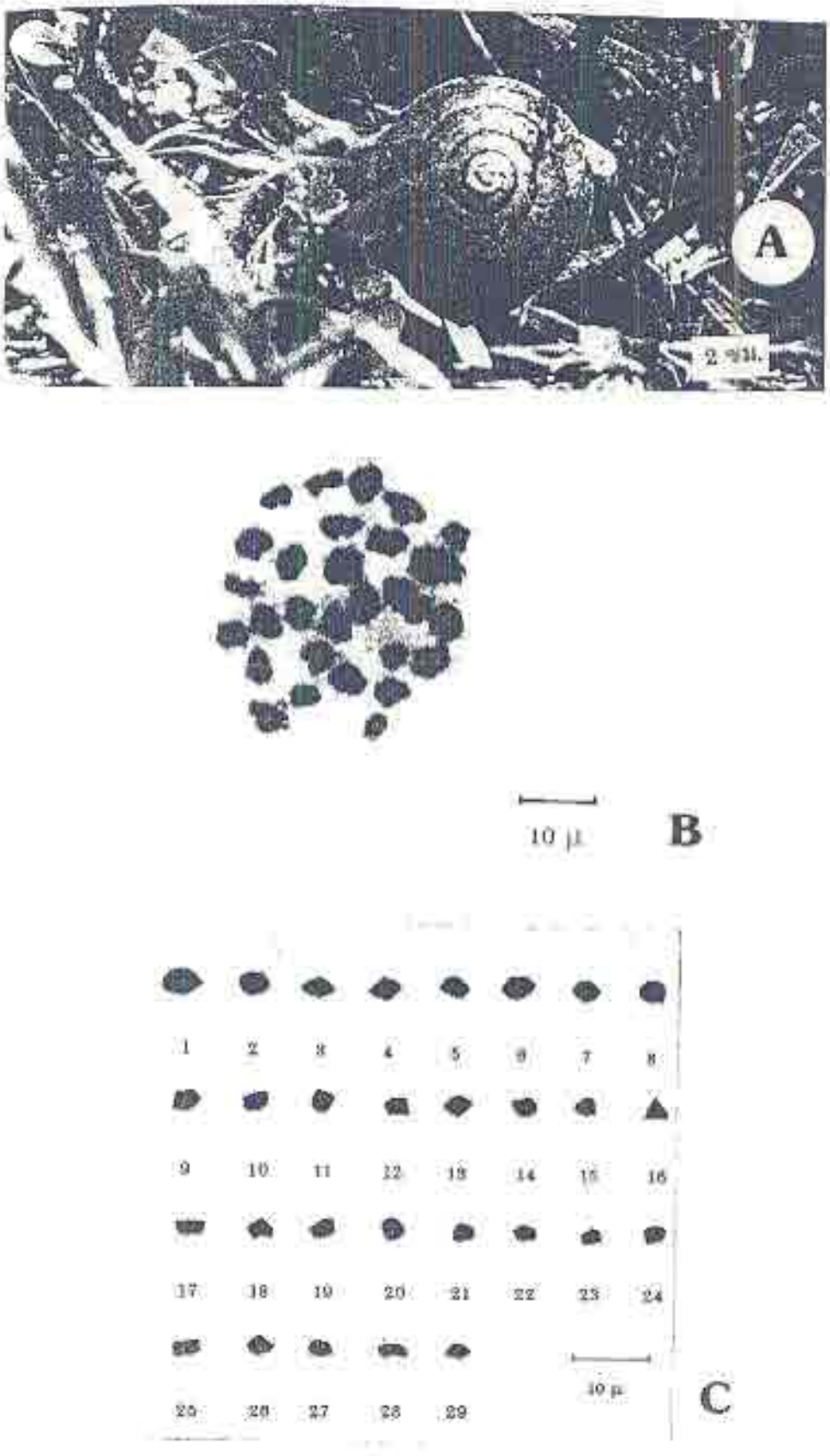
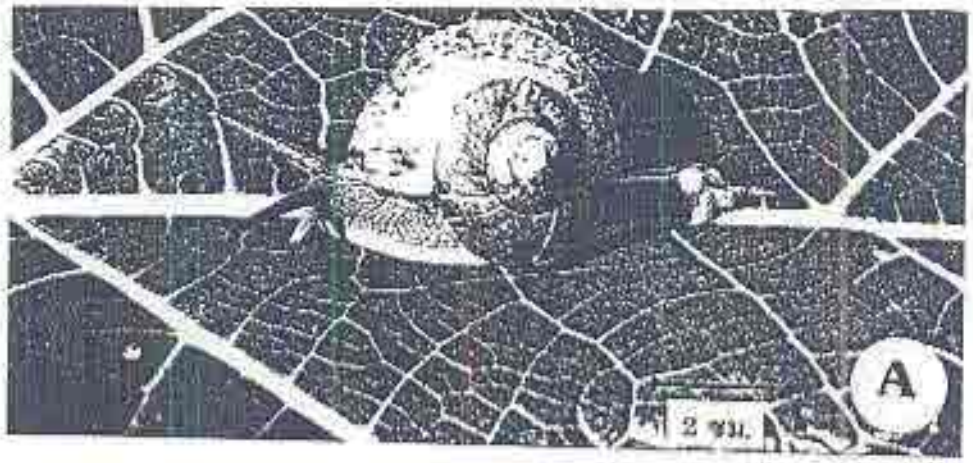


Fig. 17 The snail *Hemiplecta weinkauffiana* (A); metaphase chromosome (B); and karyotype constructed from metaphase chromosome (C).



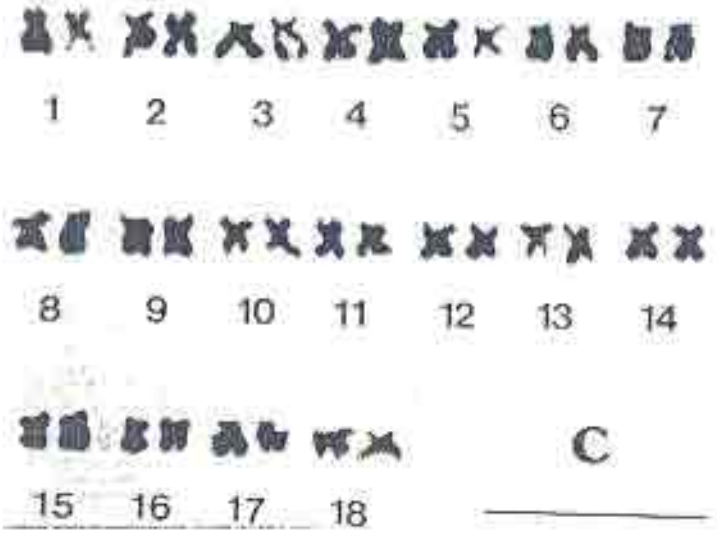


Fig. 18 The snail *Dyakia salangana* (A); metaphase chromosome (B); and karyotype constructed from metaphase chromosome (C).

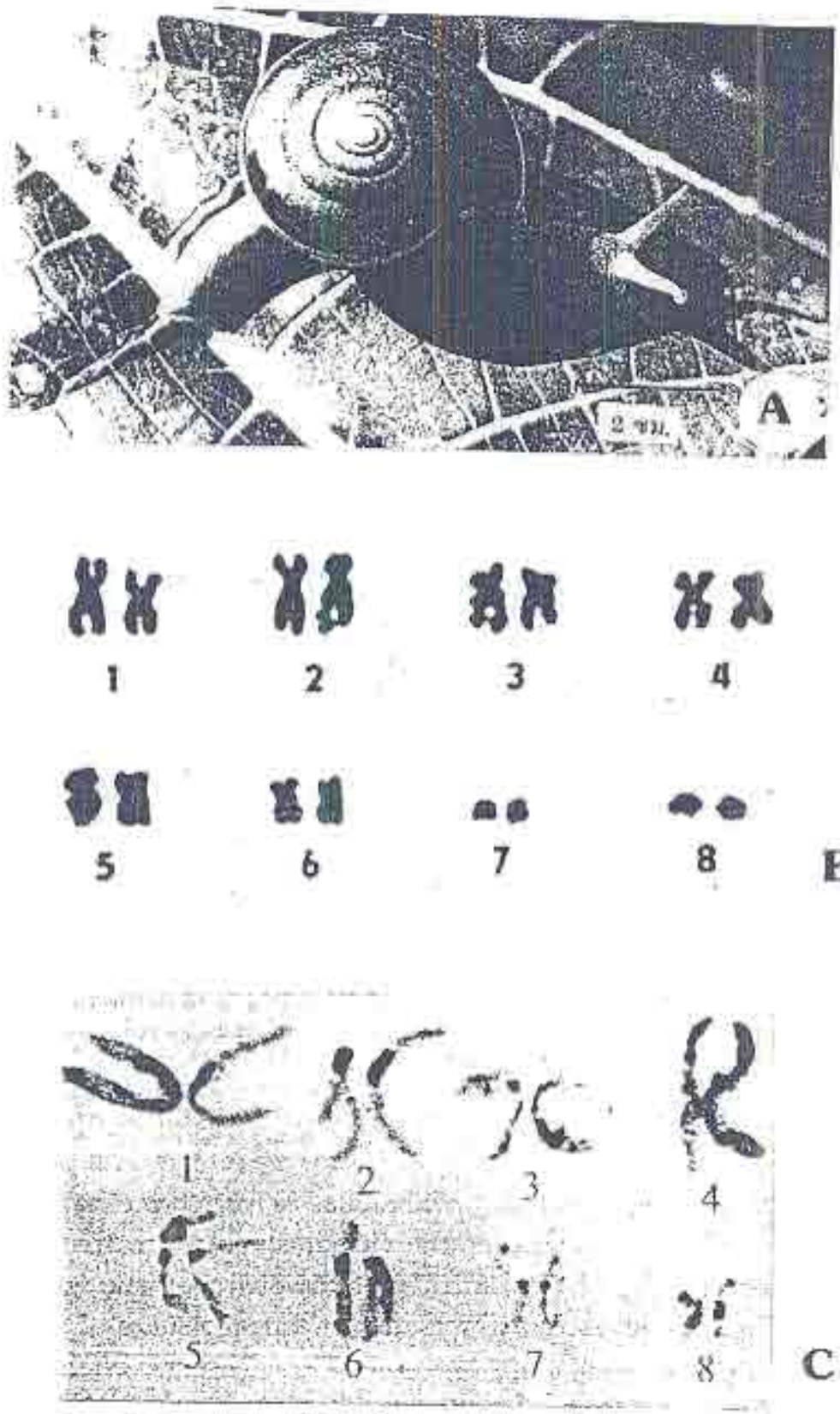


Fig. 19 The snail *Cryptozona siamensis* (A); karyotype constructed from metaphase chromosome (B); and C-banding chromosome

CAMAENIDAE

1. *Amphidromus atricallosus* (Gould 18430

Chromosome number of 2N = 48 (Fig. 20). The karyotype of the ovotestis metaphase chromosome consisted of 5 pairs of metacentric, 6 pairs of submetacentric, 2 pairs of subtelocentric and 11 pairs of telocentric. The measurements are shown in idiogram in Fig. 21.

2. *Amphidromus laidlawi* (Gould 1843)

Chromosome number of 2n = 46-48 (Fig. 22). Only diakinesis chromosomes were distictly observed.

3. *Amphidromus inversus annamiticus* (Crosse & Fischer 1863)

Chromosome number of 2N = 50-52 (Fig. 23). Only indistict metaphase chromosomes were observed.

4. *Amphidromus ciengensis* Morlet 1891

Chromosome number of 2n = 50-52 (Fig. 24). Only diakinesis chromosomes were distictly observed.

5. *Amphidromus semitessellatus* (Morlet 1884)

Chromosome number of 2N = 58 (Fig. 25). The karyotype of the ovotestic metaphase chromosome consisted of 12 pairs of metacentric, 10 pairs of subtelocentric and 7 pairs of telocentric.

6. *Amphidromus dohrni* (Pfeiffer 1863)

Chromosome number of 2n = 58 (Fig. 26). The karyotype of the ovotestis metaphase chromosome consisted of 13 pairs of metacentric, 8 pairs of submetacentric and 8 pairs of telocentric.

