SPECIES DIVERSITY, DISTRIBUTION AND HABITAT RELATIONSHIPS OF TERRESTRIAL SNAILS ON THE PHU PHAN MOUNTAIN RANGE OF NORTHEASTERN THAILAND

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A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Biological Sciences
Faculty of Science
Chulalongkorn University
Academic year 2007

ความหลากชนิด การกระจาย และความสัมพันธ์กับถิ่นที่อยู่อาศัยของหอยทากบกบนเทือกเขาภูพาน ภาคตะวันออกเฉียงเหนือของประเทศไทย

นางชนิดาพร ตุ้มปี่สุวรรณ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
สาขาวิชาวิทยาศาสตร์ชีวภาพ
คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2550

Thesis Title	SPECIES DIVERSITY, DISTRIBUTION AND HABITAT RELATIONSHIPS OF TERRESTRIAL SNAILS ON THE PHU PHAN MOUNTAIN RANGE OF NORTHEASTERN THAILAND
By	Mrs. Chanidaporn Tumpeesuwan
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Thesis Advisor	Associate Professor Somsak Panha, Ph.D.
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ร ปที่สุวรรณ: ความหลากชนิด การกระจาย และความสัมพันธ์กับถิ่นที่อยู่อาศัยของหอยทาก*บกบนเทือก*เขาภูพาน ภาคตะวันออกเฉียงเหนือของประเทศไทย (SPECIES DIVERSITY, DISTRIBUTION AND HABITAT RELATIONSHIPS OF TERRESTRIAL SNAILS ON THE PHU PHAN MOUNTAIN RANGE OF NORTHEASTERN THAILAND) อ. ที่ปรึกษา: รศ. ดร. สมศักดิ์ ปัญหา, อ. ที่ปรึกษาร่วม: อ. ดร. อาจอง ประทัดสุนทรสาร, 160 หน้า.

การศึกษาความหลากชนิด การกระจาย และความสัมพันธ์กับที่อยู่อาศัยของหอยทากบกบนเทือกเขาภูพาน พบหอยทากบก 2 ชั้นย่อย 15 วงศ์ 22 สกุล และ 26 ชนิด และมี 1 ชนิดที่เป็นสกุลใหม่ และชนิดใหม่ของโลก คือ *Phuphania globosa* มี 3 วงศ์ที่เป็นวงศ์เด่นคือ Cyclophoridae (3 ชนิด), Ariophantidae (4 ชนิด) และ Camaenidae (5 ชนิด) พบหอยทาก 9 ชนิดในป่าทั้ง 3 ชนิดคือ ป่าแต้งรัง ป่าเบญจพรรณ และป่าดิบแล้ง ได้แก่หอยทากบกชนิด *Cyclophorus consociatus*, *Cyclotus (Siphonocyclotus) hinlapensis*, *Quantula weinkauffiana*, *Phuphania globosa*, *Megaustenia siamensis*, *Hemiplecta distincta*, *Sarika resplendens*, *Amphidromus (Amphidromus) givenchyi* และ *Pseudobuliminus (Giardia) siamensis* หอยทาก 4 ชนิดได้แก่ *Amphidromus (Syndromus) zebrinus*, *Thaitropis* sp., *Semperula* sp. และ *Achatina (Lissachatina) fulica*. พบทั้งในป่าแต้งรังและป่าเบญจพรรณ หอยทาก 3 ชนิดได้แก่ *Cyclophorus* sp., *Prosopeas* sp., และ *Hemiplecta danae* มีการกระจายทั้งในป่าเบญจพรรณ และป่าดิบแล้ง หอยทาก 3 ชนิดได้แก่ *Chloritis (Trichochloritis) tenella*, *Ganesella (Ganesella) capitium* และ *Trochomorpha* sp. มีการกระจายเฉพาะในป่าแต้งรัง และหอยทาก 7 ชนิดได้แก่ *Pupina* sp., *A. (A.) schomburgki dextrochlorus*, *Vitrinopsis* sp., *Parmarion martensi*, *Durgella* sp., *Cryptozona siamensis*, และ *Oxychilus* sp. พบเฉพาะในป่าเบญจพรรณ

การเก็บตัวอย่างจาก 180 พื้นที่ศึกษาพบหอยทากบก 26 ชนิด มีค่าเฉลี่ย 5.59±2.78 ชนิดต่อ 1 พื้นที่ศึกษา (100 x 100 m) และมีค่าเฉลี่ย 76.57±33.60 ตัวต่อ 1 พื้นที่ศึกษา ค่าดัชนีความหลากหลายสูงสุดพบในป่าเบญจพรรณ (1.6566) รองลงมาคือป่าดิบแล้ง (1.5600) และค่าดัชนีความหลากหลายต่ำสุดพบในป่าแต้งรัง (1.3838) ค่าความชุกชุมของหอยทากบกพบสูงสุดในป่าดิบแล้ง (81±30) รองลงมาพบในป่าเบญจพรรณ (91±41) และค่าความชุกชุมต่ำสุดพบในป่าแต้งรัง (61±17) ค่าดัชนีความเหมือนของหอยทากบกมีค่าใกล้เคียงกันในป่าทั้ง 3 ชนิด ความหลากชนิดของหอยทากพบสูงสุดในป่าเบญจพรรณ (7.05±3.34) และพบต่ำสุดในป่าแต้งรัง (4.75±1.83) ในป่าทั้ง 3 ชนิดพบว่าค่าดัชนีความเด่นมีค่าต่ำ แสดงให้เห็นว่าในป่าทั้ง 3 ชนิดไม่มีหอยทากบกที่เป็นชนิดเด่น หอยทากบกที่มีเปลือกรูปทรงแบน (h/d ratio < 1) ส่วนใหญ่พบอาศัยบริเวณพื้นดิน ยกเว้นหอยทากบกชนิด *Prosopeas* sp. ที่มีเปลือกทรงสูง ส่วนหอยทากบกที่มีเปลือกทรงสูงหรือทรงกรวย (h/d ratio > 1) ส่วนใหญ่พบอาศัยอยู่บนต้นไม้ หอยทากกลุ่มนี้จะมีความสูงของเปลือกมากกว่าความกว้าง รูปทรงของเปลือกหอยทากบกมีความสัมพันธ์กับความสูงของถิ่นอาศัยข่อยอย่างมีนัยสำคัญ (ค่าสัมประสิทธิ์ความสัมพันธ์ 0.5817, $P< 0.05$)

สาขาวิชา วิทยาศาสตร์ชีวภาพ ลายมือชื่อนิสิต.....

ปีการศึกษา 2550 ลายมือชื่ออาจารย์ที่ปรึกษา.....

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.....

4573859423 : MAJOR BIOLOGICAL SCEIENCE
KEY WORD: LAND SNAILS / PHU PHAN MOUNTAIN RANGE / SPECIES DIVERSITY / DISTRIBUTION / HABITAT RELATIONSHIPS

CHANIDAPORN TUMPEESUWAN: SPECIES DIVERSITY, DISTRIBUTION AND HABITAT RELATIONSHIPS OF TERRESTRIAL SNAILS ON THE PHU PHAN MOUNTAIN RANGE OF NORTHEASTERN THAILAND. THESIS ADVISOR: ASSOC. PROF. SOMSAK PANHA, Ph. D. THESIS CO-ADVISOR: ART-ONG PRADATSUNDARASAR, Ph. D. 160 pp.

Species diversity, distribution and habitat relationship of land snails were investigated on the Phu Phan mountain range. Two subclasses, 15 families, 22 genera, and 26 species of land snails were collected, classified and identified. ***Phuphania globosa*** was described as a new genus and new species. Fifteen snail families were represented, of which the three most prominent were the Cyclophoridae (3 species), Ariophantidae (4 species) and Camaenidae (5 species). Nine species; *Cyclophorus consociatus*, *Cyclotus (Siphonocyclotus) hinlapensis*, *Quantula weinkauffiana*, *Phuphania globosa*, *Megaustenia siamensis*, *Hemiplecta distincta*, *Sarika resplendens*, *Amphidromus (Amphidromus) givenchyi* and *Pseudobuliminus (Giardia) siamensis* were found in the three forest types represented in the dry dipterocarp forest, mixed deciduous forest and dry evergreen forest. Four species were found both in dry dipterocarp forest and mixed deciduous forest; *Amphidromus (Syndromus) zebrinus*, *Thaitropis* sp., *Semperula* sp. and *Achatina (Lissachatina) fulica*. Three species were recorded both in mixed deciduous forest and dry evergreen forest *Cyclophorus* sp., *Prosopeas* sp., and *Hemiplecta danae*. Three species *Chloritis (Trichochloritis) tenella*, *Ganesella (Ganesella) capitium* and *Trochomorpha* sp. occurred only in dry dipterocarp forest. Seven species; *Pupina* sp., *A. (A.) schomburgki dextrochlorus*, *Vitrinopsis* sp., *Parmarion martensi*, *Durgella* sp., *Cryptozona siamensis* and *Oxychilus* sp. were found only in mixed deciduous forest.

Twenty-six land snail species were recorded in one hundred and eighty replicated plots (100 x 100 m) during the study. Mean number of species and mean land snails abundance were 5.59±2.78 species and 76.57±33.60 specimens per plot, respectively. The highest land snail diversity was recorded in mixed deciduous forest (1.6566), the second was in dry evergreen forest (1.5600) and the lowest was in dry dipterocarp forest (1.3838). The abundance was highest in dry evergreen forest (81±30), intermediate abundance was in mixed deciduous forest (91±41) and the lowest was in dry dipterocarp forest (61±17). The similarity index among three forest types was slightly different. The index of dominance in three forest types was low. It indicates that there is no dominant snail species in three forest types. The total number of species per plot was significantly highest on mixed deciduous forest, (7.05±3.34) and the lowest in dry dipterocarp forest (4.75±1.83). Most snails which have flat shell (h/d ratio < 1) predominate in the ground dweller habitats, only *Prosopeas* sp. has tall-spired shells. Most snail possessions high spire shells live in tree dweller habitats. There was positive correlation between shell shape and habitat height of land snails on the Phu Phan mountain range ($R^2 = 0.5817$; $P < 0.05$).

Field of study Biological Science Student's signature C. Tumpeesuwan

Academic year 2007 Advisor's signature

Co-advisor's signature Art-ong Pradat

Acknowledgments

I wish to express my sincere gratitude to my thesis advisor, Associate Professor Dr. Somsak Panha, for his invaluable suggestion, guidance, patience, and for providing funds throughout the study. My grateful thanks is to my thesis co-advisor Dr. Art-ong Pradatsundarasar for his kind suggestions in several aspects of ecology, valuable advice, comment and reading manuscript.

My grateful thanks to Assistant Professor Dr. Kumthorn Thirakhupt, Chairman of thesis committee for his precious advice and thank to Dr. Fred Naggs for his advice and reading manuscript. I would like to express my appreciation to Associate Professor Dr. Sompoad Srikosamatara for his kind suggestions. I also would like to thank Associate Professor Dr. Thaweesakdi Boonkerd for his advice and suggestion and to Dr. Piyoros Tongkerd for her suggestions.

Very special thanks to my husband, Mr. Sakboworn Tumpeesuwan for his encouragement, help, etc. during the period of my works. I would like to thank Mr. Pongchai Dumrongrojwatthana for his helping with GIS technique, to The Royal Forest Department for forest data, to Dr. Sombat Yumuang and GISThai for Topographic map from GIS data. I am indebted to Dr. Peter Mordan at the Natural History Museum, London for kindly permitting us to study type specimens. I would like to thank Miss Lour at the Raffle Museum of Singapore for kindly facilitate the study of type specimens. I thank Dr. Chirasak Sutcharit, Dr. Piyoros Tongkerd, Dr. Bangon Kongim, Dr. Pongpun Prasankok, and Mr. Wachira Srikoom for their helping hands.

I am indebted to the grant from Mahasarakham University for financial support during my study in Chulalongkorn University. I am indebted to the TRF/ BIOTEC Special Program for Biodiversity Research and Training grant BRT T_348013. I would like to dedicate my thesis to my father, my mother and everyone in Worachak family. Finally, I would like to express my deepest gratitude to all my teachers for their guidance and training that leading me towards this success.