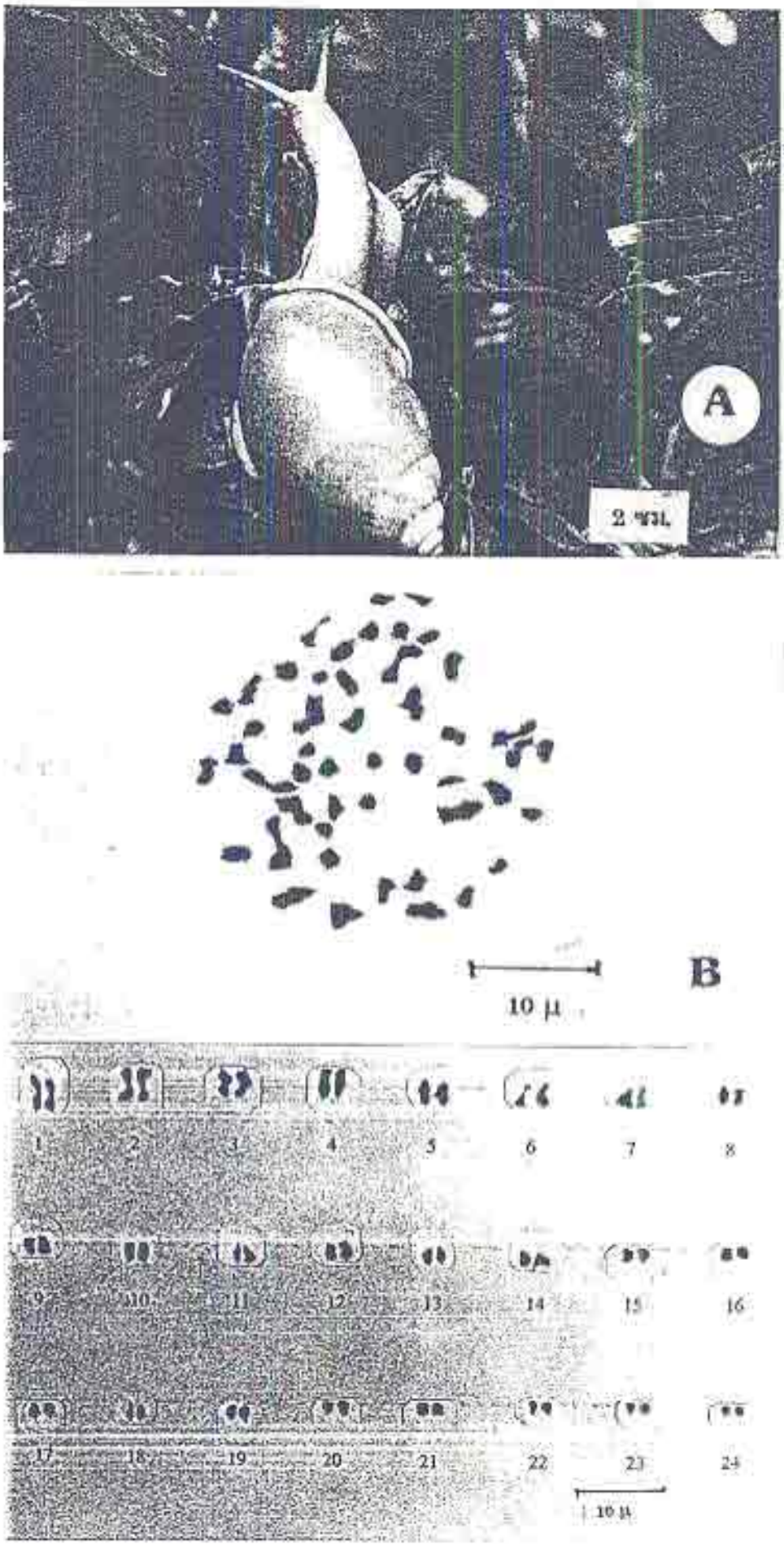


Fig. 20 The snail *Amphidromus atricallosus* (A); metaphase chromosome (B); and karyotype constructed from metaphase chromosome (C).

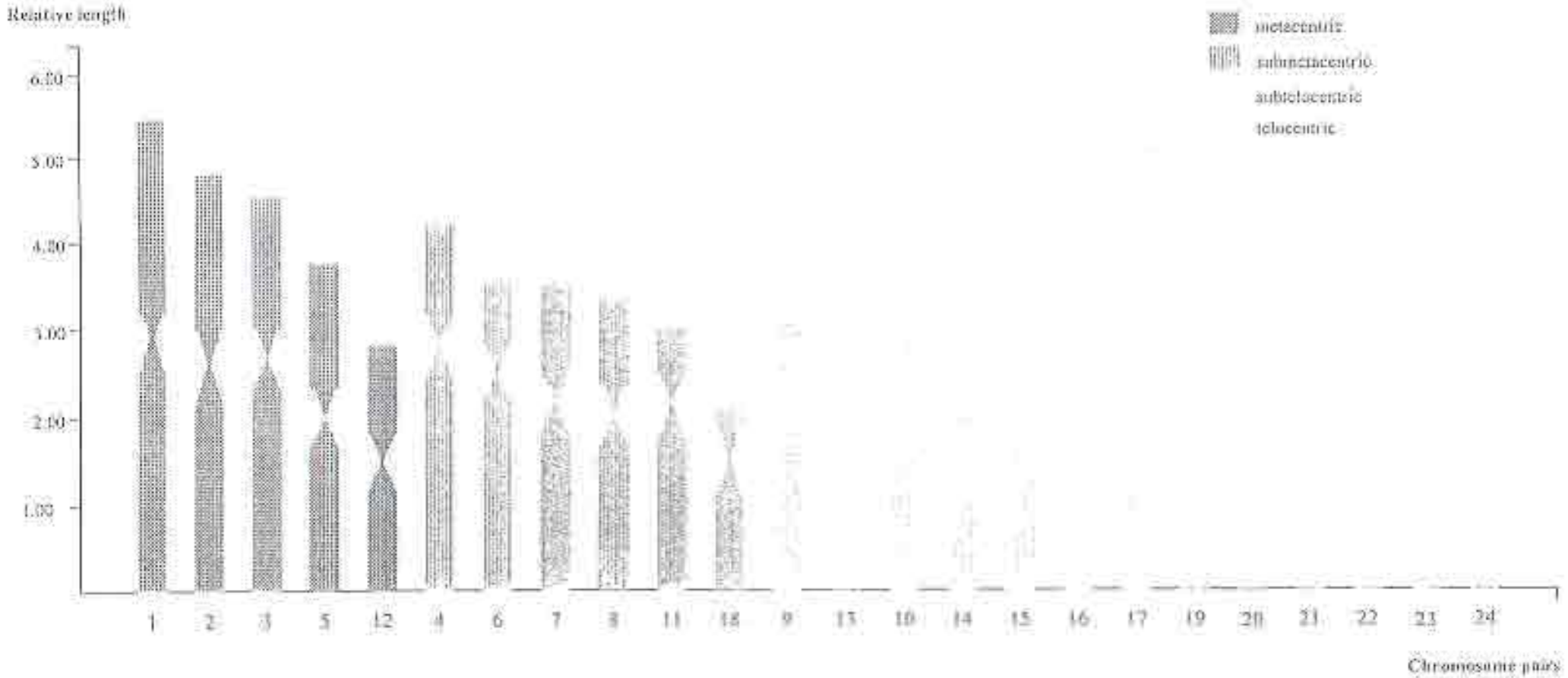


Fig. 21 Idiogram from metaphase chromosome of the snail, *Amphidromus atricallosus*

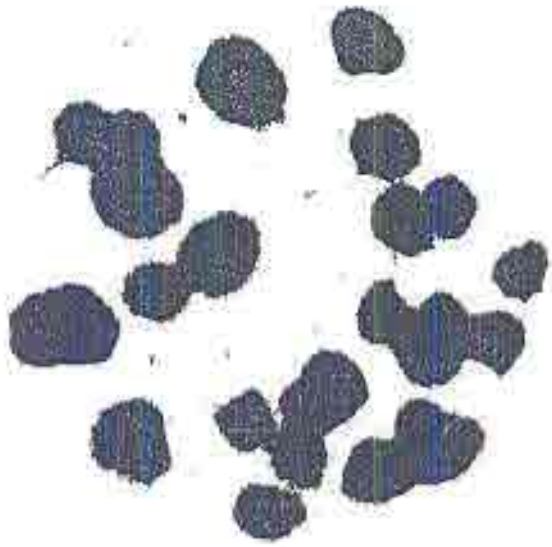


Fig. 22 Diakinesis chromosome of the snail, *Amphidromus laidlawi*

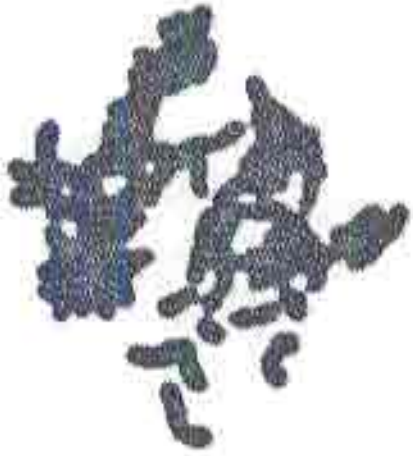


Fig. 23 Metaphase chromosome of the snail, *Amphidromus inversus annammiticus*

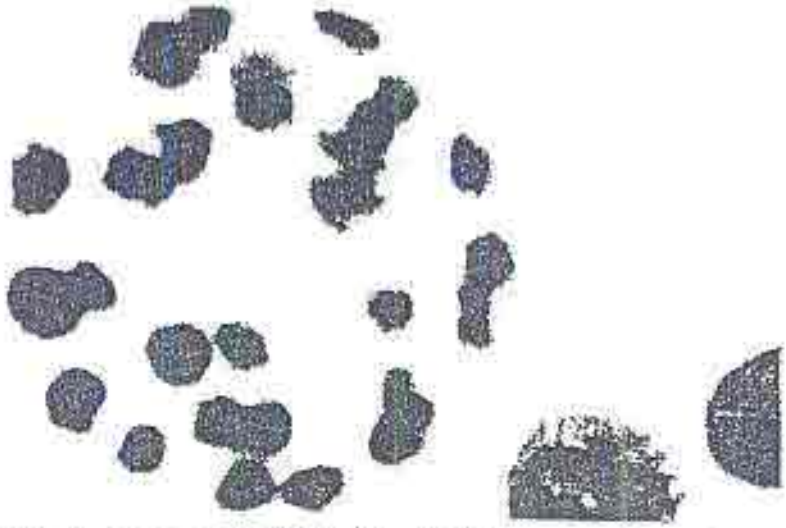


Fig. 24 Diakinesis chromosome of the snails, *Amphidromus xiengensis*

Fig. 25 Meiotic metaphase chromosome of the snail *Amphidromus remitessellatus*.

Fig. 26 Meiotic metaphase chromosome of the snail *Amphidromus dohrni*

7. *Chloritis* (*Trichochloriti*) *siamensis* Moellendorff 1902

Chromosome number of 2N = 58 (Fig. 27). The karyotype of the ovotestic metaphase chromosome consisted of 18 pairs of metacentric, 10 pairs of submetacentire and 1 pair of telocentric.

8. *Chloritis* (*Trichochloritis*) *diplochone* Moellendorff 1898

Chromosome number of 2N = 58 (Fig. 28). The karyotype of the ovotestis metaphase chromosome consisted of 12 pairs of metacentric chromosome, 10 pairs of submetacentric chromosome and 7 pairs of telocentric chromosome.

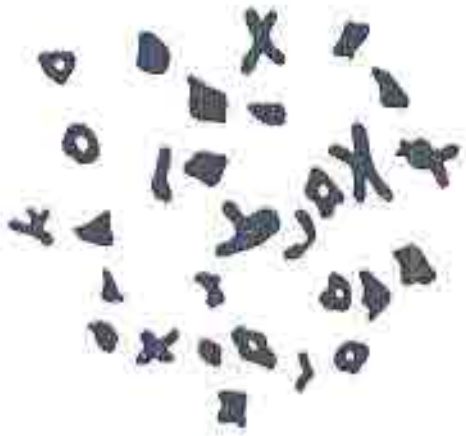


Fig. 27 Meiotic metaphase chromosome of the snail *Chloritis* (*Trichochloritis*) *siamensis*.

Fig. 28 Meiotic metaphase chromosome of the snail *Chloritis* (*T.*) diplochone.

SUCCINEIDAE

1. *Succinea cochinchinensis* Pfeiffer 1856

Chromosome number of 2n = 24 (Fig. 29). The karyotype of the pedal gland metaphase chromosome consisted of 8 pairs of metacentric and 4 pairs of submetacentric.

2. *Succinea tenella* Morlet 1863

Chromosome number of 2N = 26 (Fig. 30). The karyotype of the pedal gland metaphase chromosome consisted of 6 pairs of metacentric and 7 pairs of submetacentric.

3. *Succinea* sp. A

Chromosome number of 2N = 22 (Fig. 31). The karyotype of the pedal gland metaphase chromosome consisted of 4 pairs of metacentric, 4 pairs of submetacentric and 3 pairs of telocentric.

4. *Succinea* sp. B

Chromosome number of 2N = 24 (Fig. 32). The karyotype of the pedal gland metaphase chromosome consisted of 4 pairs of metacentric 8 pairs of submetacentric.

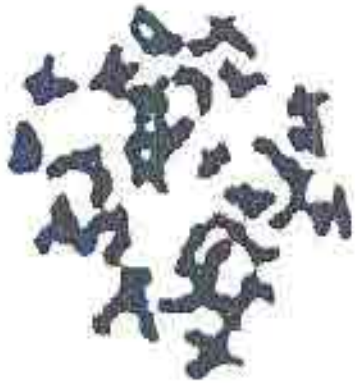


Fig. 29 Metaphase chromosome of the snail *Succinea cochichimensis*.

Fig. 30 Metaphase chromosome of the snail *Succinea limella*.

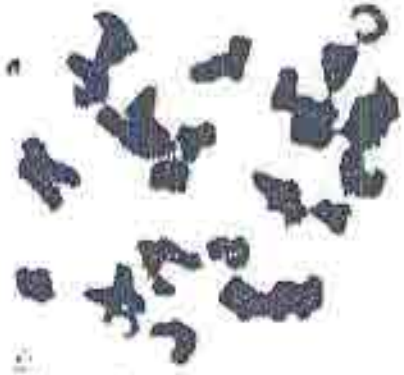


Fig. 31 Metaphase chromosome of the snail *Succinea* sp. A.

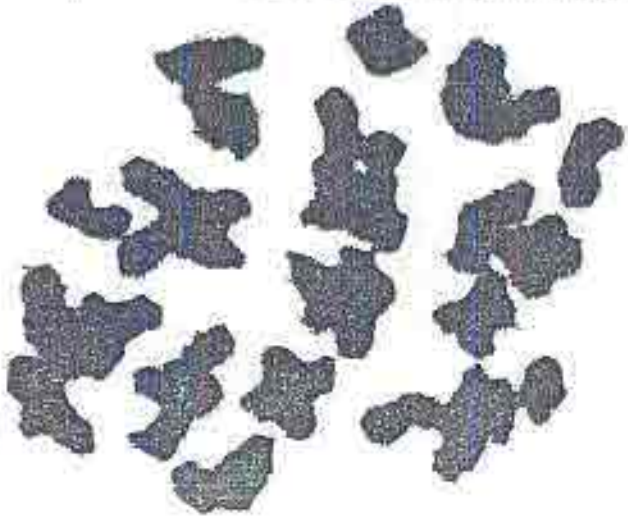


Fig. 32 B.

ANALYSIS OF LAND PULMONATE SNAILS OF THAILAND

Number of species

The literature contained approximately 160 specific names which had been applied to shells supposedly found in Thailand. Some were misidentifications, other were based on erroneous locality data, and many have been placed in synonymy. Several names listed in the systematic review (see *Macrochlamys*, *Amphidromus*, and *Chloritis*) are omitted below since they probably do not represent valid species. Their inclusion would give a distorted picture of the relative prominence of the three genera and unduly increase the marked endemism reported below.

Endemism

Among the 247 species that were found, 54 (21.8%) are endemic species that found only in Thailand. This is a high rate of geographic specificity compared with that for amphibian (12.1%), reptiles (10.4%0, birds (only 0.2%), and mammals (only 3%). The remaining nearly 200 species are distributed among nation bordering Thailand on all sides. Most of the endemic species belong to the family of minute limestone snails (Vertiginidae) about 25 species, the rest belong to very widely distributed genera; *Macrochlamys*, *Phaedusa*, *Amphidromus*, *Chloritis*, *Ganesella*, *Discartemon*, *Glessula*, *Aegista*, and *Plectopylis*.

Regarding the survival status of each species, among tree snails there are many endagered species, such as *Amphidromus flavus*, *A. metabletus*, *Camaena illustris*, and *Chloritis* (*T.*) *siamensis*. There are also many species that are threatened by deforestation and hunting, such as *Amphidromus areolatus*, *A. semitesselatus*, and *A. xiengensis*, and the limestone mountain species in the families Streptaxidae, Pleetypylidae, and Vertiginidae. Some species are abundant and able to spread in regions inhabited by humans or even in major cities, such as *Cryptozona siamensis*, *Buliminus siamensis*, and *Succinea tenella*, and 2 introduced species, *Achatina fulica* and *Lamellaxis gracilis*. Other species should be carefully monitored because the may encounter problems if there is further destruction of the environment; these include members of the genera *Amphidromus*, *Ganesella* and *Camaena*.

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Output

Publications and Presentations

1. Publicatons

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1.4 Panha, S. 1996. A new species of *Amphidromus* from Thailand (Stylommatophora; Camaenidae). Malacological Review, 29: 131-132.

1.5 Panha, S. 1997. A checklist and classification of the land pulmonate snails of Thailand. Walkerana 8: (in press).

2. Presentations

2.1 Panha, S. 1996. Land snails ... food of hornbills. Abstract on The Second International Asian Hornbill Workshop, Thailand 10-18 April 1996, p. 48.

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POTENTIALITIES OF A THAI EDIBLE LAND SNAIL FOR SNAILFARMING

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Hemiplecta distincta (Pfeiffer) is a tropical edible land snail occuring in the wild in Northeastern Thailand where it is gathered by villagers for consumption and for sale. It is a hermaphroditic snail belonging to the family Ariophantidae. With a shell diameter about 5-6cm, the mature specimens are quite similar in size and shell shape to Helix snails.

The snail is strictly nocturnal. In the wild, H.distincta enters in hibernation during the cold months and in estivation during the warmest months. High temperature under wet conditions is the best for H.distincta to grow.

The wild snails breed once a year with unimodal breeding peak. H.distincta lays its eggs under dead leaves or logs. It uses its foot to make the nest, retractes all tentacles as it lays eggs. The nest is then covered with dead leaves upon the completion of eggs laying which takes about 24-25 hours. A clutch is composed in average of about 80 small eggs. Incubation takes about 17 days and 2 to 3 days are required to complete hatching of each clutch.

H.distincta is herbivore and well known for consuming the mushrooms present in its natural habitat. Feeding experiments were carried out for assessing diet to be used in snailfarming. Food preference observations indicate that the snail prefers mushrooms of high phosphorus content but the snails grow faster on diet containing both calcium and phosphorus. The growth obtained through feeding young snails on diet based on mushroom Flammulinea velutipes, cucumber and green leaves of sweet potatoes was compared to that obtained through using 3 other artificial diets based on combinations of rice bran, soybean, calcium carbonate, phosphate and some minerals. During the first two months, the young snails growing markedly faster were those fed on mushrooms which are more succulent than the artifical diet. However, at the end of the experiment, the artificial diet groups were consistently higher by 60% for the four and five months old snails. The snails fed on artificial diet contained the highest percentage of protein (about 70% on dry matter) what is similar to the content found in wild H.distincta. This demonstrates that an appropriate combination of soybean, rice bran, calcium carbonate, phosphate and minerals is a suitable substitute for the expensive mushroom to promote fast growth and maturation by H.distincta. In fact, snails reared on the artificial diet reached a marketable size of more than 4cm within four months after hatching. This turn over rate is greater than that reported for the European "escargots" which take at least five months to fatten up.

Panha S., 198_. Effect of temperature on the growth and behaviour of a tropical land snail Hemiplecta distincta (Pfeiffer) (Gastropoda: Ariophantidae). Venus 47(3): 197-206.
Panha S., 1987. The breeding data of Thai edible land snail Hemiplecta distincta (Pfeiffer) (Pulmonata: Ariophantidae). Venus 46(1):25-34.

POTENTIALITES D'UN ESCARGOT TERRESTRE COMESTIBLE THAILANDAIS POUR L'ELEVAGE

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Hemiplecta distincta (Pfeiffer) est un escargot terrestre comestible du Nord-Est de la Thailande ou il est ramassé par les villageois pour la consommation et la vente. C'est un escargot hermaphrodite appartenant à la famille des Ariophantidae. Pourvus d'une coquille d'un diamètre de 5-6cm, les spécimens matures sont proches des escargots Helix par leur taille et la forme de leur coquille. L'escargot est strictement nocturne. Dans la nature, H.distincta entre en hibernation pendant les mois froids et en estivation pendant les mois les plus chauds. Une température élevée dans des conditions humides convient le mieux à H.distincta pour grandir. Les escargots sauvages se reproduisent une fois par an selon un pic de reproduction unimodal. H.distincta pond ses oeufs sous des feuilles ou des troncs. Il utilise son pied pour creuser un nid et rétracte ses tentacules quand il pond ses oeufs. Le nid est recouvert de feuilles mortes dès la fin de l'oviposition qui prend environ 24-25 heures. Une ponte comporte en moyenne environ 80 petits oeufs. L'incubation prend environ 17 jours et 2 ou 3 jours sont nécessaires pour l'éclosion de toute la ponte. H.distincta est herbivore et bien connu pour consommer les champignons présents dans son habitat naturel. Des expérimentations ont été menées pour établir un régime à utiliser en élevage d'escargots. Les observations sur les préférences alimentaires de l'escargot indiquent qu'il préfère les champignons à haute teneur en phosphore mais les escargots grandissent plus vite avec un régime contenant à la fois calcium et phosphore. La croissance de jeunes escargots recevant une alimentation composée de champignons Flammulinea velutipes, de concombre et de feuilles vertes de patates douces a été comparée à celles obtenues avec 3 autres régimes artificiels combinant soja, son de riz, carbonate de calcium, phosphate et minéraux. Durant les deux premiers mois, les jeunes escargots grandissant le plus vite sont ceux recevant des champignons qui sont plus succulents que le régime artificiel. Cependant, à la fin de l'expérimentation, les animaux des groupes nourris avec un régime artificiel sont significativement plus grands de 60% à l'âge de quatre et cinq mois. Les escargots nourris d'un régime artificiel contiennent le taux le plus élevé de protéine (environ 70% sur la matière sèche) ce qui est similaire à la teneur trouvée chez des H.distincta sauvages. Ceci démontre qu'une combinaison appropriée de soja, son de riz, carbonate de calcium, phosphate et minéraux constitue un substitut au champignon coûteux pour réaliser une croissance rapide et la maturation d'H.distincta. En fait, les escargots élevés avec le régime artificiel atteignent une taille commercialisable de plus de 4cm en quatre mois après l'éclosion. Ce rendement est plus élevé que celui rapporté pour l'escargot européen qui requiert au moins cinq mois d'engraissement.

Panha S., 1988. Effect of temperature on the growth and behaviour of a tropical land snail Hemiplecta distincta (Pfeiffer) (Gastropoda: Ariophantidae). Venus 47(3):197-206.
Panha S., 1987. The breeding data of Thai edible land snail Hemiplecta distincta (Pfeiffer) (Pulmonata: Ariophantidae). Venus 46(1):25-34.

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LAND SNAILS OF PHLIU NATIONAL PARK, THAILAND

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INTRODUCTION

The purpose of this paper is to describe the macro land snails of Phliu National Park area (fig. 1). This is an area of 135 square kilometers, it is a forest patch, located in the eastern area bordered on the east by Cambodia. Encompasses an isolated granite massif which dominates the surrounding plain. The high rainfall has created a rich rainforest which still contain some large mammals and the two important pheasant species.

The park's forests have been extensively logged, but they are now regenerating. The habitat is tropical broadleaved evergreen forests dominate. Rainfall averages more than 3,000 millimetres a year and humidity averages more than 80 percent. The months May till September normally have 20 or more rainy days per month, while November till March average fewer than seven. The mean annual temperature is 26° C with November to February the coolest periods and April to June are the hottest months. In such habitat many snails are living.