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Abbreviations	Terminology
Museums	
NHM	The Natural History Museum, London
ZRC	The Zoological Reference Collection of the Raffles Museum of Biodiversity in Singapore.
CUMZ	Zoological collection of the Natural History Museum, Chulalongkorn University
Radula	
B	Base
CR	Crown
EN	Endocone
EC	Ectocone
Genital system	
ag	albumen gland
am	amatorial organ
amg	amatorial organ gland
bw	body wall
ep	epiphallus
fo	free oviduct
gs	gametolytic sac
gd	gametolytic duct
hd	hermaphroditic duct
p	penis
pg	prostate gland
pr	penial retractor
v	vas deference
va	vagina
u	uterus

CHAPTER I

INTRODUCTION

Land snails belong to the Phylum Mollusca, a large and very diverse group of animals of world-wide distribution. The Phylum Mollusca are peculiar and fascinating animals, and in number of species rank second only to the arthropods (which include the multitudinous insect). The great majority of mollusks, more than 80%, are gastropods, which are unique in having the upper half of their body twisted 180° in relation to the bottom half, and in having a helically coiled shell into which to retreat in time of danger, or during unfavorable ambient conditions (Panha and Burch, 2005). Land snails and slug groups made at least seven independent invasions of the land; comprising some 30,000-35,000 species, they represent one of the more diverse terrestrial groups (Solem, 1984). They have become models for studies on the mechanisms of evolution, and have proved particularly valuable in examining the effect of ecology on evolutionary change. Their often low vagility also makes them suitable as indicators for biogeographical studies of early tectonic events (Solem, 1984). Land snails and slugs are found almost everywhere such as ground, litter, trees, and thrive in habitats offering shelter, adequate moisture, and an abundant food supply. Land snails can be used as biodiversity indicators, at least in those habitats in which there is a sufficient number of species (Burch, 1955, 1956, 1957, 1962; Mason, 1970; Cameron, 1973; Getz, 1974; Coney *et al.*, 1982; Getz and George, 1994; Tattersfield, 1996; Winter and Gittenberger, 1998; Gary and Pauline, 1999; Cameron *et al.*, 2000, Cameron *et al.*, 2003; Schilthuizen and Rutjes, 2001; Tattersfield *et al.*, 2001; Schilthuizen *et al.*, 2003).

The first publication specifically on the land snails of Thailand was by Haines (1856), who described and figured four species of land snails new to science. Louis Pfeiffer (1856) described, without figures, two more species of land snails from Siam. In 1862 the same author described and figured nine new species of land snails from Siam. In 1867 Martens included 17 species of Thai terrestrial snails in his large report on the mollusk collected by the Royal Prussian Expedition to East Asia. Möllendorf (1894) described land snails from the collection of Mr. Roebelen collected from Samui Islands, in Gulf of Thailand. The same author in 1902 described 15 species from Siam. The malacofauna reported and published since then such as Blanford (1902, 1903), Tomlin (1929, 1931, 1932, 1952), Bartsch (1932). Martens (1867) listed 26 species of non-marine mollusks from Thailand in the collection of the British Museum (London). In 1966, Solem investigated 156 species of non-marine mollusc from Thailand, mostly snails collected by Mrs. Birgit Degerbol Hansen from north Thailand near Doi Sutep and Doi Chieng Dao, also included were several sets from southeast and southwest Thailand collected by Palle Johsen, 54 land snails species were classified and identified. The checklist on Thai pulmonate snails by Panha (1996) provided an initial important checklist of 15 families 59 genera and 136 species from throughout Thailand, however the cited papers and species list to provide less in northeastern areas.

Recently the alpha taxonomy and systematic studies of land snails have been extended and focusing such as Tongkerd *et al.*, (2004) studied Thai gastrocoptine micro land snails, they test the phylogenetic utility of these characters by constructing a molecular phylogeny, base on nuclear (28S rDNA) and mitochondrial (16S rDNA) ribosomal gene fragments,

for a cross-section of Thaigastrocoptine diversity (15 species). Sutcharit and Panha (2006) carried out a taxonomic review of the tree snail *Amphidromus* Albers, 1850 in Thailand and adjacent areas. They investigated external morphology and radula, genital system and constructed a molecular phylogeny based on partial 16S rDNA sequences. Kongim *et al.*, (2006) studied karyotypes of ten species of operculate land snails of the genus *Cyclophorus* (Prosobranchia: Cyclophoridae) in Thailand. Prasankok *et al*., (2007) studied allozyme variation in two camaenid tree snails *Amphidromus atricallosus* Gould, 1843 and *A. inversus* (Muller, 1774).

Previous investigators on Thailand snail faunas reported mainly on systematic and taxonomy. However, investigation of snail biology particularly their ecology, is almost unknown in addition some geographic areas such as sandstone mountain, the dominant terrain of the northeastern region, have been particularly neglected.

The Phu Phan mountain range is a major topographic feature and the source of many important rivers such as the Song Kram, Pung, Yam and Uun. The hill is located in the upper northeast region of Thailand and separates the Sakon Nakhon Basin to the north from the Khorat Basin in the south. The mountain range begins at Sakon Nakhon Province, passing through Udon Thani, Kalasin, Mukdaharn and terminates near the Mekong River in Nakhon Phanom Province. This area occupies the plateau and ridge of a tabletop mountain covered by natural forest, the range is dominated by three forest types, dry dipterocarp forest, dry evergreen forest and mixed deciduous forest (Ngamcharoen, 1997; Chantharanothai *et al*., 2001), which provide various types of habitat for snails collecting.

In the present study, we investigated on species diversity, distribution patterns and habitat relationships of land snails on the Phu Phan mountain range. Shell morphology, genital system and radula characteristics were used to confirm snail identifications. We compared abundance, species composition, species diversity index, index of dominance, including similarity index, among the three forest habitat types. Snail distribution patterns in three forest types were analyzed using integrated techniques including field surveys and a Geographical Information System (GIS), the relationships between shell shape (h/d ratios) and vertical distribution were studied.

Objectives

1. To investigated species diversity, distribution patterns and habitat relationships of land snails on the Phu Phan mountain range.
2. To compare abundance, species composition, species diversity index, index of dominance and similarity index among dry dipterocarp forest, mixed deciduous forest and dry evergreen forest.

Anticipated

This result of this study would be of benefit to biodiversity conservation and management in northeastern Thailand.

CHAPTER II

LITERATURE REVIEW

2.1 Taxonomic study of land snails.

Early studies of land snails from Thailand taxonomic descriptions the largely neglected the northeastern of the country. For example *Buliminus siamensis* (Helicidae) Redfield (1853). Haines (1856) described and figured four species *Cyclostoma housei, C. myersii, C. disturnum* and *Vitrina siamensis*, from the north of Thailand. Louis Pfeiffer (1856) described, without figures, two more species of land snails from Thailand. In 1862, the same author described and figured as new to science nine species of land snails from Siam, which including *Helix crossei, H. goniochila, H. ptychostyla, H. breviseta, H. tenella, Streptaxis siamensis, Bulimus crossei, Hydrocena (Omphalotropis) fulvida* and *Rhiostoma bernardii.* Martens (1867) included 17 species of Thai terrestrial snails in his large report on the mollusk collected by the Royal Prussian Expedition to East Asia, which including two species of land snails i. e. *Vaginulus siamensis* and *Nanina resplendens*. In 1894, Möllendorf described and figured 32 species of land snails from the collection of Mr. Roebelen collected from the Samui Islands, Gulf of Thailand, such as *Ariophanta weinkauffiana inflate* and *Pupina artata*. In 1902 Möllendorf described 15 species from Siam; *Streptaxis siamensis, Macrochlamys ochtogyra, M. hepagyra, M. brunnea, Durgella siamensis, Xestina granulosa, Chloritis siamensis, Amphidromus kobelti, A. glaucolarynx albicans, Plectotropis diplogramme, Lagochilus pachychilus, L. concavospirum, Cyclotus (Siphonocyclotus) conoideus, Wattebledia siamensis* and *Pupina (Tylotoechus) siamensis*, the snails were described from Hinlap, Muolek and Bangkok. Blandford (1902)

described and figures of two species of land snails from Pitsanulok Province which including *Rhiostoma dalyi* and *Sesara megalodon*, which were collected by Mr. W. M. Daly. In 1903 the same author reported and identified 41 non-marine molluscs from the collection of Mr. W. M. Daly, which were collected from Lamphun and Phitsanulok Province, north of Thailand. Tomlin (1929) reported 12 species of land shells from Kaw Tao, Thailand i.e. *Discartemon roebeleni*, *Sarika kawtaoensis*, *S. dugasti*, *S. limbata*, *Sitala insularis*, *Euplecta bijuga*, *Ariophanta weinkauffiana inflate*, *Leptopoma perakensis*, *L. vitreum*, *Cyclophorus haughtoni*, *Opisthoporus setosus* and *Opeas gracilis*. The same author (1932) reported two species of land shells from a cave at Buang Bep, Surat Thani, Peninsular Siam, which collected by Dr. A. F. G. Kerr, *Sarika resplendens* and *Cyclophorus expansus*. Suvatti (1938) summarized previously published papers in a Thai- English check-list. Hass (1952) reported six species of land snails from Northwest and Southwest of Siam, while mainly devoted to collecting mammals, the Rush Watkins Zoological Expedition to Siam in 1949 gathered, a series of mollusks, *Hemiplecta siamensis*, *H. neptunus*, *Amphidromus (Amphidromus) glaucolarynx*, *Cyclophorus songmaensis*, *C. aurantiacus*, and *C. jourdyi*. Martens (1960) listed the species of non-marine mollusk from Thailand in the collection of the British Museum (London), which include 26 species of land snails. In 1966 Alan Solem investigated 156 species of non-marine mollusc from Thailand, mostly snails collected by Mrs. Birgit Degerbol Hansen from north Thailand near Doi Sutep and Doi Chieng Dao in Chiang Mai Province, north of Thailand, also included were several sets from southeast and southwest Thailand collected by Palle Johsen for the Natural museum, 54 land snails species were classified and identified. As from the checklist on Thai pulmonate snails by Panha (1996) provided an initial important checklist of 15

families 59 genera 136 species throughout Thailand, however the cited papers and species list seem to provide less in northeastern areas. Abbott (1989) published a color guide book “Compendium of Land shells” which included to 14 land snails from Thailand, but lack in the northeastern area, which including similar species of Phu Phan land snails, *Megaustenia siamensis* and related species, *Cyclophorus fulgulatus*. Panha and Thanamitramanee (1997) surveyed and reported nine families, 14 genera and 18 species of land snails in Phliu National Park, Chantaburi Province, and eastern part of Thailand. In the same year Panha described new species of *Macrochlamys asamurai* from Takun village, Surathani Province. Schileyko (2004) described new genus, *Thaitropis goniochila* from Kao Pra Put, Lop Buri Province, instead of the former used genus *Aegista*.

Recently the alpha taxonomy and systematic studies of land snails have been extended and focused on micro-snails of Thailand (Panha and Burch, 2005) studied and reported the micro-snails of Thailand, which they collected the snails from several localities throughout Thailand. Tongkerd *et al.,* (2004) studied Thai gastrocoptine micro land snails, they test the phylogenetic utility of these characters by constructing a molecular phylogeny, base on nuclear (28S rDNA) and mitochondrial (16S rDNA) ribosomal gene fragments, for a cross-section of Thaigastrocoptine diversity (15 species). Sutcharit and Panha (2006) studied taxonomic review of the tree snail *Amphidromus* Albers, 1850 in Thailand and adjacent areas. They used external morphology, radula, genital system and constructing a molecular phylogeny based on partial 16S rDNA sequences. Kongim *et al.,* (2006) studied karyotypes of ten species of operculate land snails of the genus *Cyclophorus* (Prosobranchia: Cyclophoridae) in Thailand, haploid and diploid

chromosome numbers were invariant (*n* = 14, 2n = 28, FN=56), but the karyotypes varied along a continuum with 14 metacentric chromosomes in *C. volvulus* while the remaining species contain unique representatives of every summed combination of metacentric and submetracentric types from 13m + 1sm to 6m +8sm. Prasankok *et al*., (2007) studied allozyme variation in two camaenid tree snails *Amphidromus atricallosus* Gould, 1843 and *A. inversus* (Muller, 1774), across two principal regions of Thailand and from Singapore, plus for *A. inversus*, one site in peninsular Malaysia. Using horizontal starch gel electrophoresis, 13 allozyme loci (11 polymorphic) were screen for *A. atricallosus* and 18 (5 polymorphic) for *A. inversus*. Heterozygosity was higher in *A. atricallosus* than *A. inversus*. Genetic heterogeneity among samples was higher in *A. inversus* than in *A. atricallosus*. Within *A. atricallosus*, populations were more differentiated in southern Thailand than in eastern Thailand. The southern and eastern samples of *A. atricallosus* exhibited fixed allele differences at four loci and great genetic distance, suggestion that theses two samples may actually represent, or else be evolving into, separate species.

Although land snails have been studied throughout Thailand, those of the northeastern area have received less attention and almost in previous studied nothing is known of their ecology. In the present study provided investigation on species diversity, distribution patterns and habitat relationships of land snails on the Phu Phan mountain range. Shell morphology, genital system and radula characteristics were used to confirm snail's identification.

2.2 Ecological study of land snails in various parts of the world.

Molluscs (snails and slugs) comprise the second most diverse animal phyla after arthropoda with an estimated 80,000 species world-wide (Solem, 1984 and Emberton *et al*., 1997). The majority of species are aquatic dwellers (marine and freshwater) with the terrestrial species comprising about 25% of the total fauna (Emberton *et al*., 1997). From biodiversity conservation perspective, the terrestrial species are of regional and global concern, mainly because the majority of species are forest dweller and sensitive to habitat disturbance (Tattersfield *et al.*, 2001). The tropical rainforest of Africa, South and Central America, Southeast Asia and Australia are the most biologically diverse regions in the world. They are well known to great diversity of various groups of organisms (De Winter, 1995). Land snails can be used as biodiversity indicators, at least in those habitats in which there is a sufficient number of species (Solem, 1984). Boycott (1934) observed that distribution was influenced by the life history of given species. The most critical factors influencing the distribution of snails are thought to be the availability of calcium, moisture, food and shelter.

They have many researchers studied and concluded that species diversity is positively correlated with habitat diversity and the interaction of several environmental factors. Boycott (1934) studied land Mollusca relationships to the habitats in which they are found, different species are found in different kinds of places. The normal food consists of decayed remains of the higher plants, fungi, dead leaves, lichens and algae. Shelter is important for land snails such as conditions as secure damp air and provides nooks and crannies into which they can retire to escape drought and cold and lay their eggs. It depends mostly on vegetation and on the topography and texture of the ground. Log and wood on the ground are favorite sites because they provide reservoirs of the dampness

as well as retreats and acceptable food. Karlin (1961) studied ecological relationships between vegetation and the distribution of land snails in Montana, Colorado and New Mexico, this result showed that 99% of the snails were associated with some form of deciduous tree. Getz (1974) investigated species diversity of terrestrial snails in Great Smoky Mountains. There was a positive correlation between snail diversity and the moisture regime and diversity of dominant tree species. There was no correlation between snail diversity and temperature, or shrub and herbaceous vegetation diversity. Coney *et al.*, (1982) investigated ecological study of land snail based on elevation, slope, soil moisture, pH, forest types, rock type and microhabitat. They suggested that microhabitat differences were significantly more important than any other factors and leaf litter microhabitat was the most important factors influencing snail distributions. Cameron (1986) investigated environment and diversities of forest snail faunas from coastal British Columbia. He concluded that characters of the litter and soil, and the associated vegetation appeared to explain most of the variation in diversity and abundance of snails between sites. The site which have mull litter and damper soils have richer snail faunas than site with mor litter and dry soils. Getz and Uetz (1994) investigated species diversity of the larger snails in 12 forest habitat types (six deciduous and six coniferous sites) in Great Smoky Mountain National Park, compared with elevation, soil moisture, herbaceous vegetation diversity, leaf litter diversity, surface cover and leaf litter depth. It was a significant positive correlation between species diversity of snails and tree leaf litter diversity, there was also a positive correlation of species diversity of snails with both moisture and elevation. Tattersfield, 1996 investigated terrestrial snails in indigenous forest and plantation plot in Kakamega forest, the plantations sampled supported fewer species per plot and

lacked several of the small, litter- dwelling species found in the indigenous forest. Gary and Pauline (1999) studied patterns of diversity and habitat relationships in terrestrial mollusc communities of the Pukeamaru ecological District, northeastern New Zealand. Ninety four indigeneous mollusc species were recorded, two species were endemic. Species richness range from two to three indigenous species in dune habitats and fifty nine species in a floristically rich forest. Beta diversity was high and site occupancy per species was low, indicating communities structured by successive replacement of ecological equivalents. Sites differing in vegetation had characteristics species assemblages, indicating a degree of habitat specialization. For canopy tree species, canopy height, floristic diversity, altitude, litter mass, and pH were important determinants of species assemblage. Shell shape distributions were essentially Cainian unimodal, with communities dominated by snail species with subglobose to discoidal shell. Mean and variance of shell size increased with mollusc species richness and floristic diversity at sites. The relationships between floristic diversity at site and richness, diversity, and shell size distributions of the mollusc suggest assemblages structured around niche partitioning among competing species.

The study variation in shell shape and size is made of the distribution of values of shell height and maximum breadth d. In most terrestrial gastropod faunas, plotting h against d gives two separate scatters, the upper one corresponding to high spired shells, the lower to equidimensional to discoidal ones (Cain, 1981). Some pulmonate families are found only in the upper scatter (of tall shells), some only in the lower, but several have a few or many representatives in both, there are strong indications that within fauna families tend to be mutually exclusive within a scatter, each occupying a definite area and combining

with the others to fill up the scatter area (Cain, 1977a). This suggests that ecological explanations might account for the bimodality, with shell shape tied evolutionally to niche characteristics.

Tattersfield *et al.,* (2001) studied land snail faunas of afromontane forest of Mount Kenya, Kenya concentrated in ecology, diversity and distribution patterns. They collected land snails in a total of sixty-four replicate plots along four elevations transects in the east, west, south and north-northwest sides of Mount Kenya. Land snail diversity and species richness declined with increasing elevation, the snail fauna variation appears to be more closely related to rainfall levels, than to altitude, acidic soils tend to have richer and more abundant snail faunas. Lange and Mwinzi (2003) investigated snail diversity, abundance and distribution in three forest type at Arabuko Sokoke, Kenya, this result show that eight species were restricted to one forest type, seventeen species shared among forest types. The highest snail diversity was recorded in mixed forest. Konrad and Michael (2004) studied relationships between land snails assemblage patterns and soil properties in temperate-humid forest ecosystems. They concluded that soil moisture is the strongest determinant of snail density and species richness. In addition habitat characteristics such as vegetation or litter quality can be important for species dominance in addition. Microhabitat such as log, moss and leaf litter may provide snail with specific food requirement. The snail distribution was determined chiefly by food requirements. Fungi are believed to be the favorite food for some snails (Burch, 1956; Newell, 1967; Mason, 1970)

Ecological study of land snails in Southeast Asia

In tropical Southeast Asia, malacological field works have been concentrated mainly on limestone hills, which are a common feature of the region's geology (Tweedie, 1961; Vermeulen, 1993, 1996). Limestone hills have alkaline soils and are rich in calcium; these factors induce an abundance of living land snails, and also retard the breakdown of empty shells in the soil, which make these areas favored spots for shell collectors. Moreover, limestone has a very patchy distribution in large parts of Southeast Asia.

Schilthuizen and Rutjes (2001) surveyed the land snail fauna in a single square kilometer of undisturbed acidic soil tropical rainforest in the Danum Valley Conservation Area, in Sabah, Borneo Malaysia. Five hundred and forty-six individuals belonging to 61 species of at least 14 families were found. They suggested that land snail diversity in Southeast Asian rainforest exhibits high levels of species richness, but very low densities.

Schilthuizen *et al.,* (2003) studied abundance and diversity of land snails on limestone hills and non-limestone habitats in Sabah, Borneo Malaysia. Their study showed that limestone habitats do indeed support higher land snail densities than those of a non-limestone substrate, and abundance was positively correlated with both pH and calcium carbonate. The diversity on limestone areas is not much higher than non-limestone substrate.

Schilthuizen *et al.,* (2005) examined effects of Karst forest degradation on pulmonates and prosobranch land snail communities in Sabah, Borneo Malaysia, they studied paired primary and secondary forest localities on six separate limestone hills. In the most sites, snail

diversities did not differ between disturbed and undisturbed plots and pulmonate snails were significantly more abundant at disturbed localities than prosobranch snails, whereas abundances for both groups were similar at undisturbed sites.

Land snails studied have been investigated in Thailand, Panha, (1994) studied an intensive three years field and laboratory investigation of the biology of Thai edible land snail *Hemiplecta distincta* (Pfeiffer, 1850), the information and the life cycle of this species were studied, near Wanatha village, Pakchong District, Nakhon Ratchasima Province, this area was formerly a deciduous forest and following deforest station. The total of 3,631 living individuals of these snails was colleted throughout the studied period. This species were found most commonly found i.e. on tree trunks, under object (stones, logs, or any other objects) and in leaf litter. Juveniles were always represented abundantly on tree trunks, whereas the majority of individuals under objects and in leaf litter were adults, indicating difference in microhabitat between the two age groups. Newly-hatched individuals were found in the hollows of soil and in leaf litter. Juvenile were almost always found concealed in rolled up leaves, usually above the ground, in the axils of banana or coconut trees. They were always above the ground, and this may be a mechanism to avoid daytime predation by the bandicoot rat. Juvenile were occasionally observed being eaten by the rat. Most adult snails were in leaf litter, with only a few on tree trunks. The same author in 1996 reported a checklist on Thai pulmonate snails, provided initial important collecting information such as 15 families 59 genera 136 species were recorded throughout Thailand but less in northeast areas. Fifteen families indicate varies microhabitats such as ariophantid snails are ground dweller while camaenid snails occupies tree habitats. The pupillid micro-snails are

obligate limestone dweller. The camaenid and ariophantid taxa proved to be especially abundant and diverse.

Sittiprom (2001) investigated and reported species diversity and distribution of land snails in Phu Phan National Park, the area was some part of the Phu Phan mountain range, three species in 3 families (Hericaronidae, Zonitidae, Cyclophoridae) of land snails were reported.

Phu Phan is a range of sandstone hills. The name of the mountain range is derived from the characteristic tabletop shape of its peaks (Phu being the word for mountain in the Isan/Lao language, as opposed to Khao in central and southern Thai and doi in Northern Thai; Phan meaning a kind of pedestal or tray). The area is the source of many big and small important rivers such as Song Kram river, Pung river, Yam river and Uun river. The mountain range is one of the most significant locations. It locates in the upper of the Northeast region of Thailand and separates the Sakon Nakhon Basin to the north from the Khorat Basin to the south. The mountain range begins at Song-Dao District (northwest) in Sakon Nakhon Province, passing through Udon Thani, Kalasin, Mukdaharn and terminates near the Mekong River at Na Kae District in Nakhon Phanom Province (southeast). The mountain range has an average height of only 420 meters, with many parts of the range having small hills, rising out of the plain. Average annual rainfall range from 1200, 1400 and 1600 mm. The mountain range occupies the plateau and ridge of tabletop hills covered by natural forest, (Ngamcharoen, 1997,) the range is dominated by several of three forest types dry dipterocarp forest (DDF), dry evergreen forest (DEF) and mixed deciduous forest (MDF).

The dry diptercocarp forest is a deciduous broad-leaved forest community type occurring on relatively dry sites, and is mainly composed of trees belonging to the Dipterocarpaceae family (Sahunalu and Dhanmanonda, 1995) the dry dipterocarp is dominated by up to four species of dipterocarp trees and tend to be a relatively uniform. The dry evergreen forest is usually referred to as the tropical semi-evergreen rain forest. Tree species in this forest are mainly evergreen, while some shed leaves during the dry season (Bunyavejchewin, 1986). Mixed deciduous forest is a transitional forest type found between dry dipterocarp forest and dry evergreen forest, bamboo is a frequent component of mixed deciduous forest. The mixed deciduous forest is a richer, more diverse forest type, the trees are generally taller and the forest more layered than in dry dipterocarp forest.

Dry dipterocarp forest is the most common and found mostly in the western part of the Phu Phan mountain range, mixed deciduous is the second most common and found mostly in the eastern part, and dry evergreen forest found mostly in the middle part of the mountain range.

Chantharanothai *et al*., (2001) studied plant diversity in Phu Phan National Parks and collected 1,835 specimens. Specimens were classified into 13 families, 23 genera and 40 species of ferns, 2 families, 2 genera and 2 species of gymnosperms, 19 families, 75 genera and 122 species of monocotyledons, and 94 families, 267 genera and 398 species of dicotyledons. Plants communities in 4 sample plots (100x100 m) in dry dipterocarp forest were investigated.

In previous studies the land snails have been identified, described and reported throughout Thailand but the northeastern areas have receive

less attention and ecological studies of snail from the northeastern Thailand are almost unknown. The present study is an investigation on species diversity, distribution patterns and forest habitat relationships of land snails on the Phu Phan mountain range. Species composition, species diversity index, index of dominance, including similarity index among the three forest types, dry dipterocarp forest, mixed deciduous forest and dry evergreen forest are evaluated. Distribution pattern of the snails on the Phu Phan mountain range were analyzed by Geographical Information System (GIS) tools. Shell heights were plotted against shell diameters for analysis of shell shape distribution (Cain, 1977, 1981). Relationships between shell shape (h/d ratios) and vertical distribution of land snails were studied.

CHAPTER III

MATERIALS AND METHODS

3.1 Sampling

3.1.1 Field survey and sampling design

The study was conducted on the Phu Phan mountain range. The mountain range begins at Song-Dao District, Sakon Nakhon Province passing through Udon Thani, Kalasin, Nakon Phanom and Mukdaharn Province. We selected the areas which have an altitude from 300 meters above mean sea level for snail sampling by using a 1:250,000 topographic map. The area was divided into 45 grids, each grid covered an area of approximately 10 x 10 km^2. All snail specimens were collected by random sampling techniques with three stages sampling method adapted from William (1996).