METHOD

Macro snails were intensively collected in December 1995, February and June 1996. The snails were identified by using the according papers:
Crosse & Fischer, 1963; Godwin-Austen, 1919; Gude, 1903, 1914; Moellendorff, 1891, 1894; Pfeiffer, 1962; Solem, 1965, 1966; Zilch, 1966.

OUTLINE OF CLASSIFICATION AND LIST OF SPECIES

Subclass PROSOBRANCHIA
Order Mesogastropoda
Family Cyclophoridae
Cyclophorus malayanus (Benson, 1852)
Rhiostoma smithi Bartsch, 1932
Family Pupinidae
Moulinsia sp.

Subclass PULMONATA
Order Stylommatophora
Family Ariophantidae
Cryptozona siamensis (Pfeiffer, 1856)
Dyakia salangana (von Martens, 1891)
Hemiplecta distincta (Pfeiffer, 1850)
Hemiplecta weinkauffiana (Pfeiffer, 1894)
Macrochlamys limbata Moellendorff, 1894

Family Bulimulidae
Bulimulus siamensis Redfield, 1866

Family Camaenidae
Amphidromus atricallosus (Gould, 1843)
Amphidromus schomburgki (Pfeiffer, 1860)
Amphidromus (Syndromus) xiengensis (Morlet, 1891)
Chloritis (Trichochloritis) siamensis Moellendorff, 1902
Chloritis (T.) diplochone Moellendorff, 1899

Family Clausiliidae
Formosana siamensis (Pfeiffer, 1861)

Family Plectopylidae
Plectopylis (Chersaesia) dextrorsa Godwin-Austen, 1888

Family Rathousiidae
Atopos sp.

Family Streptaxidae
Haploptychius porrectus (Pfeiffer, 1862)

DISCUSSION

Nine families, 14 genera and 18 species of macro landsnails were identified. Only three species of Subclass Prosobranchia were found. There is a species reported here as a new record, *Chloritis (Trichochloritis) diplochone* (Fig. 2). The distribution of this species was reported by Zilch (1966) in Annam (Central Vietnam). Most of the snails collected were found on forest floor or in leaflitter except snails in the family Camaenidae, genus *Amphidromus*. They were collected on tree trunks or on leaves. There are many unidentified microsnails, collected in this area.
They will be reported at the next opportunity.

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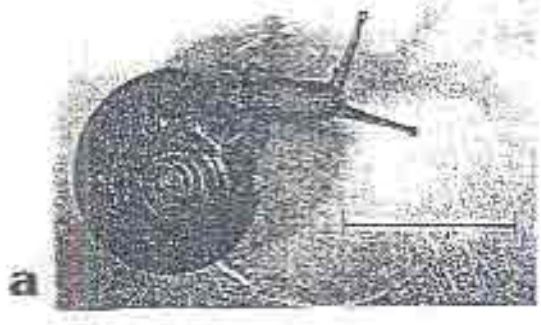
Map of Thailand showing Phlio National Park area (arrow), compared with the largest national park of Thailand, Kaeng Krachan National Park



Chloritis (Trochocloritis) diplochone (a)
Baliminus siamensis (b)
Amphidromus (Syndromus) siengensis (c)
(Scale bar = 1 cm).

Malacological Review 1996 (1997), 29: 101-105

A NEW SPECIES OF *MACROCHLAMYS* FROM THAILAND (STYLOMMATOPHORA: ARIOPHANTIDAE)

Somsak Panha

ABSTRACT

Macrochlamys asamurai n. sp., a mountain species from a tropical evergreen forest of Surathani (near Takun village, Surathani, Thailand) is described. It is compared to the closely related *Nanina* (*Macrochlamys*) *diadema* Dall 1897, differing from the latter by its deeply channeled ribs, which are more slender in the upper shell after two and a half whorls. Anteriorly, the body is very dark coloured, and is red posteriorly, with a black caudal foss and caudal horn.

Key Words: *Macrochlamys asamurai* n. sp., Pulmonata, Stylommatophora, Ariophantidae, Thailand.

INTRODUCTION

Thailand is one of the most poorly studied areas in Asia in regard to its malacological fauna, but it is an area of considerable interest due to the great number of species it contains. During a systematic faunistic study of land pulmonate molluscs in southern Thailand, representatives of a new species were discovered in February, 1995; they were found in the small crevices of a mountain at 525 metres elevation near Takun village, Surathani Province (Fig. 1). These specimens are described below as a new species of *Macrochlamys*.

Macrochlamys asamurai n. sp.
(Figs. 2a; 2b1)

Description of holotype

The shell is translucent, polished, brown, narrowly umbilicate, depressed, with six and a half whorls. The apical two and a half whorls are pale and smooth; the remaining four have narrow, relatively deep, regularly spaced, radiating grooves on the exterior. There are 58 of these divisions on the last whorl. The shell of *Macrochlamys asamurai* (Fig. 2b1) is different from *Nanina* (*Macrochlamys*) *diadema* (Fig. 2b2), by its more slender, deeply channeled radiating grooves on the shell dorsum after two and a half whorls. *Macrochlamys asamurai* also does not show a faint double suture in the last whorl. *Macrochlamys asamurai* was compared to paratype number USNM 150277, *N.* (*M.*) *diadema*, from the National Museum of Natural History, Smithsonian Institution.

Dimensions. Maximum diameter = 1.6 cm; height = 0.8 cm.

Body. The anterior portion of the body is very dark coloured, posteriorly the body is red, with a black caudal foss and caudal horn.

Jaw. Very thin, crescent shaped, with a medial projection.

Radula (Fig. 3). Central plate of the radula with lateral cusps; lateral teeth with inner and outer cusps; marginal teeth bicuspid.

Genitalia (Fig. 4). Dart apparatus (amatorial organ) large, long, with a cylindrical shape; penis long and S-shaped; female with a brown bursa copulatrix and spermatheca.

Etymology. The specific epithet *asamurai* is used after the name of Mr. Yutaka Asamura, who strongly encouraged and supported research on land pulmonate snails in Thailand.

Type locality. Thailand, Takun village, Surathani Province, 525 metres elevation (CUIZM 6325), 1995, leg. S. Panha.

Type material. The holotype (CUIZM 6325) is deposited in the Chulalongkorn University Zoological Museum together with 15 specimens and 42 shell paratypes (CUIZM 6326). Other paratypes (CUIZM 6327), in total 15 specimens and 23 shells, are stored in The Field Museum

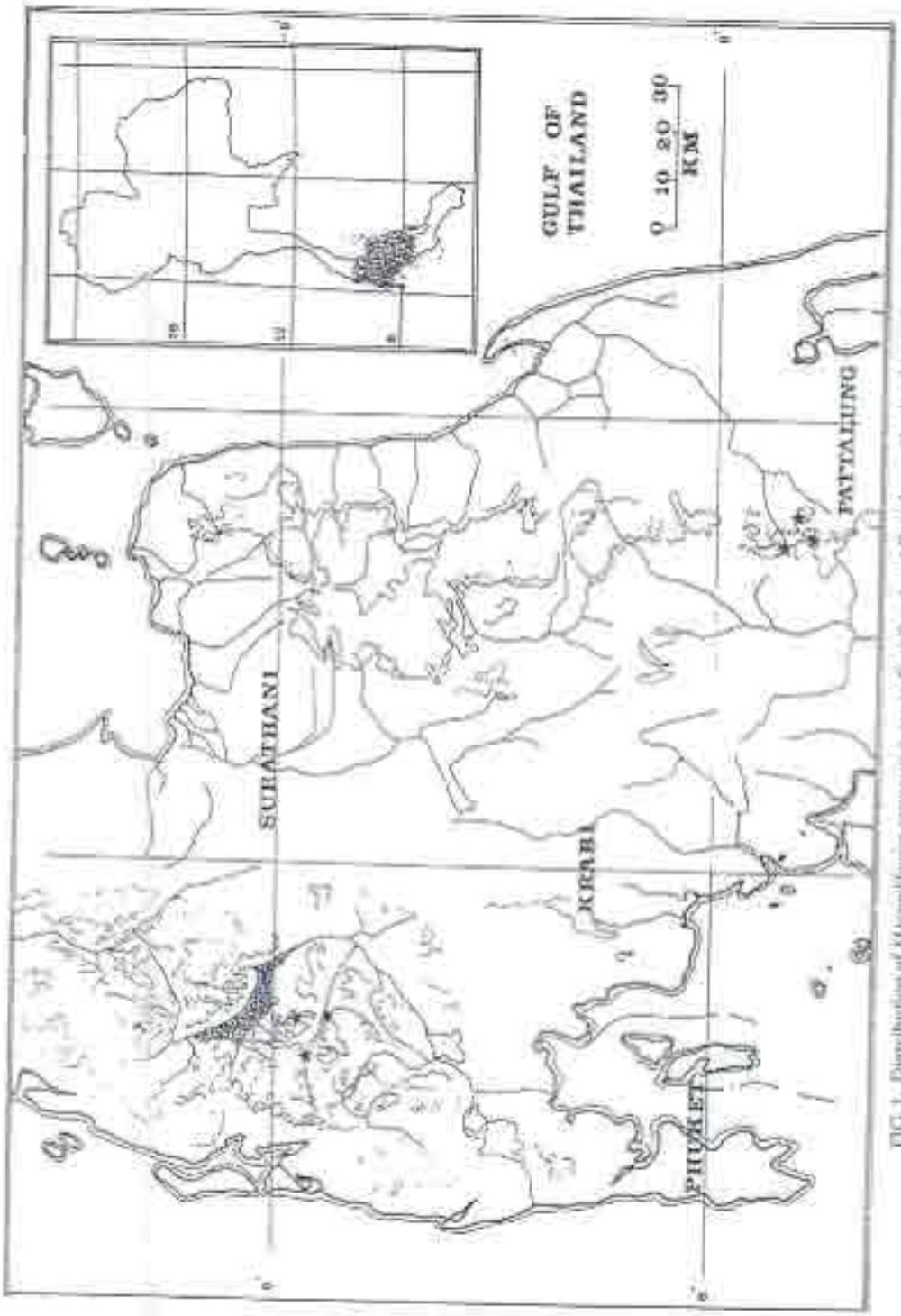
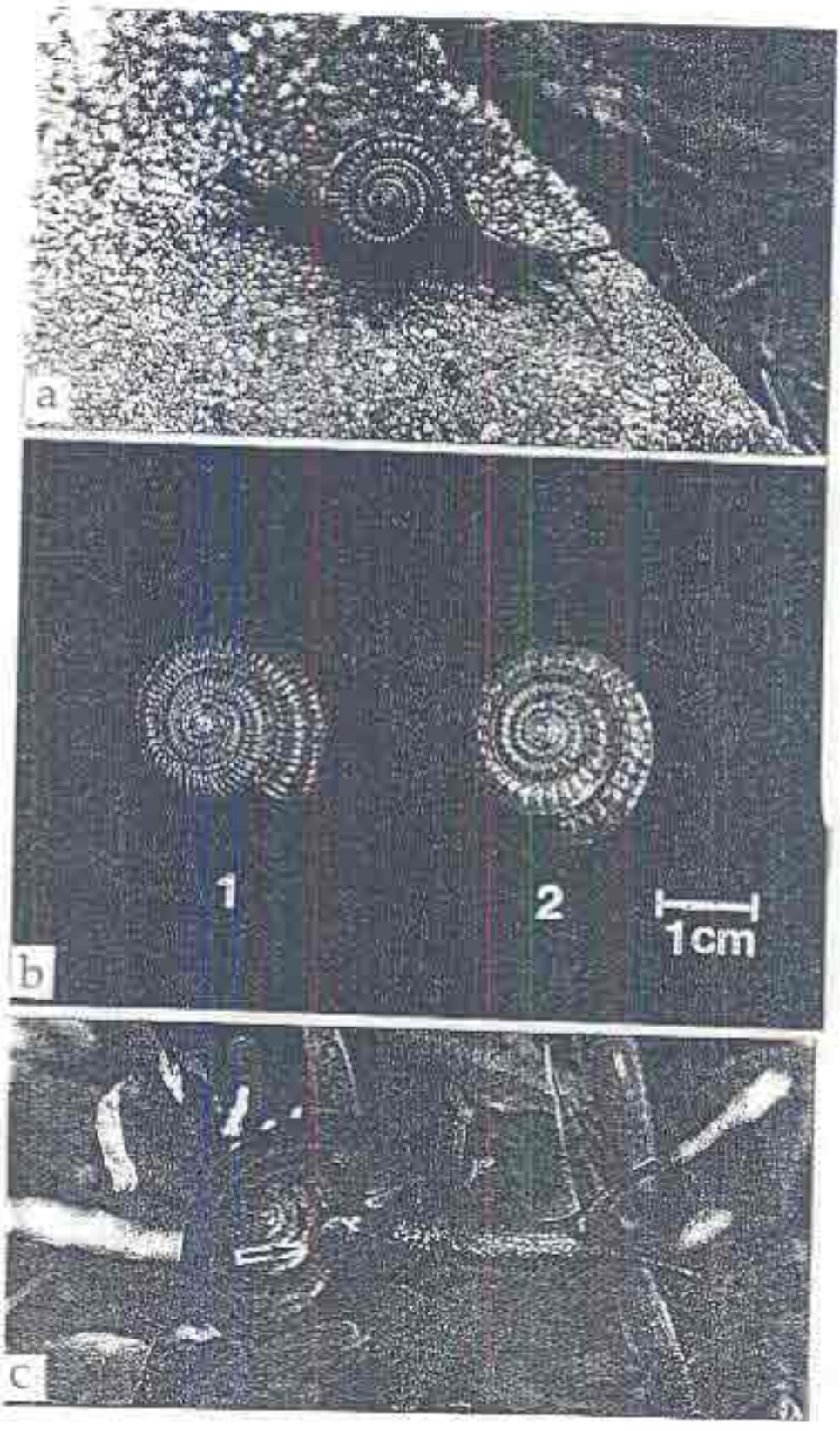


FIG. 1. Distribution of *Macrochlamys asamurai* n. sp. in Surathani and Pattalung, Thailand (stars).