From 1:50,000 topographic map, each of these grid area were divided into one hundred 1x 1 km^2 sites, two of them were chosen randomly for snail collecting. These chosen sites were then divided into one hundred 100x100 m^2 plots and two of them were chosen randomly as sampling units (fig. 3.1). A total of 180 plots were sampled. Elevation of each site was recorded by altimeter and co-ordinates of each locality were recorded by GPS. The three stages sampling methods was used for the study of species composition and distribution patterns of land snails on the Phu Phan mountain range.

3.1.2 Snails sampling

The study was conducted from September 2004 to August 2006. The snails were systemically collected throughout the mountain range in

the 100 x 100 m^2 plots by direct searching from 180 plots, for each plot snail searching was for five person hours. For each plot all snails, slugs, empty shells and shell fragments were collected from different microhabitats including ground surface, soil, leaf litter, tree trunk, shrubs, and herbaceous plants, moss, rocks and rotten logs. Collecting was carried out both in wet (May to October) and dry (November to April) seasons.

For comparison the diversity indices and abundance of land snails in three forest types was determined. These included 20 dry dipterocarp forest plots, 19 mixed deciduous forest plots and 6 dry evergreen forest plots. One plot was randomly selected (100 X 100 m^2) from each of us the grids published in the 1: 250,000 topographic maps. For analysis land snail species composition, Shannon Weiner Index, Index of Dominance and Similarity Index in three forest types. All snails, slugs, empty shells and shell fragments were directly searched for and collected by two persons in one hour. The numbers of species of land snail were listed and each species was counted. Collecting was carried out in the rainy seasons.

Relationship between shell shape and vertical distribution

We collected and recorded the position and measured the distance of vertical location in maters above ground of each living adult snails. Shell height (SH) and shell width (SW) of the snails were measured for study relationships between shell shape (h/d ratios) and vertical distribution (high above ground level).

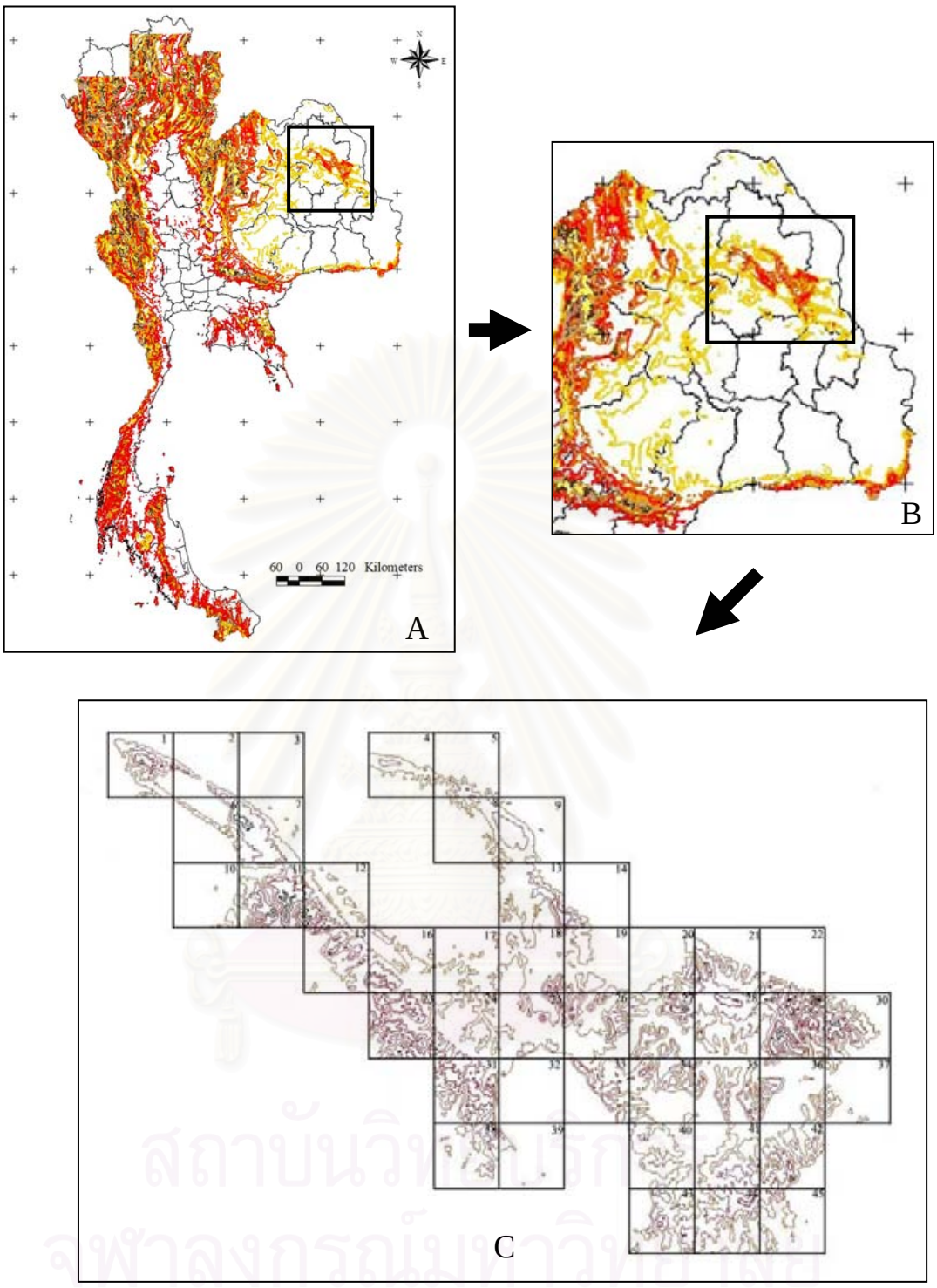

Figure 3.1 Map of the northeastern Thailand indicating the location of the collecting sites. A, Thailand map; B, northeastern Thailand map; C, 45 grids on the Phu Phan mountain range.

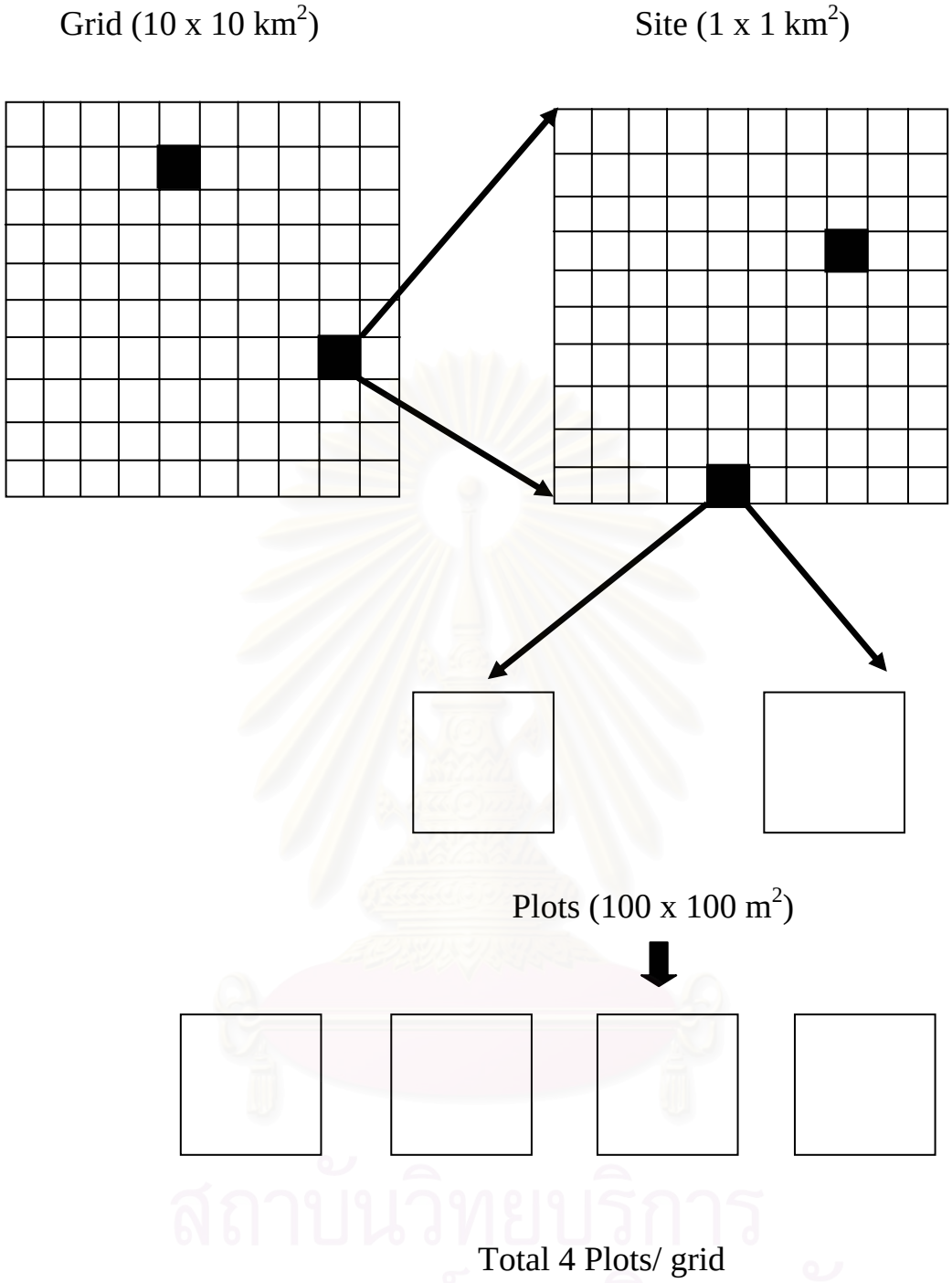

Figure 3.2 Three stages sampling methods.

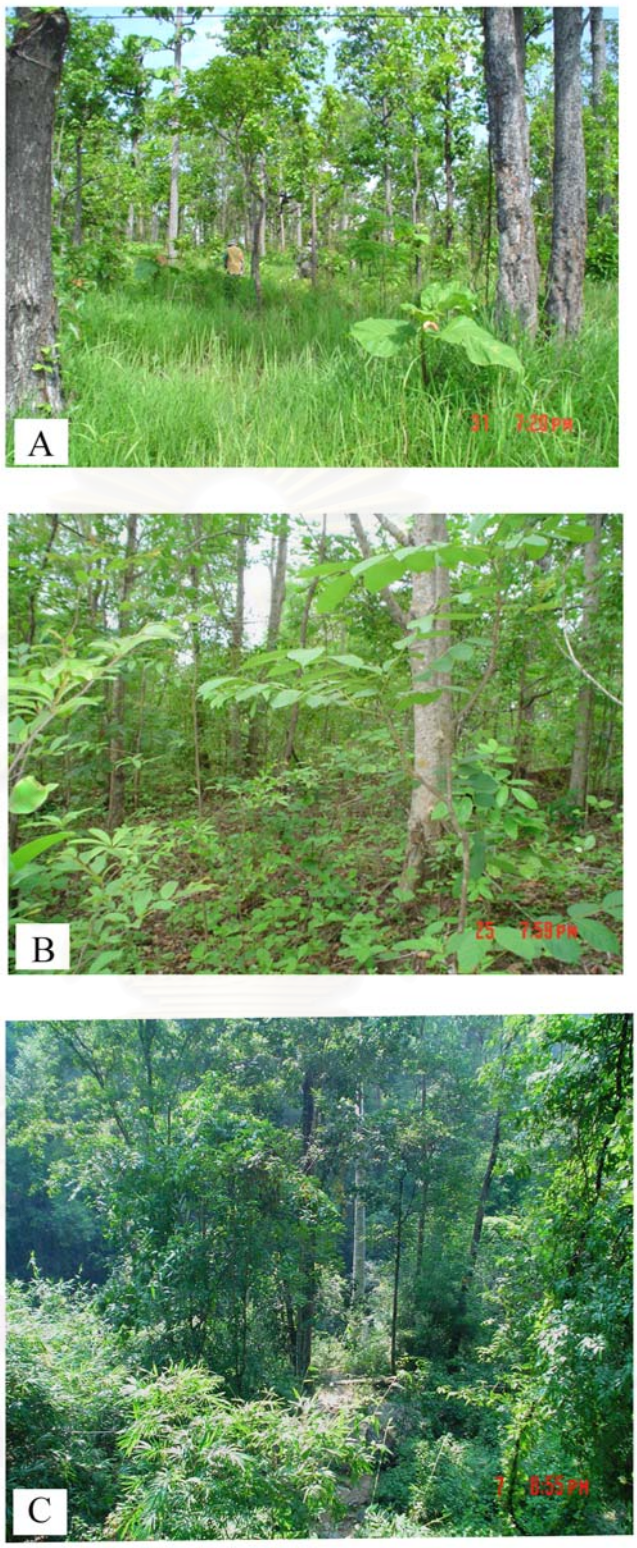

Figure 3.3 Three forest types**;** A, Dry dipterocarp forest; B, Mixed deciduous forest; C, Dry evergreen forest.

Table 3.1 collecting sites for snail species structure in three forest types

grid	forest types	altitude (m)
1	dry dipterocarp forest	375
2	dry dipterocarp forest	355
3	dry dipterocarp forest	325
4	dry dipterocarp forest	468
5	dry dipterocarp forest	350
6	dry dipterocarp forest	470
7	dry dipterocarp forest	435
8	mixed deciduous forest	310
9	dry dipterocarp forest	350
10	dry dipterocarp forest	320
11	dry dipterocarp forest	430
12	dry dipterocarp forest	460
13	mixed deciduous forest	450
14	mixed deciduous forest	350
15	mixed deciduous forest	360
16	dry evergreen forest	320
17	dry evergreen forest	480
18	mixed deciduous forest	380
19	mixed deciduous forest	360
20	mixed deciduous forest	355
21	dry dipterocarp forest	330
22	dry dipterocarp forest	360
23	dry evergreen forest	450
24	dry evergreen forest	430
25	mixed deciduous forest	330
26	mixed deciduous forest	380
27	dry evergreen forest	410
28	mixed deciduous forest	390
29	dry evergreen forest	380
30	dry evergreen forest	380
31	dry evergreen forest	370
32	mixed deciduous forest	340
33	mixed deciduous forest	380
34	dry dipterocarp forest	410
35	mixed deciduous forest	380
36	mixed deciduous forest	360
37	mixed deciduous forest	340
38	mixed deciduous forest	380
39	mixed deciduous forest	360
40	mixed deciduous forest	310
41	dry dipterocarp forest	360
42	mixed deciduous forest	370
43	dry dipterocarp forest	330
44	dry dipterocarp forest	350
45	dry dipterocarp forest	330

3.2 Classification

All collected specimens were classified and identified to species level where possible, by comparison with type specimens from the Natural History Museum, London (BMNH) and Raffle Museum (The National University of Singapore) and using the following literature sources; Gould (1843), Philippi (1846), Benson (1856), Pfeiffer (1850, 1852, 1856, 1860, 1861, 1862), Redfield (1853), Haines (1855), Reeve (1860, 1861), Marten (1867), Stoliczka (1872), Nevill (1881), Bowdich (1882), Morret (1883, 1891, 1889), Cockerell (1891, 1929, 1930), Godwin-Austen (1891, 1897, 1906, 1907, 1919), Smith (1893), Möellendorff (1894, 1902), Kobelt (1902), Blandford (1903, 1908), Sykes (1903), Gude (1921), Gude and Woodward (1921), Laidlaw (1931), Thiele (1931), Hass (1934), Tielecke (1940), Baker (1941), Benthem Jutting (1948, 1950, 1952), Zilch (1956a, b, 1959), Laidlaw and Solem (1961), Laidlaw (1963), Habe (1964), Solem (1959, 1966), Abbott (1989), Staistic (1998), Hemmen and Hemmen (2001), Massen (2002), Schileyko (2003) and Sutcharit and Panha (2006).

Living specimens were suffocated in bottle for 24 hrs and preserved in 70% ethanol. The large size specimens (shell are more than 6-8 cm.) were injected by 70% ethanol to their body cavity. Living specimens and empty shells were labeled to recorded collection number, scientific name locality, collection date, collector, number of specimens and habitats. All specimens were deposited in Zoological collection of the Natural History Museum, Chulalongkorn University (CUMZ: see Appendix I).

3.3 Description

The specimens of each species were investigated as follows.

3.3.1 Shell characters

The best specimens of each species were chosen for photographing, drawing and describing, some important and unique characters of each species were drawn for identification key construction.

Shell morphology of land snails and slugs including shell height (SH) and shell width (SW) were measured in centimeters using vernier caliper to determine the average shell size, these parameters are illustrated in figure 3.4

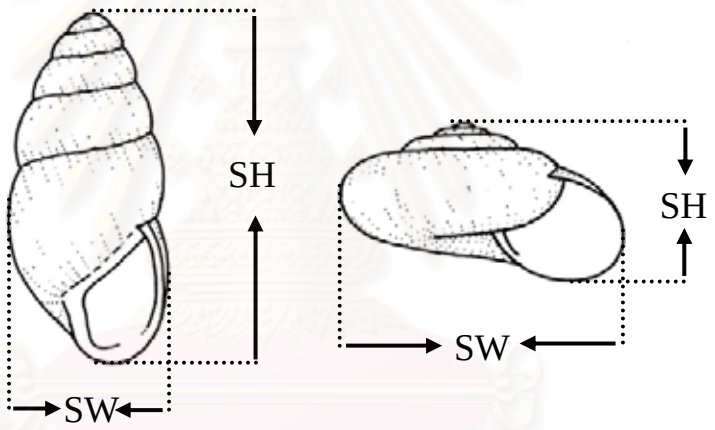

Figure 3.4 Terminology of shell measurement of land snails (after Panha and Burch, 2005)

External morphology of slugs *Laevicaulis* {body length (BL), body width (BW)} were measured as follows body length is measured by anterior to posterior body edge, body width is measured by left to right body edge.

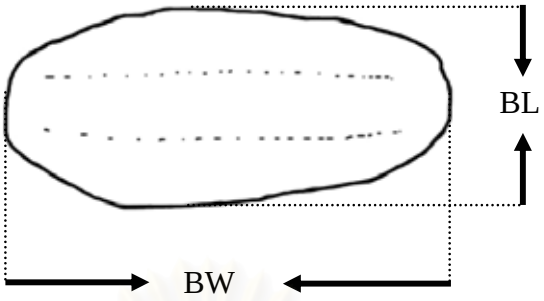

Figure 3.5 Terminology of shell measurement of slug.

Shell terminology used in this study followed Panha and Burch (2005).

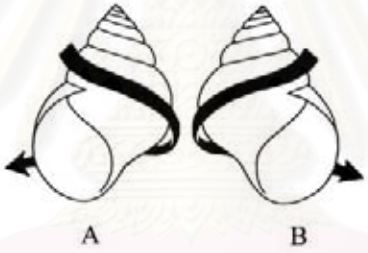

Figure 3.6 Direction of shell coiling. A, shell coil to the left (sinistral); B, shell coil to the right (dextral) (after Panha and Burch, 2005).

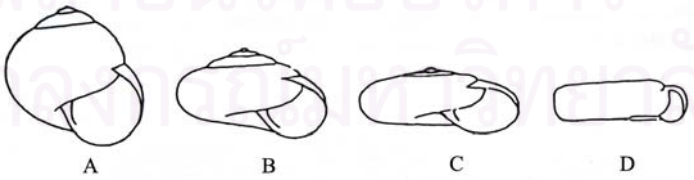

Figure 3.7 Shell terminology. A, globose shell; B, depressed shell; C, strongly depressed shell; D, discoidal shell (After Burch, 1962).

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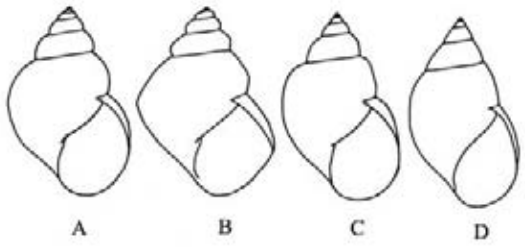


Figure 3.8 Shell whorl terminology. A, shell with well round whorls; B, shell with angular whorls; C; shell with shouldered whorls; D, shell with flattened whorls (after Panha and Burch, 2005).

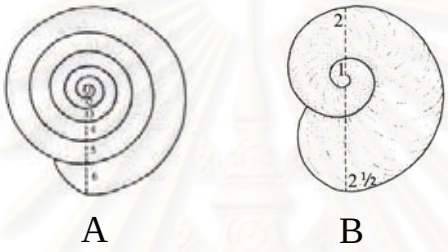


Figure 3.9 A, shell with many, slowly increasing whorls; B, shell with few rapidly increasing whorls. The dotted lines on the whorls illustrate the method of counting whorls (after Panha and Burch, 2005).

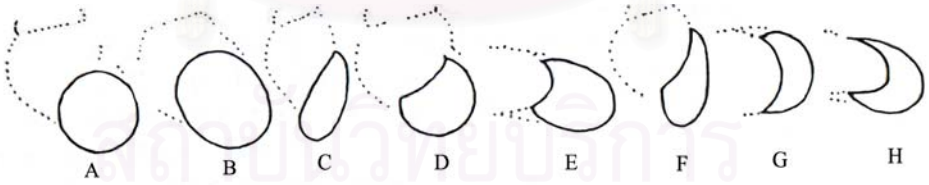
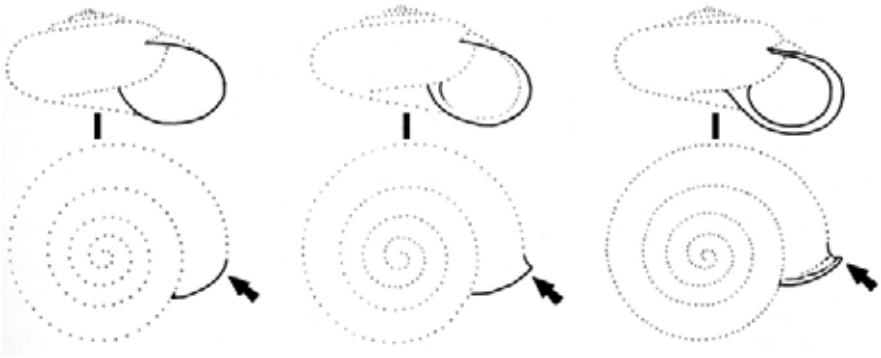


Figure 3.10 Terminology of aperture. A, round aperture; B, oval aperture; C, narrowly oval aperture; D, roundly lunate aperture; E, ovate-lunate aperture; F, narrowly ovate- lunate aperture; G, broadly lunate aperture; H, deeply lunate aperture (After Burch, 1962).



A B C

Figure 3.11 Shell lip characters. A, shell lip neither expanded nor reflected; B, lip expanded; C, lip reflected (after Panha and Burch, 2005).

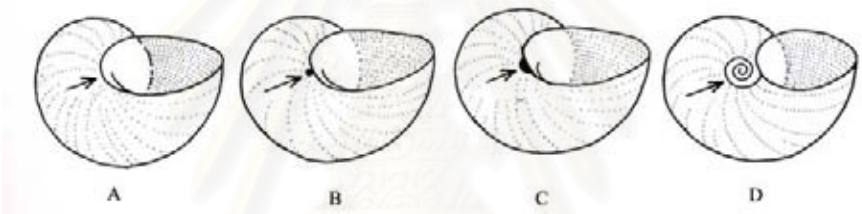


Figure 3.12 Basal shell characters. A, imperforate shell; B, perforate shell; C, rimately perforate shell; D, umbilicated shell (after Panha and Burch, 2005).

3.3.2 Reproductive system

The animals were examined under dissecting microscope for examination of reproductive morphology. Genitalia details were studied and drawn under stereoscopic light microscope with camera lucida. The terminology of reproductive system followed Godwin- Austen (1907) and Solem (1966)

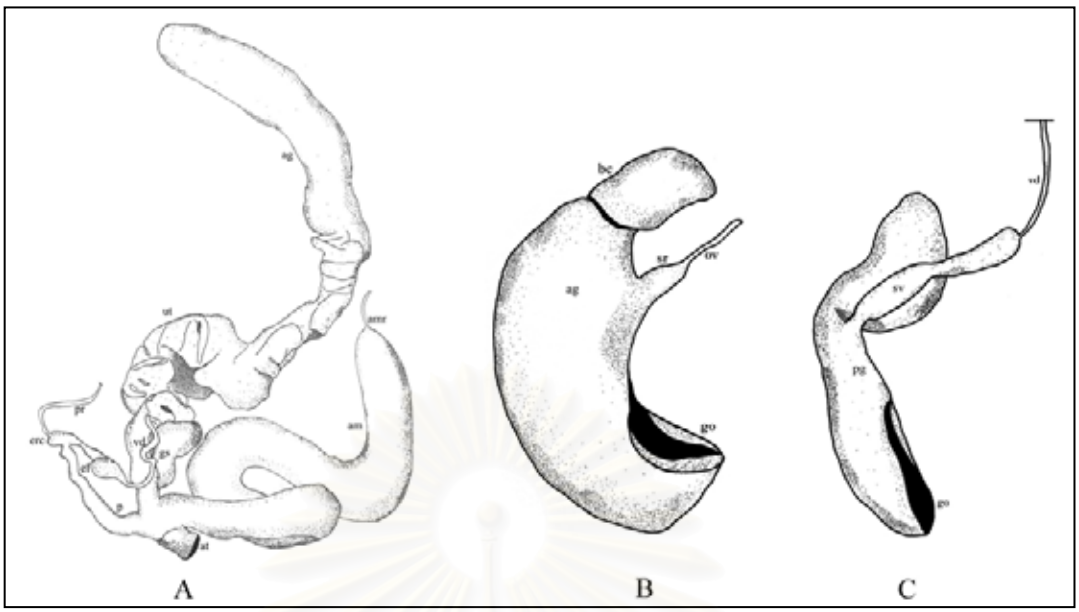


Figure 3.13 Terminology of genital system; A, genital system of Pulmonate snails; B, genital system of land operculate snails

3.3.3 Radula characters

Radulae were removed from buccal masses placed in 10% NaOH in and warmed in a water bath. They were washed in water transferred to 95% ethanol and then examined under Scanning Electron Microscope (SEM).