FIG. 2 [facing page]. a, *Macrochlamys asamurai* n. sp.; b1, shell of *Macrochlamys asamurai* n. sp.; b2, shell of *Namiria* (*Macrochlamys*) *diadema*. Paratype (USNM 150277); c, shell rubbing behavior in *Macrochlamys limbata* (arrow = mantle tippet).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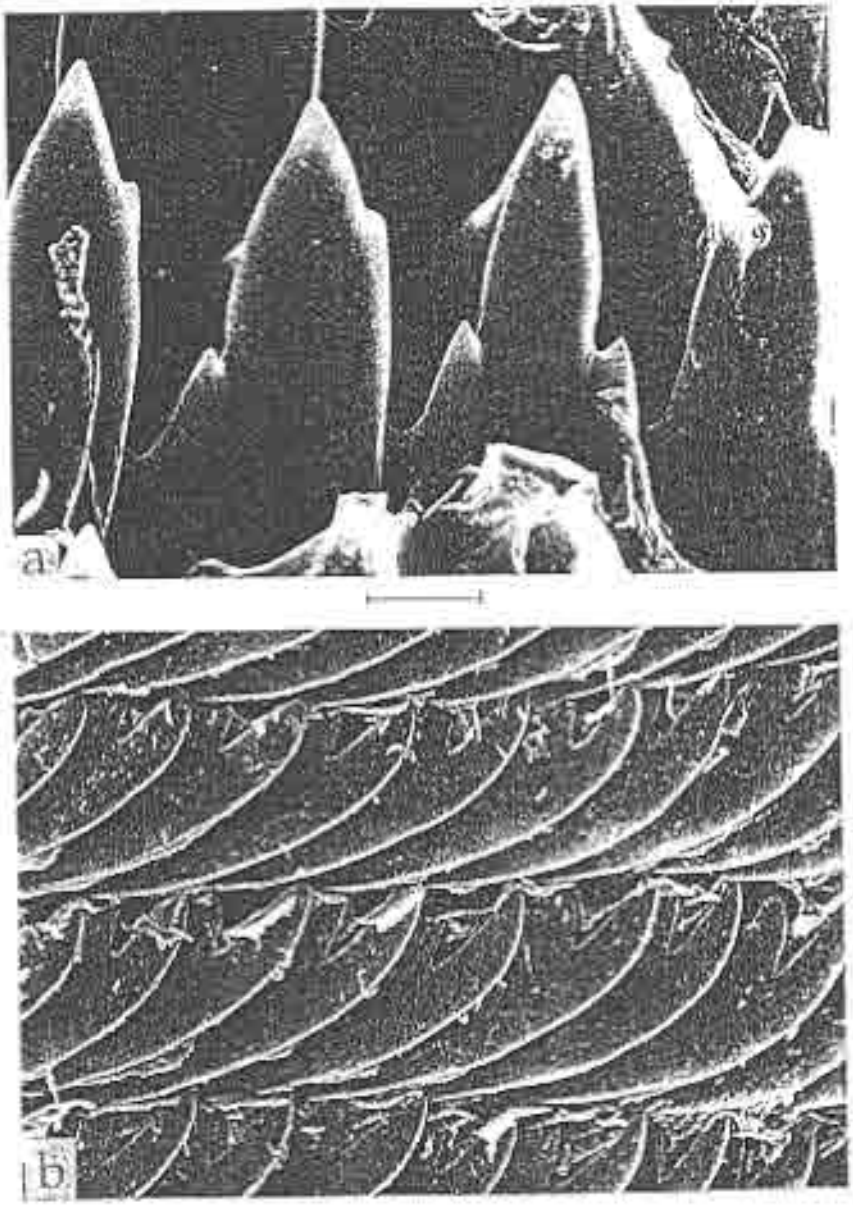

FIG. 8. Radula of *Macrochlamys* n. sp. a. Central and lateral teeth; b. marginal teeth. Bar = 10 µm.

of Natural History (FMNH), Chicago, three specimens, five shells; Zoologisch Museum Universiteit Van Amsterdam (ZMUA), Amsterdam, three specimens, five shells; the National Museum of Natural History, Smithsonian Institution (USNM), Washington D.C., three specimens, three shells; University of Michigan Museum of Zoology (UMMZ), Ann Arbor, two specimens, three shells; Senckenberg Museum (SMF), Frankfurt, two specimens, three shells; Universitetets Zoologiske Museum Kobenhavn (UZMK), Copenhagen, one specimen, two shells.

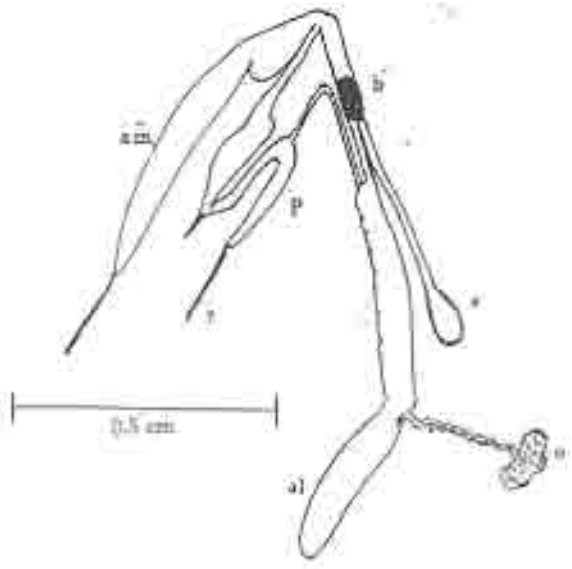

FIG. 4. Reproductive organs of *Macrochlamys asamurai* n. sp. al = albumen gland, am = dart sac, b = bursa copulatrix, o = ovotestis, p = penis, r = retractor muscle, s = spermatheca

Habitat and geographical distribution. *Macrochlamys asamurai* seems to be limited to southern Thailand and the Malay Peninsula. The only known localities are at Suratham, and Patalung, Siam. (The Siam representatives are two broken shells collected by H.M. Smith and are stored in the NMNH Smithsonian Institution, collection number USNM 420342.) *Macrochlamys asamurai* lives at the base of vegetation that grows in the cracks of rocks on exposed limestone substrates. The following species were also found in this habitat: *M. herbigyra* (Moellendorff), *Chloritis platyrrhyta samaana* (Moellendorff), *Discartemon roebelen*i (Moellendorff).

Variability. The shell diameter of the type material ranges from 0.8 to 1.7 cm and the height from 0.4 to 1.0 cm (Fig. 5). The channeled ribs in the upper shell vary in number from 54 to 59.

DISCUSSION

Macrochlamys asamurai n. sp. is similar in shell morphology to *Nanina (Macrochlamys) diadema* Dall 1897 [the name *Syama diadema* (Dall 1897) was used by Abbott in 1989] from Penang, Malay Peninsula. In comparison to a paratype shell of *N. (M.) diadema* at the NMNH (cat. no. USNM 163299), *M. asamurai* n. sp. has smaller and more numerous ribs, and more delicate sculpture in the upper shell. *N. (M.) diadema* possesses 38 radial grooves, while *M. asamurai* has radial grooves varying in number from 54 to 59. I used the generic name *Macrochlamys* for this snail because of the significance of its anatomical characters. After dissecting this species, I found a large dart apparatus (amatorial organ) in *M. asamurai*, as described by Benson (1832), Gray (1847), and Solem (1966). A small dart sac was described in *Nanina* by Albers in 1850, and no dart apparatus was described in *Syama* by Blanford & Godwin-Austen (1908). The caudal tip of the foot of *Macrochlamys* possesses a caudal foss and a horn-shaped process above it, while *Syama* possesses a cauda) lobe. The jaw and radular teeth are typical of *Macrochlamys*.

One of the most important defining characters in the snail genus *Macrochlamys* is the shell rubbing behavior. When a snail is exposed to sunlight, it often uses the mantle lappet with a mass of mucus to rub on the upper shell (Fig. 2c), which is the reason for the polished shell in this genus. *Macrochlamys asamurai* demonstrates this shell rubbing behavior, which probably protects the thin shell from heat and desiccation.

Three shells of *Syama splendens* were also observed and studied by the author at the University of Michigan, Museum of Zoology, Ann Arbor, two from lot UMMZ 145856 and one from

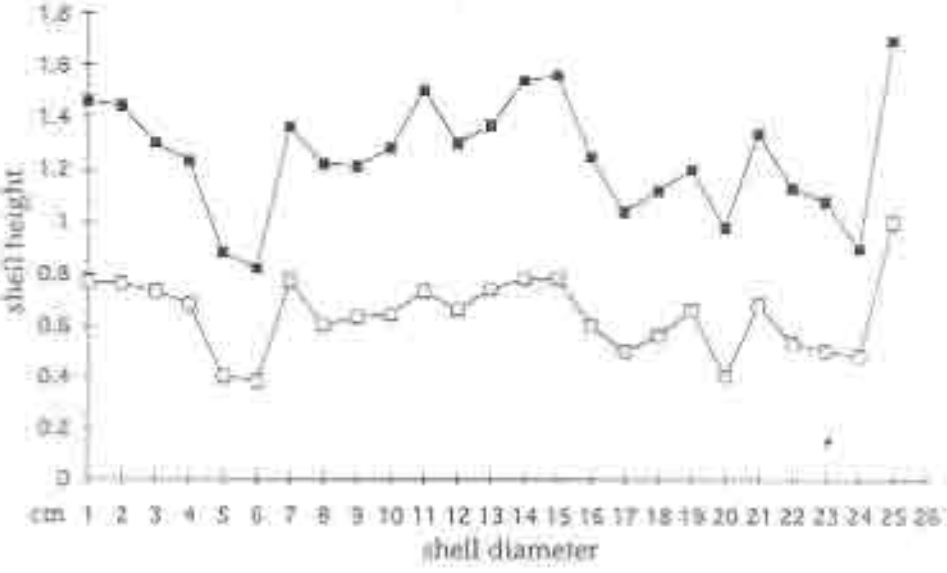

FIG. 5. Graph showing relationship between shell height and shell diameter of 25 shells of *Macrochlamys asamurai* n. sp. (■ = shell diameter; □ = shell height in cm).

lot UMMZ 232775. This species is distinctly different from *M. asamurai*.

ACKNOWLEDGMENTS

This research was supported by a grant from the Thailand Research Fund (TRF) 1995. I wish to thank Dr. Robert Hershler of the National Museum of Natural History, Smithsonian Institution, Washington, D.C., for his help during my visit to the museum to study type specimens and for the loan of the paratype of *Namina* (*Macrochlamys*) *diadema*, and Dr. Rüdiger Bieler and John Slapcinsky of the Field Museum of Natural History, Chicago, for their help during my visit to study the land pulmonate snail collection at FMNH. Thanks are also due Dr. Robert Moolenbeek, Zoological Museum, Universiteit van Amsterdam, for his help in supplying literature; to Mr. Yutaka Asamura, the Hitachi Scholarship Foundation, Japan, for his encouragement to study the land snails of Thailand; and to Professor John B. Burch, Museum of Zoology, University of Michigan, Ann Arbor, for critically reading the manuscript.