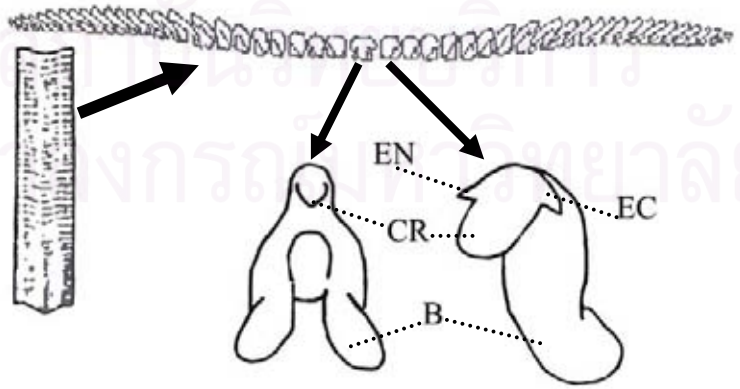


Figure 3.14 Terminology of radula. Above is a single row of radula teeth, below left is radula sheath, and the two rights are central and lateral teeth (B, base; CR, crown; EN, endocone; EC, ectocone).

3.4 Ecological analysis

The number of species (species richness, S), was used as an indicator of the diversity of snails in each forest types, the number of species of snails on the Phu Phan mountain range were recorded.

Distribution patterns

The distribution of land snails in this study was investigated by using Geographical Information System (GIS) program Arcview analytical tools. We Constructed the 45 grid covering the study area and overlaying the grid with a database of ecological data such as their distribution. The data of three forest types from the Royal Forest Department were imported into ArcView GIS 3.3 (ESRI, 1992-1999).

α, γ and β diversity in 45 grids on the Phu Phan mountain range.

To examined differences among taxon groups. From the ratio of the total species to mean number of species per sites, Whittaker's index (Whittaker, 1975) was calculated as an estimate of between site (beta) diversity.

Local diversity or alpha diversity (α diversity) is the number of species in small area of homogeneous habitat.

Regional diversity or gamma diversity (γ diversity) is the total number of species observed in all habitats within geographic area.

α diversity = species per site

γ diversity = species per region

β diversity = gamma per alpha

The greater the difference in species between habitats, the greater is beta diversity.

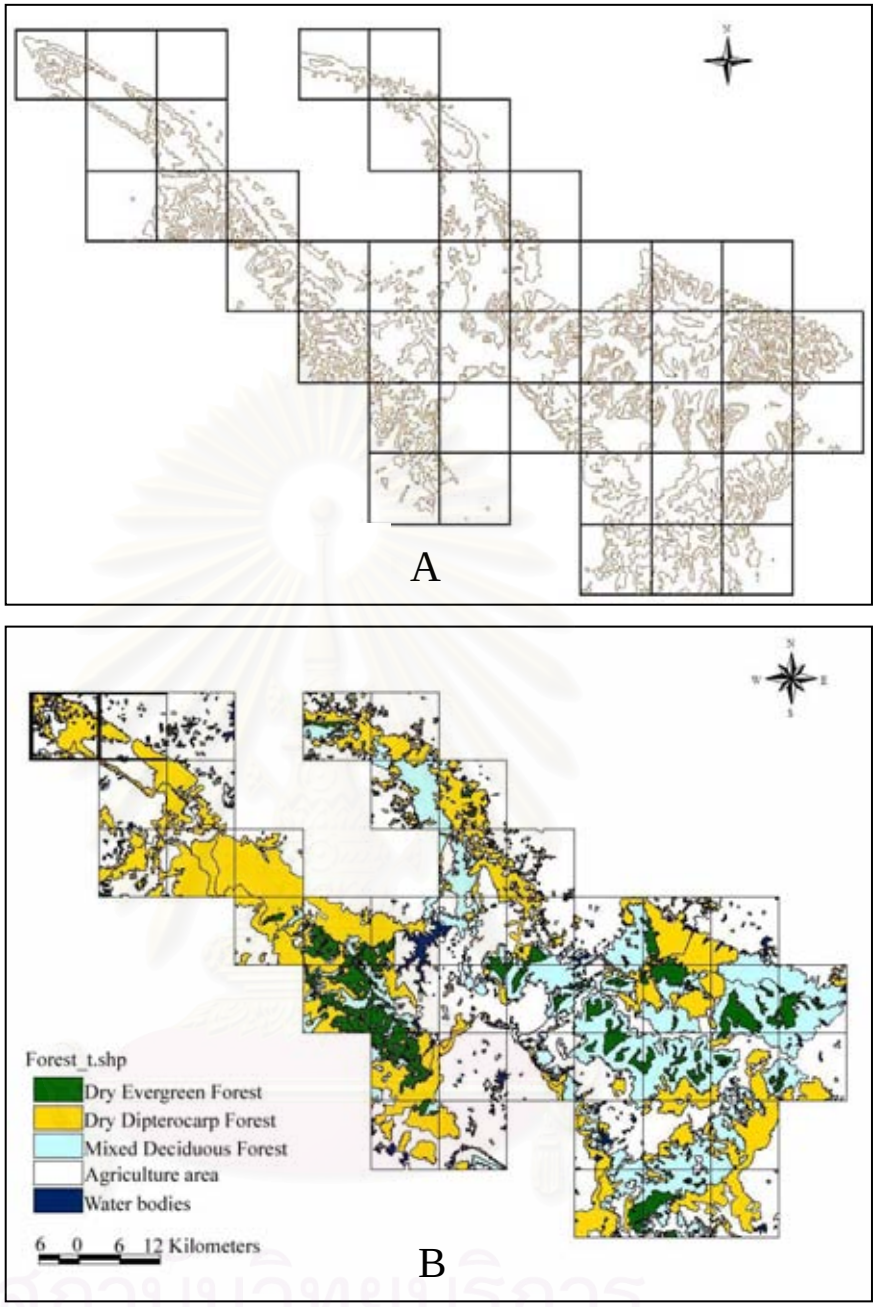


Figure 3.15 Map of the Phu Phan mountain range. A, 45 grids on the Phu Phan mountain range; B, three forest types (dark green: dry evergreen forest; pale green: mixed deciduous forest and yellow: dry dipterocarp forest).

Land snail diversity in three forest types

Land snail species were listed and the total numbers of species present in each forest type were recorded for species composition, species diversity index, index of dominance and similarity index in three forest types, dry dipterocarp forest, mixed deciduous forest and dry evergreen forest.

Shannon Weiner's Index (Krebs, 1999) was used to calculate the species diversity index of the empty shell and living snails in each forest type as follows:

$$H = \sum_{i=1}^{s} (p_i)(\ln p_i)$$

Where H = species diversity index

s = number of species

p_i = proportion of the total sample belonging to i^{th} species

The measurement of dominance species index (Odum, 1971) in each forest type, was calculated using the equation as follows;

$$C = \sum (p_i)^2$$

Where C = Index of dominance

P_i = proportion of the total sample belonging to i^{th} species

To measure the similarity between two community samples, coefficient of Sorensen equation:

$$Ss = \frac{2a}{2a+b+c}$$

Where *Ss* = Sorensen's similarity coefficient

a = number of species in sample A and sample B

b = number of species in sample A

c = number of species in sample A but not in sample B

Variation in shell shape and size of land snails

Measurement of shell height and diameter were made on adult shells. Shell height was plotted against shell diameters for analysis of shell shape distributions of ground snails and tree snails. The upper one corresponding to high-spired shells and the lower one corresponding to equidimensional to discoildal shells (Cain, 1977).

Habitat relationship

Relationship between shell shape (h/d ratios) and vertical distribution (high from ground level or distances in vertical distribution from ground) were analyzed by Regression Analysis using SPSS Program version 13.3.

CHAPTER IV

RESULTS

Two subclasses, 15 families, 22 genera, and 26 species of land snails on the Phu Phan mountain range were collected, classified and identified. The list is shown in Table 4.1. The descriptions of each species are presented below.

Table 4.1 The list of land snails on the Phu Phan mountain range.

Subclasses	Families	Species
Prosobranchia	1. Cyclophoridae	1. *Cyclophorus consociatus*
		2. *Cyclophorus* sp.
		3. *Cyclotus (Siphonocyclotus) hinlapensis*
	2. Pupinidae	4. *Pupina* sp.
Pulmonata	3. Ariophantidae	5. *Hemiplecta distincta*
		6. *Hemiplecta danae*
		7. *Sarika resplendens*
		8. *Cryptozona siamensis*
	4. Helicarionidae	9. *Megaustenia siamensis*
	5. Camaenidae	10. *Amphidromus (Amphidromus) givenchyi*
		11. *Amphidromus (Amphidromus) schomburgki dextrochlorus*
		12. *Amphidromus (Syndromus) zebrinus*
		13. *Ganesella (Ganesella)capitium*
		14. *Chloritis (Trichochloritis) tenella*
	6. Trochomorphidae	15. *Vitrinopsis* sp.
		16. *Trochomorpha* sp.
	7. Durgellidae	17. *Durgella* sp.
	8. Zonitidae	18. *Oxychilus* sp.
	9. Bradybaenidae	19. *Thaitropis* sp.
	10. Subulinidae	20. *Prosopeas* sp.
	11. Veronicellidae	21. *Semperula* sp.
	12. Pamarionidae	22. *Parmarion martensi*
	13. Bulimulidae	23. *Pseudobuliminus (Giardia) siamensis*.
	14. Achatinidae	24. *Achatina (Lissachatina) fulica*
	15. Dyakiidae	25. *Quantula weinkauffiana*
		26. *Phuphania globosa*

Descriptions

Family Cyclophoridae

Genus *Cyclophorus* Montfort, 1810

Type species: *Helix volvulus*

Diagnosis: Shell moderate medium to large (2 to 7 cm width), low conical, generally broadly than high. Peristome continuous, thickened, expanded. Lip mostly reflected. Operculum thin, horny, multispiral with a central nucleus.

Cyclophorus consociatus (Smith, 1893)

(Figures 4.1A, 4.2C, D, 4.3A, 4.4A)

1893 *Cyclophorus consociatus* Smith, 13 p.

Shell 2.0-3.7 cm high and 2.5-4.2 cm wide, dextral, depressed, solid, pale brown to dark brown, with band marking below the periphery, transverse striae, from 5 to 7 slightly shouldered convex whorls, lip reflected, embryonic whorls smooth, periostracum very thin. Operculum rounded, thin, dark brown, multispiral. Umbilicate shell.

Reproductive system

Male: Testis confined entirely within the uppermost part of visceral hump, dull color. Vas deferens runs forward from testis to prostate gland on the columella side of visceral mass, thin, slender, and pale yellowish, it lies parallel to large esophagus. Prostate gland is located on the culumella side of visceral mass, and visible from above of mantle. The shape is fusiform, flattened, pale yellowish, divided in two parts by thickness. The posterior part is ¼ of the length, flattened in quadrangle

shape, pale organ in color, Seminal vesicle slender, long and its pouch enlarge posterior end.

Female: Ovaries are locates on the culumella side of the early whorls. Which they are embedded in the digestive gland. Pale yellowish oviduct, runs forward from ovary to uterus along the columella alongside larger esophagus duct. Seminal receptacle project from posteriors of uterus. Bursa copulatrix is lunate, ¼ of the length of uterus; uterus is lunate, very large, light yellow.

Radula: Taenioglossate radula sheet contain 7 teeth in each row. Central tooth has 4 to 5 cusps. Lateral teeth locate alternately with central tooth, endocone small with sharp cusp, ectocone large. Marginal teeth turn in, have different arrangement into two layers, the inner marginal teeth have 3 cusps, locates the same level of central tooth, the shape similar to crab great chela, small sharp endocone and large sharp inflate ectocone, the outer marginal teeth have 3 cusps, locates at the edge of the ribbon with a little lower position from lateral teeth.

Habitat notes: The snails frequently found under leaf litter and ground surface or forest floor in three forest types including dry dipterocarp forest, dry evergreen forest and mixed deciduous forest.

Distribution on the Phu phan mountain range: The snails were collected from 45 grids throughout the mountain range.

World distribution: South and East Asia, Indo-Australian Archipelago, Philippines, various Pacific Islands, Australia.

Remarks: Shell shape very closed to *C. volvulus* in their shape but it has more high spire and larger than the later species.

***Cyclophorus* sp.**

(Figures 4.1B, 4.2A, B, 4.3B, 4.4B)

Shell: shell is 2.7-2.9 cm high and 3.8-4.0 cm wide, dextral, depressed shell, with about 5 to 6 slightly convex whorls, shell surface with transverse or growth lines or striae, shell lip both expanded and reflected, the color of shell lip is orange, red. The last whorl rounded with keel. Embryonic whorls smooth. Aperture descending in front. Operculum circular, thin, dark brown in color. Umbilicate shell.