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A NEW SPECIES OF *AMPHIDROMUS* FROM THAILAND (STYLOMMATOPHORA: CAMAENIDAE). — Somsak Panha.

Abstract. *Amphidromus tanyai*, n. sp., is a mountain species from a fully tropical evergreen forest in the Phuluang Wildlife Sanctuary in northeastern Thailand. It is distinguished by its shell, which is dextral, greenish, glossy, with a brown spiral band on the last whorl and a narrow pale blue sutural band on the two last whorls. The suture on the penultimate whorl is smooth. Six teen other species of *Amphidromus* have been found previously in Thailand, making this the largest genus of land snails in the country. — Key words: *Amphidromus tanyai*, Camaenidae, terrestrial Pulmonata, Thailand.

The family Camaenidae is one of the most diverse groups of terrestrial pulmonate snails in Thailand. As presently known in Thailand, the family includes 31 species (Panha, 1996), which are placed in five genera. Of these genera, *Amphidromus* Albers has the largest number of species in the country, with 16 species previously reported (Laidlaw & Solem, 1961; Solem, 1965, 1966). The genus *Amphidromus* was reviewed by Laidlaw & Solem in 1961, and Solem in 1983, but since then a new species has been described from Indonesia (Dharma, 1993). I am now describing a second species, which was collected in 1993 in the Phuluang Wildlife Sanctuary in northeastern Thailand by Mr. Tanya Chanard, Chief of the Sanctuary.

Amphidromus tanyai n. sp. (Fig. 1)

Holotype. Shell relatively small (height 2.24 cm, width 1.15 cm), conical, dextral, imperforate, green, translucent, polished, and with five whorls. The apex is yellow, little obtuse, smooth and glossy. The last whorl is slightly convex and has a brown spiral band. There is a narrow, pale blue sutural band on the two last whorls. The aperture is ovate, yellowish within, and pale brown at the outer and inner lip. The peristome is white, narrowly expanded; the umbilicus closed.

Type locality. Thailand, near Tad Loei Waterfall, Phuluang Wildlife Sanctuary, Loei Province, 1,200 metres elevation (CUIZM 6331), November, 1993, leg. T. Chanard.

Habitat and geographical distribution. The genus *Amphidromus* Albers in southeast Asia seems to be limited to northeastern Thailand, Laos, Cambodia and Vietnam. The only known locality for *A. tanyai* is the type locality at the Phuluang Wildlife Sanctuary in northeastern Thailand. Other land snails found at this locality were *Camaena illustris* (Pfeiffer) and *Chloritis (Trichochloritis) deliciosa* (Pfeiffer), both of which are also known from Cambodia and Vietnam.

Variability. The shell height of the type material ranges from 2.12 to 2.24 cm, the shell width from 1.04 to 1.15 cm (Table 1).

Type material. The holotype (CUIZM 6331) and two shell paratypes (CUIZM 6332) are deposited in the Chulalongkorn University Zoological Museum. One shell paratype is in the Field Museum of Natural History, Chicago, Illinois, U.S.A.

Etymology. The specific epithet *tanyai* is from the name of Mr. Tanya Chanard, Chief of the Phuluang Wildlife Sanctuary, who collected the first shell of the new species.

Diagnosis. Amphidromus tanyai can be distinguished by the brown spiral band on the last whorl and the narrow pale blue sutural band on the two last whorls. The suture on the penultimate whorl is smooth.

Discussion. *Amphidromus tanyai* n. sp. is distinctly different from other *Amphidromus* species in Thailand, Malaysia, Laos, Cambodia, Vietnam and Indonesia. Shell characteristics, including the color pattern, are the main diagnostic characters. The shells of *A. tanyai* are most similar to *A. glaucolarynx* (Dohrn), but differ in possessing a smooth suture at the last two whorls, while *A. glaucolarynx* has a deep suture. The color pattern is absolutely different and the chirality of the new species is only dextral, while *A. glaucolarynx* is both dextral and sinistral. The other species are distinctly different in both shell shape and color pattern, as shown in Fig. 2. The anatomy of the new species will be described if anatomical specimens become available.

Amphidromus is represented in Thailand by 17 species. Laidlaw & Solem (1961) divided

Amphidromus into three subgenera, *Amphidromus* s. str., *Comadromus* and *Syndromus*. However, that classification may be useful on the Indonesian islands, but is less reliable on the mainland (Solem, 1965). Solem (1965) examined 500 specimens of *Amphidromus* from Thailand and confirmed that all had close affinities, particularly in regard to the species *A. xiengensis*, *A. areolatus*, *A. semihesellatus* and *A. glaucolaryns*, all members of the subgenus *Syndromus*. The new species described here is closely related to those four species, and particularly to *A. glaucolaryns*. The characteristics of the other four species of *Syndromus* are as follows (see also Table 1). In *A. glaucolaryns* (Fig. 2a), the shell has a slender shape, broad vertical purple-brown streaks, and a violet-purple aperture. In *A. xiengensis* (Fig. 2b), the basic color pattern of the shell consists of narrow to moderately brown radial bands that are interrupted by one or more narrow spiral zones of ground color. Most varieties have a red subsutural band present. The shell of *A. semihesellatus* (Fig. 2c) has a subsutural band of black or purple and two interrupted spiral bands of brown on all but the last whorl, which is solid yellow, but occasionally has spiral basal bands. The shell of *A. areolatus* (Fig. 2d) is irregulary painted with slanting brown flames which branch above, and has a reddish patch near the columella.

TABLE 1. Size variation in five species of Thai *Amphidromus* (*Syndromus*).

Species	No. of Specimens	Height (cm)			Width (cm)			Whorls
		Mean	Range	S.D.	Mean	Range	S.D.	Mean
A. glaucolaryns	8	2.30	2.22-2.46	0.08	1.16	1.12-1.22	0.04	5.5
A. xiengensis	10	2.77	2.63-2.82	0.06	1.14	1.12-1.15	0.01	6.0
A. semihesellatus	6	2.51	2.14-3.03	0.34	1.14	1.07-1.25	0.07	6.2
A. areolatus	9	2.83	2.60-3.36	0.30	1.24	1.16-1.32	0.08	6.5
A. simpsi	4	2.16	2.12-2.24	0.05	1.11	1.09-1.13	0.03	5.3

Acknowledgments. This research was supported by a grant in 1996 from the Thailand Research Fund (TRF) and Chulalongkorn University. I wish to thank Dr. Rüdiger Bieler, Curator, and Mr. John Slapcinsky, Collection Manager, Division of Invertebrates, Field Museum of Natural History, Chicago, Illinois, U.S.A., for their role in my opportunity to study land snails at the Field Museum in October 1995, and in July and August 1996. Thanks are also due Professor John B. Burch, Museum of Zoology, University of Michigan, Ann Arbor, U.S.A., for his valuable suggestions.

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* * * * * * * * *

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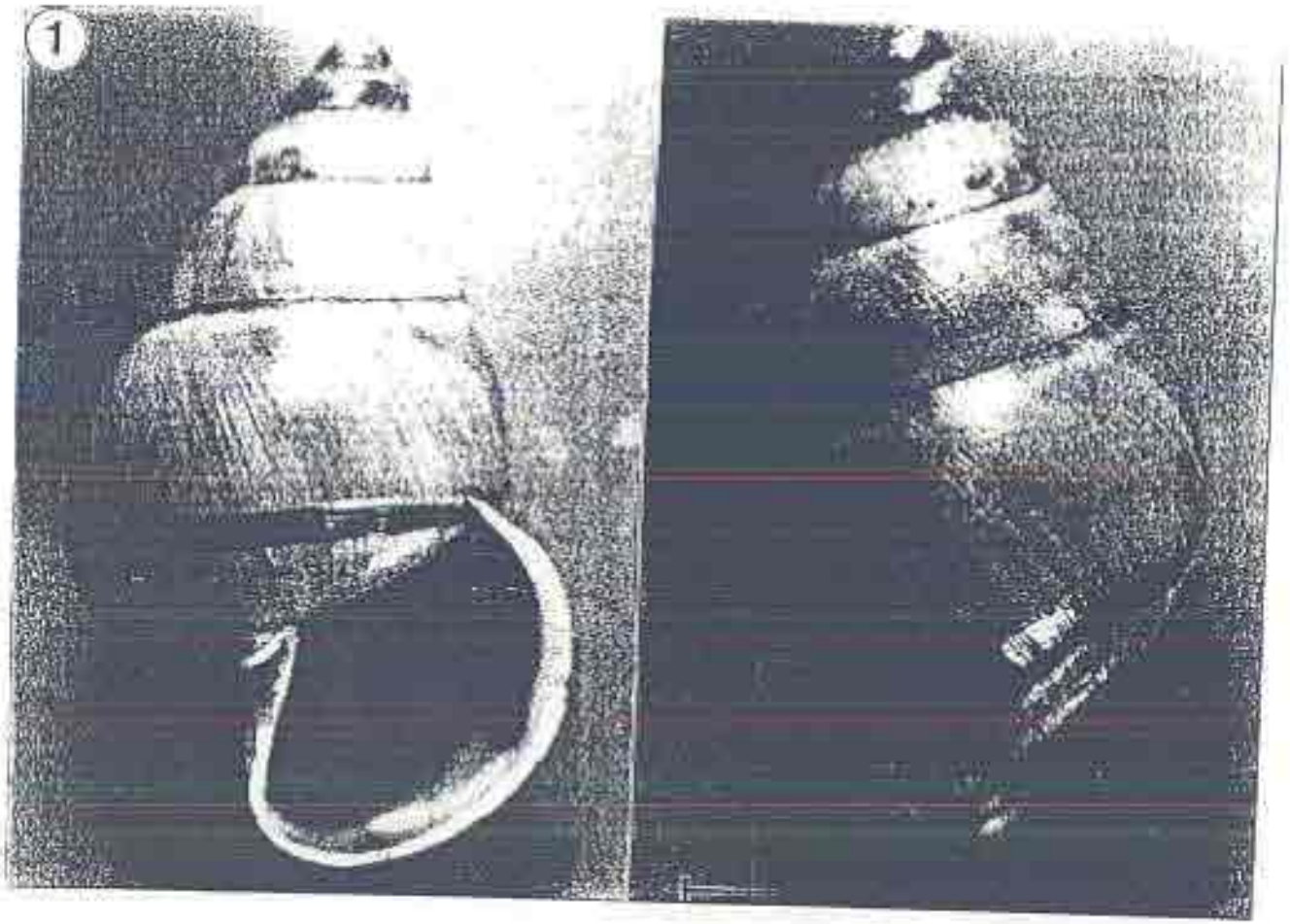
FIGS. 1 and 2 [facing page, front and back]. FIG. 1. *Amphidromus (Syndromus) hirsui* n. sp. (Bar = 1 cm). FIG. 2. a, Shell of *Amphidromus (Syndromus) glaucolaryns*; b. *A. (S.) xiengensis*; c. *A. (S.) semihesellatus*; d. *A. (S.) areolatus*. (Bars = 1 cm).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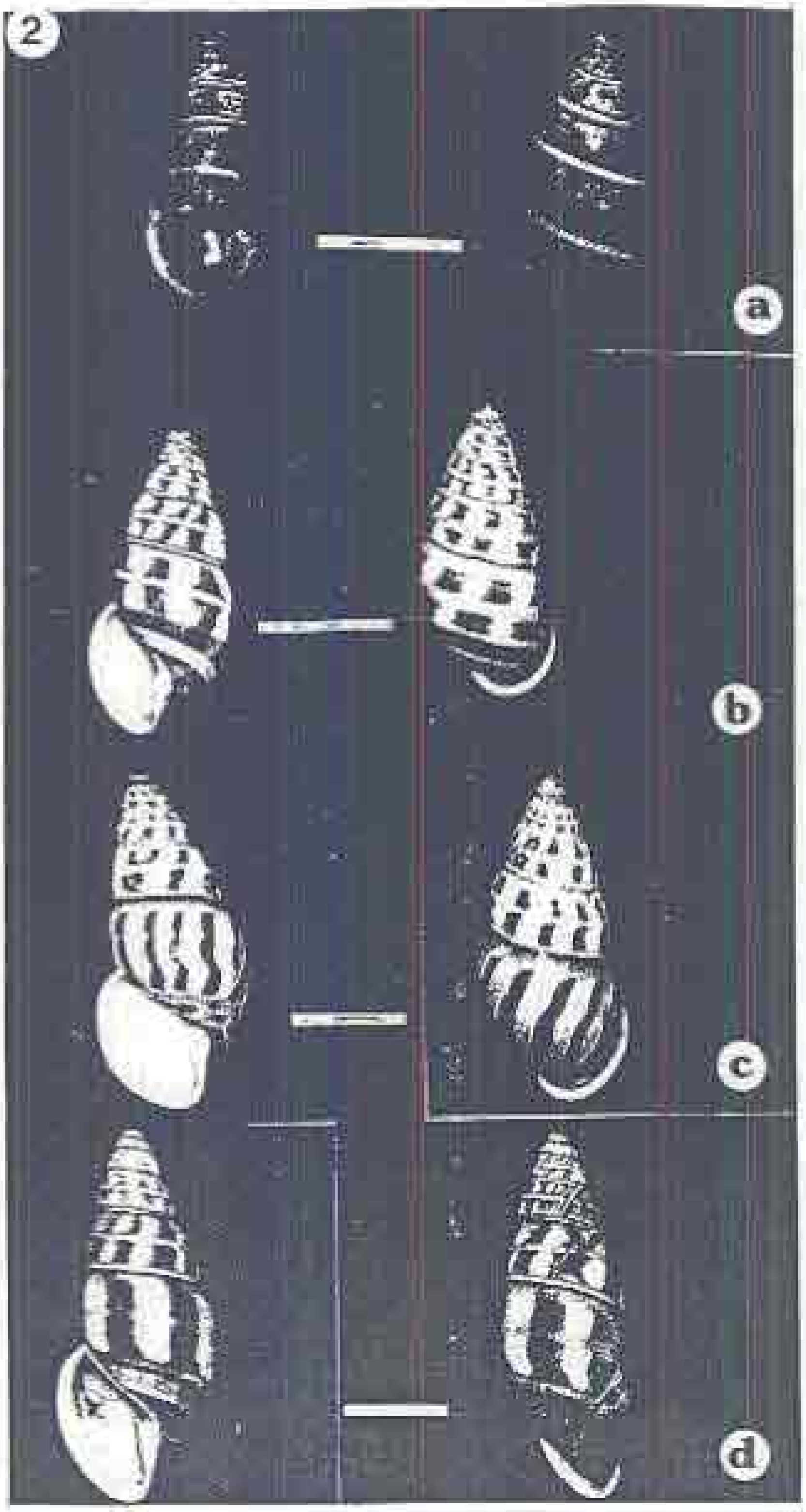
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Walkerana, 1996, 8:

A CHECKLIST AND CLASSIFICATION OF THE LAND PULMONATE SNAILS OF THAILAND

Somsak Panha[1]

~~Key words: land pulmonate snails, Thailand, Pulmonata, Stylommatophora.~~

INTRODUCTION

Land pulmonate snails have been recorded from Siam or Thailand since the 19th century. Gould (1844), in the first article on the description of land shells from Burmah and Siam collected by Francis Mason, In 1860, Martens listed the Mollusca of Siam which included 17 species of land pulmonate snails.

Other authors describing or listing land pulmonate snail species from Thailand during this early period were Pfeiffer (1860, 1861a, b, 1862), Dohrn (1861), Crosse & Fischer (1863), Wallace (1865), Godwin-Austen (1882, 1888, 1898), Morlet (1883, 1884, 1886, 1889, 1891a, b), Tryon (1885), Cockerell (1891) and Moellendorff (1891, 1894).

During the 20th century, the number of publications dealing with land pulmonate snails found in Thailand increased, and the fauna was becoming better known. These included the works of Gude (1901, 1903a, b, c, 1907, 1914), Blanford (1902, 1903), Sykes (1902), Pilsbry (1902), Godwin-Austen (1909, 1916, 1919), Schepman (1912), Fulton (1915), Cooke (1915), Kennard & Woodward (1923), Woodward (1918, 1925), Benthem Jutting (1929), Cockerell (1929), Laidlaw (1931), Tomlin (1929, 1932), Haas (1934, 1952), Sweedie (1947), Zilch (1953, 1961, 1966, 1984), Hubendick (1956), Solem (1963, 1966), Bruggen (1972), Loosjes & Loosjes-Van Benmmel (1973), Mead (1979), Thompson & Lee (1988) and Panha (1996a, b). Some of these publications were faunistic surveys, and some were mainly taxonomic in nature. Some taxonomic problems still need to be resolved, and much more information is needed on the snail ecology, ecological physiology, and responses to human modified-environments. But more details on these aspects must await further studies.

The list below contains 15 families, 5 genera and 136 species. Some additional taxa undoubtedly will be added as Thailand is more thoroughly surveyed.

OUTLINE OF CLASSIFICATION AND LIST OF SPECIES

Subclass Pulmonata Cuvier
- Order Stylommatophora Schmid
- Superfamily Pupilloidea
- Family Vertiginidae
  - Genus *Hypselostoma* Benson
    - *H. hollinumae* Thompson & Lee
  - Genus *Gyliotrachela* Tomlin
    - *G. transitans* (Moellendorff)

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Superfamily Buliminoidea
Family Bulimnidae
Genus *Buliminus* Beck
B. siamensis Redfie l
Genus *Coccoderma* Moelle dorff
C. ceratina (Reeve)
Family Cerastuidae
Genus *Cerastua* Strand
C. siamensis (Redfi d)

Superfamily Clausilioidea
Family Clausillidae
Genus *Formosana* Boettge
F. cambodjensis (Pfe ffer)
Genus *Clausilia* Draparna d
C. (Pseudonenia) ke ntanese Sykes

Superfamily Achatinoidea
Family Subulinidae C
Genus *Curvella* Chaper
C. puta (Benson)
Genus *Glessula* Von Marte s
G. latestriata Moell ndorff
Genus *Lamellaxis* Strebel & Pfeiffer
L. gracilis (Hutton) [introduced]
Genus *Prosopeas* Mörch
P. filiforme Moeller lorff
P. walkeri (Benson)
Genus *Plicaxis* Sykes
P. mirabilis Sykes
Genus *Stenogyra* Shuttlew rth
S. erecta (Benson)
Family Achatinidae
Genus *Achatina* Lamarck
A. fulica (Férussa [introduced]

Supperfamily Streptaxoidea
Family Streptaxidae
Genus *Streptaxis* Gray
S. depressa Moelle dorff
S. moidoti Pfeiffer
S. pelluceus Pfeiffe
S. porrectus Pfeiffe
S. siamensis Pfeiffe
Genus *Discartemon* Pfeiff
D. roebelenі (Moell ndorff)

Genus *Haplopychitus* Moe llendorff
H. mirificus (Moel ndorff)
Genus *Micratemon* Moell ndorff
M. prestoni (Gude
Genus Oophana Ancey
O. strangulatus (M ellendorff)
O. subbubulus (Mo llendorff)
Genus *Perrottetia* Kobelt
P. siamensis depress (Moellendorff)
P. siamensis expans abris (Moellendorff)
P. siamensis subglol isus (Moellendorff)

Superfamily Helicarionoidea
Family Helicarionidae
Genus *Helicarion* Férussa
H. siamensis Haine
Genus *Geotrochus* Hasselt
G. perakensis Cross
Genus *Kaliella* Blanford
K. subsculpta Moel ndorff
Genus *Hemiglypta* Moelle dorff
H. siamensis (Moel ndorff)
Genus *Scara* Albers
S. megalodon Blanf rd
S. parva Solem
Genus *Sivella* Blanford
S. castra (Benson)
S. grubaueri Moelle ndorff
S. kalantanensis Mc llendorff
Family Ariophantidae
Genus *Cryptozona* Mörch
C. siamensis (Tomli)
C. praestans (Gould
C. granulosa (Moel' ndorff)
Genus *Euplecta* Semper
E. hijuga (Stoliczka
E. dichromatica Mo et
E. pataniensis (G M rgan
Genus *Hemiplecta* Albers
H. crossei Pfeiffer
H. danae (Pfeiffer)
H. distincta (Pfeiffe)
H. hugonis Pfeiffer
H. neptunus (Pfeiff r)
H. siamensis (Pfeiff r)
H. weinkauffiana Cr sse & Fischer
H. zimmuyensis Go win-Austen
Genus *Dyakia* Godwin-Au sten
D. hugonis Pfeiffer
D. salangana (Mart ns)

D. striata (Gray)
Genus *Parmarion* Fischer
P. setchuanensis H ude
Genus *Austenia* Nevill
A. doisutepensis Sc em
Genus *Cryptaustenia* Coc erell
C. gadinodramica S lem
Genus *Cryptogirasia* God in-Austen
C. rubra (Godwin- usten)
Genus *Macrochlamys* Ben an
M. anceps (Gould)
M. asamurai Panh
M. dugasti Morlet
M. limbata Moelle dorff
M. molecula Benso
M. pumicata (Morl t)
M. resplendens (Ph) (Philippi)
Genus *Megaustenia* Cocke ell
M. siamensis (Hain s)
Genus *Muangnua* Solem
M. limua Solem
Genus *Sarika* Godwin-Au ten
S. hainesii (Pfeiffer
S. kautaoensis Torni n
S. obesior (Martens
Genus *Ternia* Solem
T. crenulata (Yen)
T. thailandica Solem
Genus *Durgella* Blanford
D. libas Solem
Genus *Nanina* Sowerby
N. benoiti Crosse & Fischer
N. mouhoti Pfeiffer
N. pedina Benson
N. subcornea Pfeiffe
Genus *Minyongia* Godwin Austen
M. kempi Godwin- usten
Genus *Myolesta* Collinge
M. fruhstorferi Coll ge
M. punctata Collin
Genus *Sitala* Adams
S. insularis Moeller dorff
S. trochulus (Moell dorff)
Genus *Ariophanta* Desmo ins
A. laevis Muller
Genus *Ibycus* Heynemann
I. perakensis Godwi -Austen
Genus *Trochomorpha* Alber
T. capitium Benson

Family Zonitidae
Genus *Bertia* Ancey
B. cambodjensis Re ve

Superfamily Vitrinoidea
Family Vitrinidae
Genus *Vitrina* Draparnau :
V. cochinchinensis ! lorlet

Superfamily Camaenoidea
Family Camaenidae
Genus *Camaena* Alber
C. illustris (Pfeiffer
Genus *Amphidromus* Albe
A. areolatus (Pfeiff :)
A. atricallosus (Gou d)
A. dohrni (Pfeiffer)
A. fultoni Ancey
A. glaucolarynx (D(um)
A. hemicyclus Rock br
A. inversus annami cus (Crosse & Fischer)
A. leucoxanthus Ma tens
A. metabletus Moel ndorff
A. moellendorffi Has
A. tanyai Panha
A. perversus Linnae us
A. rhombostomus Pf iffer
A. schomburgki (Pfe ffer)
A. semitesselatus (M orlet)
A. sinensis indistinc us Pilsbry
A. siangensis Morle
Genus *Chloritis* Beck
C. breviseta Pfeiffer
C. (T.) deliciosa (Pfe ffer)
C. (T.) diplochone M ellendorff
C. (T.) fouresi Morle
C. (T.) insularis Mo llendorff
C. (Trichochloritis) s imensis Moellendorff
C. platytropis Moell ndorff
C. platytropis samui na Moellendorff
C. platytropis siame sis Moellendorff
C. tenella Pfeiffer
Genus *Ganesella* Blanford
G. capitium Benson
G. mudelni (Bavay : Dautzenberg)
G. dipplogramme M. ellendorff
G. kuriola carinella I loellendorff
G. perakensis Cross
G. ptychostyla Mart ns

Genus *Trachia* Alber
T. gabata Gould

Superfamily Helicoidea
Family Bradybaenidae
Genus *Bradybaena* Beck
B. (Acusta) brevispi a Morlet
B. jouresi Morlet
B. norodomiana Mc let
Genus *Aegista* Alber
A. (Plectotropis) en nsa (Godwin-Austen)
A. (P.) goniochila P: iffer
A. (P.) oldhami Pfei fer
A. (P.) orthocheilis I eude
A. (P.) trichotropis I feiffer
A. (P.) winteriana F eiffer
Genus *Cathaica* Moellend rff
C. brevispira Haine

Superfamily Succinoidea
Family Succineidae
Genus *Succinea* Draparna d
S. cochinchinensis F eiffer
S. tenella Morlet

Superfamily Plectopylidoidea
Family Plectopylidae (Corillidae
Genus *Plectopylis* Benson
P. (Chersaecia) dege olae Solem
P. (C.) simplex Sole t

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Proof

A NEW SPECIES OF *DISCARTEMON* FROM THAILAND (PULMONATA : STREPTAXIDAE)

Somsak Panha and John B. Burch

ABSTRACT

Discartemon khaosokensis n. sp. (Pulmonata: Streptaxidae) is described from limestone mountains, Khaosok National Park, Surathani Province, Thailand. It is compared to the closely related species *D. paradiscus* (Moellendorff 1900), differing by its planorbiform shell with 5 1/2 whorls, and the deep suture at the ultimate and last whorls. Aperture with a lamellar parietal tooth, peristome expanded and reflected. Body with a greenish-yellow coloration, and a reddish color on the upper third of the long dorsal tentacles.

Key Words: *Discartemon khaosokensis*, Pulmonata, Streptaxidae, Thailand.

INTRODUCTION

The terrestrial gastropod Family Streptaxidae is widely distributed in South America, tropical Africa, southern Asia and several Indo-Pacific Islands (Richardson, 1988). Thirteen streptaxid species have been recorded from Thailand (Zilch, 1961; Panha, 1996). During a faunistic study of land molluscs in southern Thailand, a new streptaxid species was found in May, 1997. The specimens were collected from limestone areas at 8°59'2" N, 98°42'11" E, Khaosok National Park, Surathani Province, Thailand (Fig. 1). This is the 14th species of the family and the second species of the genus *Discartemon* to be found in Thailand. The only species of *Discartemon* previously known from Thailand is *Discartemon mabelani* (Moellendorff 1894). The new species is described below.

Discartemon khaosokensis n. sp. (Fig. 2)

Description of holotype. Shell flat, thin, semi-transparent, widely umbilicated, striated above, smooth below, whorls 5 1/2 with a deep suture where the penultimate whorl joins the last whorl. Apex concave planorbiform in shape. Aperture with a lamellar parietal tooth; peristome expanded and reflected. Shell diameter 11.5 mm. Body with a greenish-yellow color. The upper third of the long dorsal tentacles have a red color. The dimensions of holotype and paratype shells are shown in Table 1.

Type locality. Khaosok National Park, Surathani Province at 8°59'02" N, 98°42'11" E, 70 meters elevation (CUIZM, St 001), Thailand, 1997 (leg. S. Panha and J. B. Burch).

Etymology. The specific epithet *khaosokensis* is from the name of Khaosok National Park.

Type material. The holotype (CUIZM, St 001) is deposited in the Chulalongkorn

University Zoological Museum together with six paratype shells (CUIZM, St 002). Other paratype shells (CUIZM, St 003) are in the University of Michigan Museum of Zoology (UMMZ), Ann Arbor (five shells).

Habitat and geographical distribution. *Discartemon khaosokensis* is known so far only from Surathani, Nakornsrithamarat and Trang provinces, southern Thailand. *Discartemon khaosokensis* lives on limestone mountain walls with some vegetation and is sometimes found in rock crevices. The following species were also found in this habitat: *Macrochlamys asamurai* Panha 1997, *Chloritis* (*Trichochloritis*) *diplochone* Moellendorff 1898, *Discartemon roebelleni* (Moellendorff 1894), and *Amphidromus atricallosus* (Gould 1844).

Diagnosis. *Discartemon khaosokensis* is similar in shell morphology to *D. paradiscus* (Moellendorff 1900). In comparison with paratype shells of *D. paradiscus* (SMF 108535/5, Senckenberg Museum of Natural History, Frankfurt am Main, Germany) in May, 1996, *Discartemon khaosokensis* has a flatter shell, its apex is concave, and the shell is planorbiform like *Chloritis* (*Trichochloritis*) *diplochone*, and is larger in size. Apertural tooth smaller when compared to the size with shell aperture.

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This research is supported by The Thailand Research Fund (TRF) in 1997. We wish to thank Surakeit Pholkoksoong, Pongrat Dumrongrojwatana and two third year students, Department of Biology, Chulalongkorn University for their kind assistance in this field survey. Thanks are also due to Dr. Ronald Janssen, Curator of Molluscs, Senckenberg Museum of Natural History, for generously permitting one of us (S.P.) to study the type collection of streptaxid snails, and for permitting photography of some of the type specimens in the Senckenberg collection.

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John B. Burch
Museum of Zoology and Department of Biology
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session 10; April 14, 1996; 12:00-12:20

Land snails... Food of hornbills.

Somsak Panha

Department of Biology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand

ABSTRACT

Two species of land prosobranchs, *Cyclophorus siamensis* and *Rhiostoma smithi*, and three species of land pulmonates snails, *Hemiplecta distincta*, *H. weinkauffiana* and *Cryptozona siamensis* were known to be the foods of hornbills. The snails are dominant and abundant in Thai forests. They are ground dwellers, and are sometimes found on tree leaves or trunks during the wet period (rainy season). The two prosobranchs are litter feeders belonging to family Cyclophoridae, but the pulmonates are polyphagous belonging to family Ariophantidae. The distributions of the two prosobranchs are very wide, but *Hemiplecta distincta* and *H. weinkauffiana* are found Myanmar, Thailand, Cambodia and Laos; *Cryptozona siamensis* was found to be an endemic species of Thailand. The snails live in various types of forests from dipterocarp forests, mixed-deciduous forests and dry evergreen forests to moist evergreen forests.

Abstracts

ATP Mini-Symposium

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PAPER NUMBER 2

SPEAKER Somsak Panha
INSTITUTE Department of Biology , Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand

TITLE ARE SHELL CHARACTERISTICS ASSOCIATED WITH HABITATS ? : A HYPOTHESIS FOR SOUTHEAST-ASIAN CAMAENID SNAILS

ABSTRACT

Seventy one of 873 shells from 4 common genera of Southeast Asian camaenid snails were randomly selected from the collections at The Field Museum, Chicago. The measures of shell shape, shell height, shell width and apertural diameter were compared between these genera. Shell shape of the arboreal snails in the genus *Amphidromus* is significantly different at p .01 from shells of the ground dwelling genera. Field observation of snail habitat use were compared with shell shape characteristics. Other qualitative characters also show distincly different pattern between the two groups for example shell shapes of ground dwelling genera is mostly heliciform while arboreal genus is bulimiform or turettiform, color patterns of ground dwelling genera are mostly monotone brown or dark green while arboreal coloration and pattern are diverse with color bands and patches ; the chirality of ground dwelling genera is mostly dextral, with some sinistral but no variation within species while arboreal genera like *Amphidromus* have variable chirality. Shell shape, color and chirality may be associated with habitat type. Advance analysis and field work will be done to investigate this hypothesis.

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S-59

NATURAL HISTORY OF LAND PULMONATE SNAIL COLLECTION AND SPECIES DIVERSITY IN THAILAND

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The study of the natural history of living things and that of the history and culture of humans are closely intertwined. They both involve the study of documents, ancient sites, and ancient objects. Samples of living things have been systematically collected in museums in general, and natural history museums in particular, throughout the world. The history of the study and collection of land pulmonate snails of Thailand began over 200 years ago with the first report by the German naturalist A. A. Gould in 1844, and other reports that followed. Europeans, from England, France, Germany, Denmark, and Holland, played a special role in the regions of Indochina, Burma, India, Malacca, Java, and Siam (Thailand). Two merchants who influenced the natural history of the study of land pulmonate snails in this part of the world were the Englishman W. C. Fulton and the German H. Fruhstorfer, as these men sold such snails. Research up to the present has shown that land pulmonate snails of Thailand have a very large variety of species and habitats. So far, researchers have found 14 families and 146 species, with diameters ranging from 1 millimeter to 10 centimeters. The true number of species is believed by experts to be as high as 500, based on the characteristics of tropical ecosystems.

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ประวัติศาสตร์ธรรมชาติของการเก็บรวบรวมและความหลากหลายของสัตว์หอยบกในประเทศไทย

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การศึกษาประวัติศาสตร์ธรรมชาติของสิ่งมีชีวิตและศึกษาประวัติศาสตร์และวัฒนธรรมของมนุษย์ชาติมีความเกี่ยวข้องกันอย่างยิ่ง เนื่องจากเป็นการศึกษาจากเอกสาร โบราณสถาน โบราณวัตถุ และตัวอย่างของสิ่งมีชีวิตที่ถูกเก็บรวบรวมไว้อย่างเป็นระบบในพิพิธภัณฑ์ตลอดจนพิพิธภัณฑ์ธรรมชาติวิทยาทั่วโลก ประวัติในการศึกษาและการเก็บรวบรวมหอยบกของประเทศไทยนั้น เริ่มมาตั้งแต่เมื่อกว่า 200 ปีที่ผ่านมา จากรายงานฉบับแรกของชาวเยอรมันชื่อ A. A. Gould เมื่อ ค.ศ. 1844 และรายงานฉบับอื่น ๆ ต่อ ๆ มา ชนชาติยุโรป โดยเฉพาะ อังกฤษ ฝรั่งเศส เยอรมัน เดนมาร์ก และฮอลันดา มีบทบาท โดยเฉพาะในบริเวณภูมิภาคอินโดจีน พม่า อินเดีย มาลัคกา ชวา และสยาม ส่วนคนของคนที่มีบทบาทต่อประวัติศาสตร์ธรรมชาติของการศึกษาหอยบกในภูมิภาคนี้คือชาวอังกฤษชื่อ W. C. Fulton และชาวเยอรมันชื่อ H. Fruhstorfer เนื่องจากทั้งสองคนเป็นผู้จัดจำหน่ายหอยบก ผลวิจัยจนถึงปัจจุบันได้แสดงให้เห็นว่าหอยบกของประเทศไทยนั้นมีความหลากหลายของชนิดและความหลากหลายของถิ่นอาศัยสูงมาก คาดว่ามีถึง 14 วงศ์ 146 ชนิดที่มีขนาดเส้นผ่าศูนย์กลางตั้งแต่ 1 มิลลิเมตร ไปจนถึง 10 เซนติเมตร จำนวนชนิดที่แท้จริงของผู้เชี่ยวชาญคาดว่าจะมีมากถึง 500 ชนิดที่มีเมื่อพิจารณาจากลักษณะของระบบนิเวศป่าเขตร้อน

งานวิจัยนี้ได้รับทุนสนับสนุนจากสำนักงานกองทุนสนับสนุนการวิจัย (สกว.) และ The Field Museum of Natural History (FMNH), Chicago

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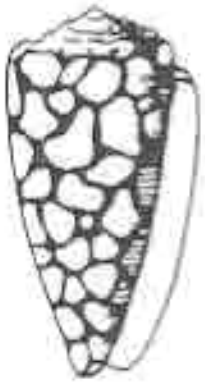

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ARE SHELL CHARACTERISTICS ASSOCIATED WITH HABITATS?: A SHELL MORPHOLOGY FOR SOUTHEAST-ASIAN CAMAENID SNAILS

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Five hundred and ninety eight shells from nine genera of Southeast Asian camaenid snails of the collections at the Field Museum, Chicago and 113 shells with known information from Thailand were measured for shell shape, shell height, shell width, and vertical and horizontal apertural diameter. These shell characteristics of the arboreal snails in the genus *Amphidromus* are significantly different from shells of the ground-dwelling genera. Other qualitative characters also show distinctly different patterns between the two groups, for example shell shapes of ground-dwelling genera are mostly heliciform while arboreal genera are bulimiform or turettiform; colour patterns of ground-dwelling genera are mostly monotone brown or dark green while arboreal colouration and pattern are diverse, with colour bands and patches; the chirality of ground-dwelling genera is mostly dextral, with some sinistral but no variation within species while arboreal genera like *Amphidromus* have variable chirality.

PHYLOGENY OF GASTROPODS - TOWARDS 2000

W.F. Ponder, Australian Museum, Sydney, NSW 2000.

The old classification of gastropods into Prosobranchia, Opisthobranchia and Pulmonata is no more. Recent work on the phylogeny of gastropods has provided new insights into the composition of the major clades and the relationships of these clades. Using morphology, ultrastructure and molecular data individuals and teams in various parts of the world have made considerable progress in our understanding of this large and important group. This work is reviewed, along with a summary of the work undertaken in the Australian Museum.