Reproductive system

Male: Testis occupies entirely on the uppermost part of visceral hump, dull organ in color. Vas deference runs forward from testis to prostate gland on the columnella side of visceral mass, thin, slender, and pale yellowish color, its lies parallel to large esophagus. Prostate gland locates on the culummella side of visceral mass, and visible from above of mantle. The shape is fusiform, flattened, pale yellowish color, divided in two parts, thickens and long, the posterior part is very large, flattened in quadrangle shape, pale organ in color, seminal vesicle slender, very long stalk, short pouch and enlarge at posterior part before connect vas deferens.

Female: Ovaries are locates on the culummella side of the early whorls. It's embedded in the digestive gland. Oviduct is pale yellowish color, runs forward from ovary to uterus along the columnella side with nearby the greater duct of esophagus. Seminal receptacle is project from posterior of uterus, small and slender. Bursa copulatrix is lunate shape, ¼

of the length of albumen gland size. Albumen gland most thickens in lunate shape, no labial at anterior end. Uterus is lunate shape, very large, light yellow in color.

Radula: Taenioglossate radula sheet contain 7 teeth in each row. Central tooth is triangular shape, lateral teeth locates alternately with central tooth, endocone small with sharp cusp, ectocone large. Marginal teeth turn in, have different arrangement into two layers, the inner marginal teeth have 3 cusps, locates the same level of central tooth, the shape similar to crab great chela, small sharp endocone and large sharp inflate ectocone, the outer marginal teeth have 3 cusps, locates at the edge of the ribbon with a little lower position from lateral teeth.

Habitat notes: The snails were found under leaf litter beside the small canal and stream in dry evergreen forest.

Distribution on the Phu phan mountain range: The snails were collected from 3 grids in the middle parts of the mountain range.

Remarks: It closed to *C. borneensis* (Metcalfe, 1851) and *C. orthostylus* (Möllendorff, 1898) in having a sharp keel surrounds the body whorl on its periphery. But *Cyclophorus* sp. different from the two species by having a large shell, stronger peripheral keel, red-orange color of aperture and the shape of aperture.

***Cyclotus (Siphonocyclotus) hinlapensis* Zilch, 1956**

(Figures 4.1C, 4.5A)

1956 *Cyclotus (Siphonocyclotus) hinlapensis* Zilch

Shell: Shell is 0.8-1.1 cm high and 1.4-1.6 cm wide, dextral, almost entirely flat, spire hardly projecting and last whorl only descending very little. Plain grayish- dark, somewhat glossy, not transparent, finely striated. Epidermis fibrous, grey-dark, deciduous. With about 4-5 whorls, coiled in an almost flat spiral. Periphery round. Last whorl somewhat descending toward the aperture. Suture deep. Umbilicus very wide. Aperture oblique, round, peristome continuous, somewhat thickened and expanded. Operculum round, calcified, multispiral with a central nucleus.

Habitat notes: The snails were found under leaf litter, undergrowth vegetation and dead leave in dry dipterocarp forest, dry evergreen forest and mixed deciduous forest. In this study we found only juvenile snails, so the detail of reproductive anatomy and radula were not studied.

Distribution on the Phu phan mountain range: The snails were collected from 11 grids through the mountain range.

World distribution: South Asia, Malay Archipelago, Philippines, New Guinea, various Pacific Islands.

Family Pupinidae

Genus *Pupina* Vignard, 1829

Diagnosis: Shell pupaeform, ovoid-cylindrical, glassy or porcellaneous, polished. Pristome simple, somewhat thickened, little expanded. With two canals, one at the upper angle close to the suture, and one in the middle or at the base of the columella. Operculum thin, horny, multispiral with a central nucleus.

***Pupina* sp.**

(Figures 4.1D, 4.3C, 4.5B)

Shell: Shell very small, dextral, whorls 5 increasing in size regularly, rounded, suture well impressed. Based rounded, umbilicus closed. In the umbilical region the shell exhibits a shallow concavity just behind the peristome. Aperture round, almost vertical. On the parietal wall there is a well-developed tooth, which in vertical direction, reaches about 1/3 way the last whorl to penultimate one. Canal between parietal tooth narrow and peristome relatively narrow. Opposite the parietal tooth the peristome bears a small tooth-like elevation or small palatal tooth. Peristome relative thickened, not continuous. The columellar side interrupted by a short canal in horizontal direction, at some distance from the base. The columellar lamella short not covered the columellar canal.

Radula: Taenioglossate radula sheet contain 7 teeth in each row. One central tooth, 2 laterals teeth and 4 marginal teeth. Central tooth is tricuspid, 3 cusps, the central cusp is larger than other cusps. Lateral teeth have 4 cusps, the third is largest. Marginal teeth turn in, the first and the second marginal teeth have 4 cusps.

Habitat notes: The 5 dead shells and 9 living specimens were found in accumulated litter, soil and rock debris under the shade of mixed deciduous forest. The habitat is near ephemeral stream, foot hill.

Distribution on the Phu phan mountain range: The snails were collected from 1 grid in the western part of the mountain range.

World distribution: Japan, South China, Malay Penninsula, Malay Archipelago, Philippines, New Guinea, various Pacific Islands, Australia.

Remarks: It closed to *P. artata* and *P. limitanea* in having a small shell, but this species different from the two species by having a columnellar and parietal canal open. The parietal lamella very narrow, the pointed end formed parietal tooth, the rest of parietal lamella formed vertical ridge, reaches about 1/3 way the last whorl to penultimal whorl, the ridge and peristome is convex inside. This species is may be new to science.

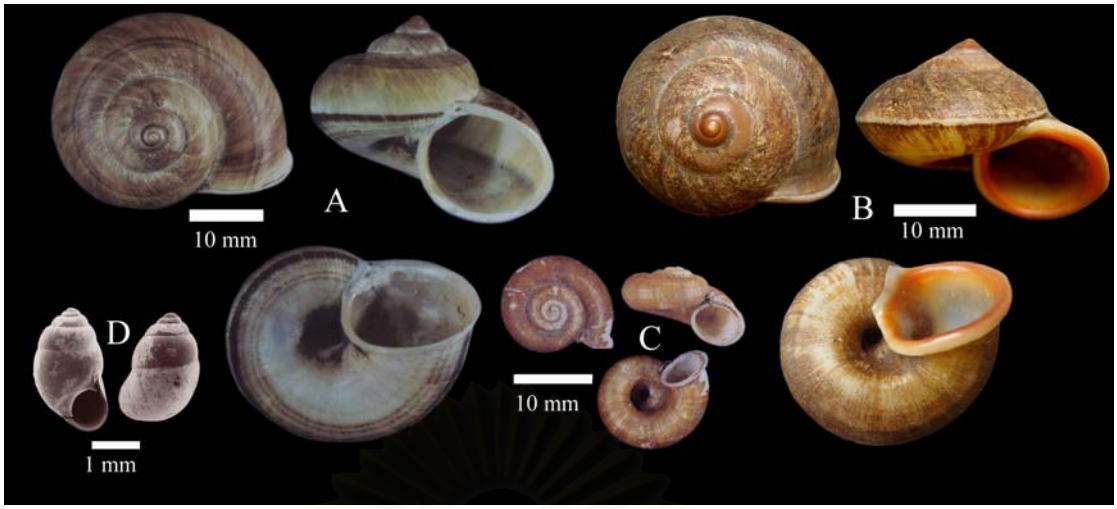


Figure 4.1 Shell shape of land operculate snails; A, *C. consociatus*; B, *Cyclophorus* sp.; C, *C. (S.) hinlapensis*; D, *Pupina* sp.

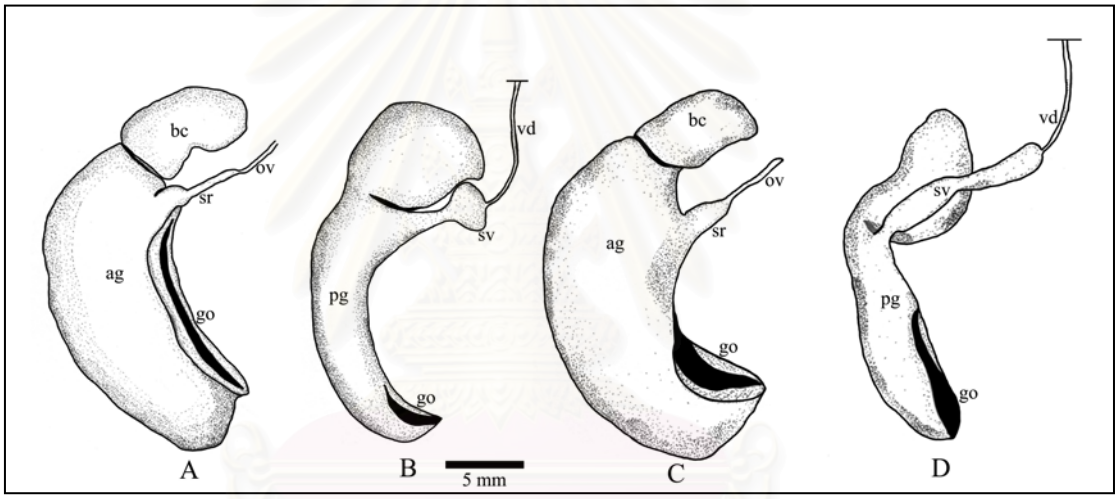


Figure 4.2 Genital system of *Cyclophorus*; A, female organ; B, male organ of *Cyclophorus* sp.; C, female organ; D, male organ of *C. consociatus*.

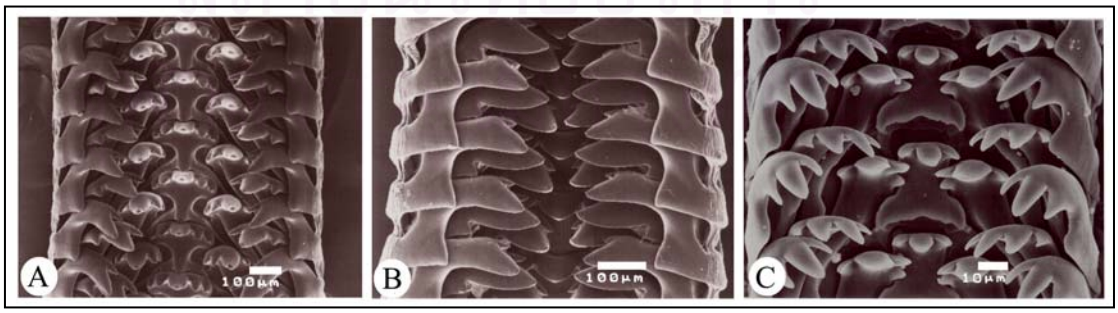


Figure 4.3 Radula of *Cyclophorus*; A, *C. consociatus*; B, *Cyclophorus* sp. and C, radula of *Pupina* sp.

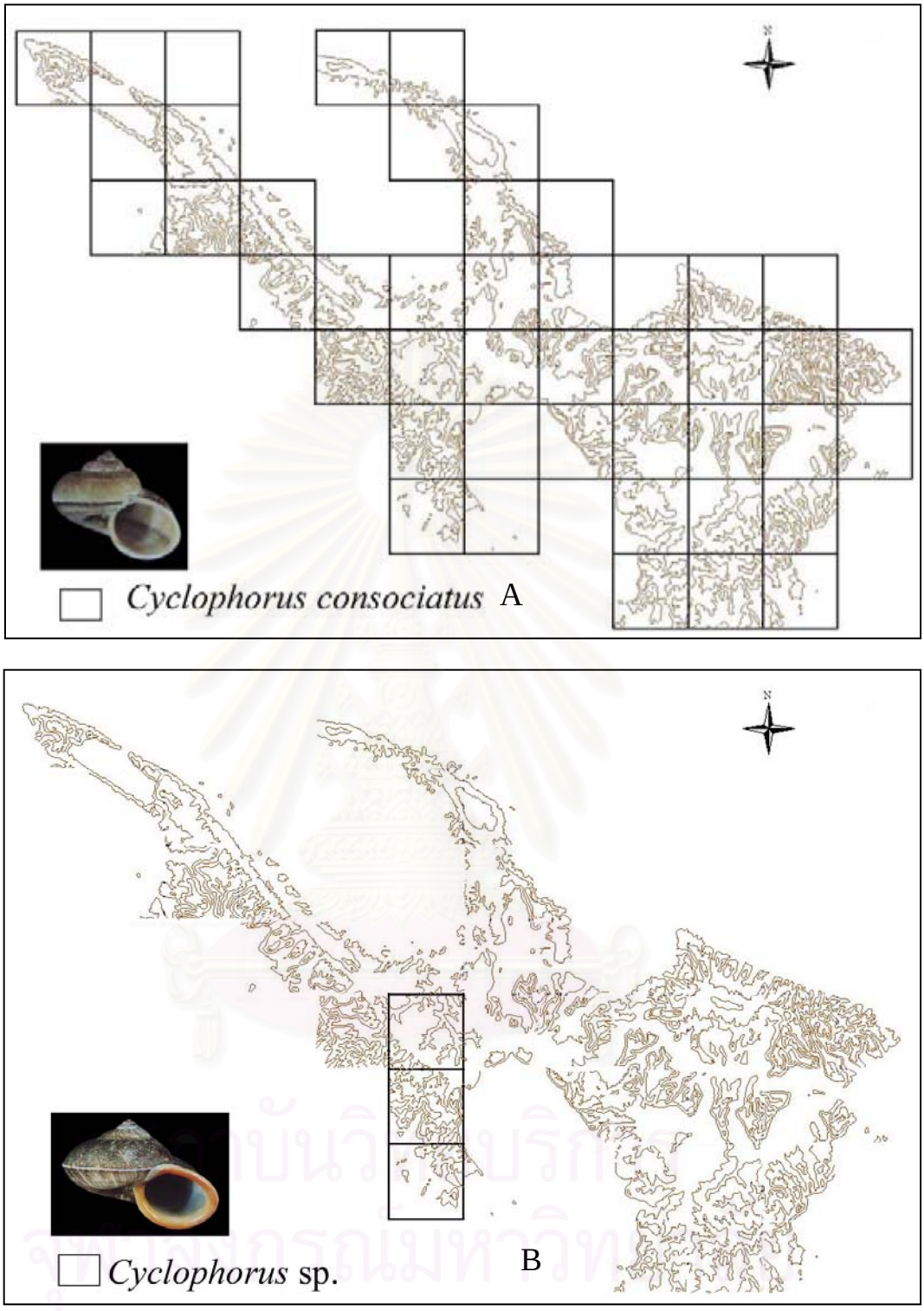


Figure 4.4 Distribution patterns of land operculate snails on the Phu Phan mountain range. A, *C. consociatus*; B, *Cyclophorus* sp.

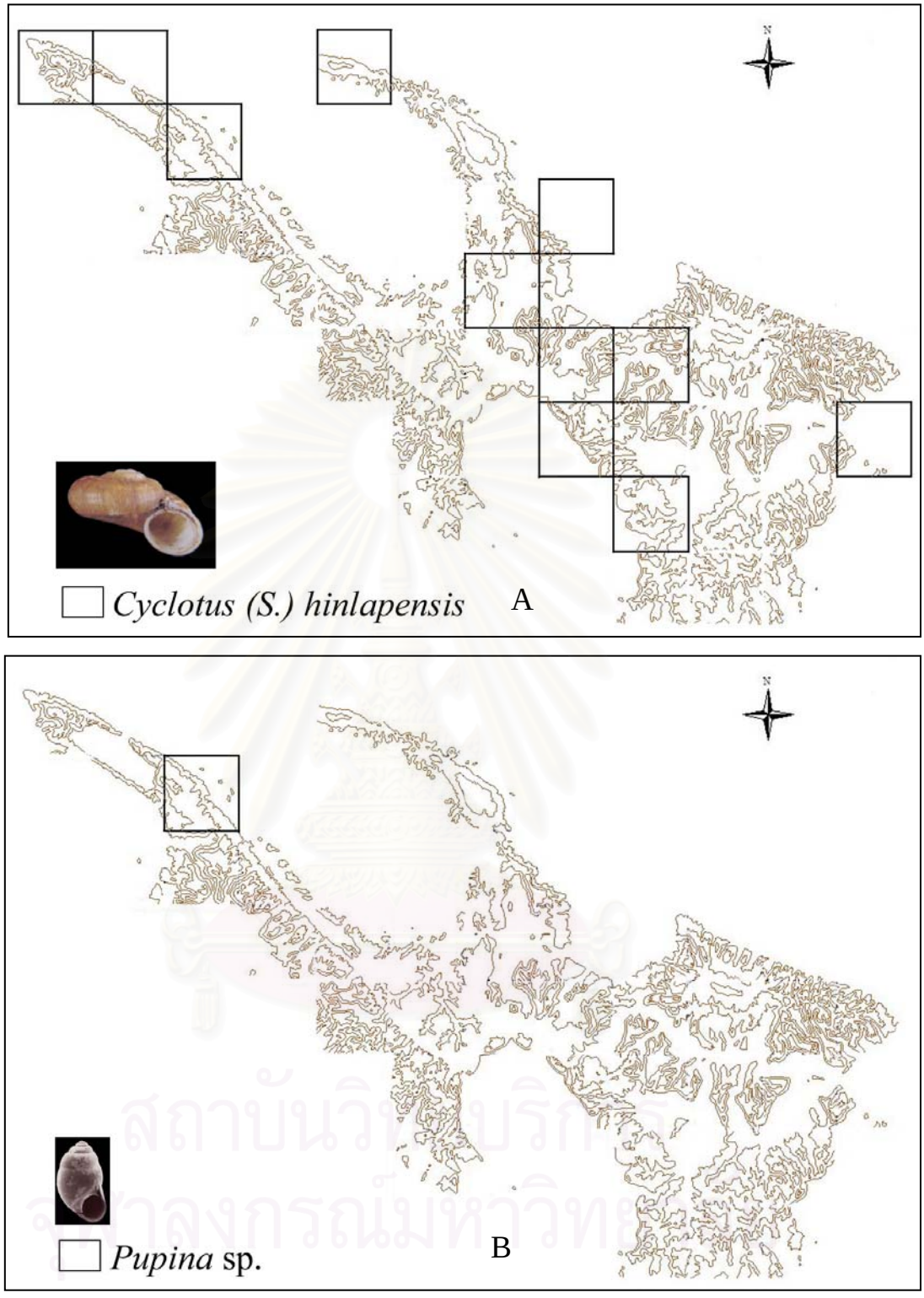


Figure 4.5 Distribution patterns of land operculate snails on the Phu Phan mountain range. A, *Cyclotus (S.) hinlapensis*; B, *Pupina* sp.

Family Camaenidae

Amphidromus (Amphidromus) givenchyi Geret, 1912

(Figures 4.6A, 4.7A, 4.8I, 4.9A)

1912 *Amphidromus (Amphidromus) givenchyi* Geret. 55-56, pl. 2, figs 21-22.

Shell: Shell is 3.7-4.9 cm high and 2.2-2.9 cm wide, dextral, relative large, ovate-conic, solid, umbilicus imperforate or rimate, spire conic, suture wide and slightly flattened. Last whorl relatively large and rounded-ovate. Shell surface glossy, with smooth or minute and continuous greenish radial streaks, most distinct on last whorl. A narrow dark green subsutural band present and fades to yellowish or disappears in upper whorls. Apex acute, tiny black apex present in some specimens. Aperture truncated and oblique, periostome thickened, expanded, reflected. Colummella white, straight.

Reproductive system: Vas deferens thin and enters from free oviduct to distal epiphallus. Penial retractor muscle long, insert proximally near penis. Penis long, slender. Epiphallus relative short, curved. Flagellum small, equal in length to epiphallus; proximal to appendix it is enlarged and coiled. Appendix slender, short. Vagina slender, cylindrical. Gametoytic duct long; proximal to vagina it is wide and distally tapers abruptly to small tube that connects to enlarge gametolytic sac. Free oviduct short, oviduct small. Albumen gland curved.

Radula: Central tooth unicuspid, broadly gouge or spatulate shaped, lateral teeth bicuspid, endocone relatively small with sharp cusp, ectocone large, broad and rounded with posterior cusp. Inner marginal

teeth asymmetric tricuspid, endocone medium size with wide notch, mesocone large with curved posterior margin, and ectocone minute with sharp cusp. Outermost marginal teeth tricuspid with wide and deep endocone-ectocone notch.

Habitat notes: The empty shells of *A. (A.) givenchyi* were collected on ground and the living snails were found on bamboo trunks in mixed deciduous forest and dry dipterocarp forest.

Distribution on the Phu Phan mountain range: The snails were found in 13 grids in the middle parts to the eastern parts of the mountain range.

Word distribution: Thailand, Laos

***Amphidromus (Amphidromus) schomburgki dextrochlorus* Sutcharit & Panha, 2006**

(Figures 4.6B, 4.8II, 4.9B)

2006 *Amphidromus (Amphidromus) schomburgki dextrochlorus* Sucharit *et al*: 1-30 pp.

Shell: Shell is 4.4-5.0 cm high and 2.8-3.0 cm wide, dextral, relative large, periostracum deciduous with oblique greenish radial streaks on whitish background, apex white, peristome, columnella and parietal callus whitish, shell lip expanded. Aperture truncated and oblique, periostome thickened, reflected. Columnella white, straight.

Radula: Central tooth unicuspid, spatulate shaped, lateral teeth bicuspid, endocone smaller than ectocone, ectocone relative broad. Inner

marginal teeth asymmetric tricuspid, endocone medium size, mesocone large with curved posterior margin, and ectocone medium size with sharp cusp. Outermost marginal teeth tricuspid.

Habitat notes: The empty shells of *A. (A.) schomburgki dextrochlorus* were found on ground surface or forest floor and the living snails were found on trees, undergrowth vegetation in mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 5 grids in the middle parts to the western parts of the mountain range.

Word distribution: Tao Ngoi District, Thailand

***Amphidromus (Syndromus) zebrinus* (Pfeiffer, 1861)**

(Figures 4.6D, 4.10A)

1861 *Amphidromus (Syndromus) zebrinus* Pfeiffer

Shell: Shell is 2.1-3.0 cm high and 1.1-1.6 cm wide, sinistral, relative small, periostracum deciduous with oblique brownish radial streaks on whitish background, apex white, peristome, columnella and parietal callus whitish, shell lip slightly expanded. Aperture truncated and oblique, periostome thickened, reflected. Columnella is white.

Habitat notes: The empty shells of *A. (S.) zebrinus* were collected on ground surface or forest floor and the living snails live on tree, which the tall more than 10 meters above ground in dry dipterocarp forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 2 grids in the western parts of the mountain range.

Word distribution: Thailand

***Ganesella (Ganesella) capitium* (Benson, 1848)**

(Figures 4.6E, 4.11)

1848 *Ganesella (Ganesella) capitium* Benson, 2: 158-164

Shell: Dextral, more or less trochiform, moderately thin to solid, of 4.5-6 rather convex whorls. Last whorl angulated or carinated, a little descending in front. Color light. Monochromatic or with a few dark bands. Embryonic whorls smooth. Postapical whorls with irregular radial ridgelets and spiral lines (smooth below peripheral angle or keel). Shell lip neither expanded nor reflected. Aperture widely ovate, moderately oblique, with variously reflexed margins. Umbilicus narrow open, rarely closed.

Habitat notes: The snails were collected under rock in dry dipterocarp forest. In this study we found only empty shell and shell fragment, so the detail of reproductive anatomy and radula were not studied.

Distribution on the Phu Phan mountain range: The snails were found in 1 grid in the eastern parts of the mountain range.

Word distribution: India, Japan, China, Indo-China, Malaya, Sumatra, Java, Borneo, Hindustan Peninsula, Southeast Asia, Taiwan, Indonesia, Philipines, New Guinea.

***Chloritis (Trichochloritis) tenella* (L. Pfeiffer, 1862)**

(Figures 4.6C, 4.7B, 4.8III, 4.10B)

1862 *Chloritis (Trichochloritis) tenella* Pfeiffer

Shell: Dextral, discoidal shell, flat, moderate thin, of about 4 to 6 convex whorls. Shell lip well reflected. Last whorl rounded, not descending. Color brownish. Embryonic whorls smooth. Suture is deep. Periostracum brown, aperture roundly, margins expanded and reflexed. Umbilicus moderately narrow, open, cylindrical.

Reproductive system: Vas deferens thin and enters to distal epiphallus. Penial retractor muscle relative short, insert proximally near penis. Penis relative long, thin, slender. Epiphallus relative long, straight. Flagellum very long. Appendix slender and short. Vagina slender, cylindrical. Gametoytic duct very long; proximal to vagina it is wide and distally tapers abruptly to small tube that connects to enlarged gametolytic sac.

Radula: Central tooth is indistinct tricuspid, smaller than first lateral. First lateral are also indistinct tricuspid, entocone very tiny and set nearer the mesoconal tip, ectocone is also very tiny. After tenth lateral, are also tricuspid, ectocones very small and set nearer the mesoconal tip, ectocone is also very tiny, inner marginal teeth are tricuspid, outer marginal teeth are also tricuspid, entocones and ectocones have three to five small cusps.

Habitat notes: The empty shell were collected on ground surface or forest floor and the living snails live on small rock and undergrowth vegetations in dry dipterocarp forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were collected in 2 grids in the eastern parts of the mountain range.

Word distribution: Sulawesi, Ceram, New Guinea, Molluccas, New Ireland, Solomons, Louisiades

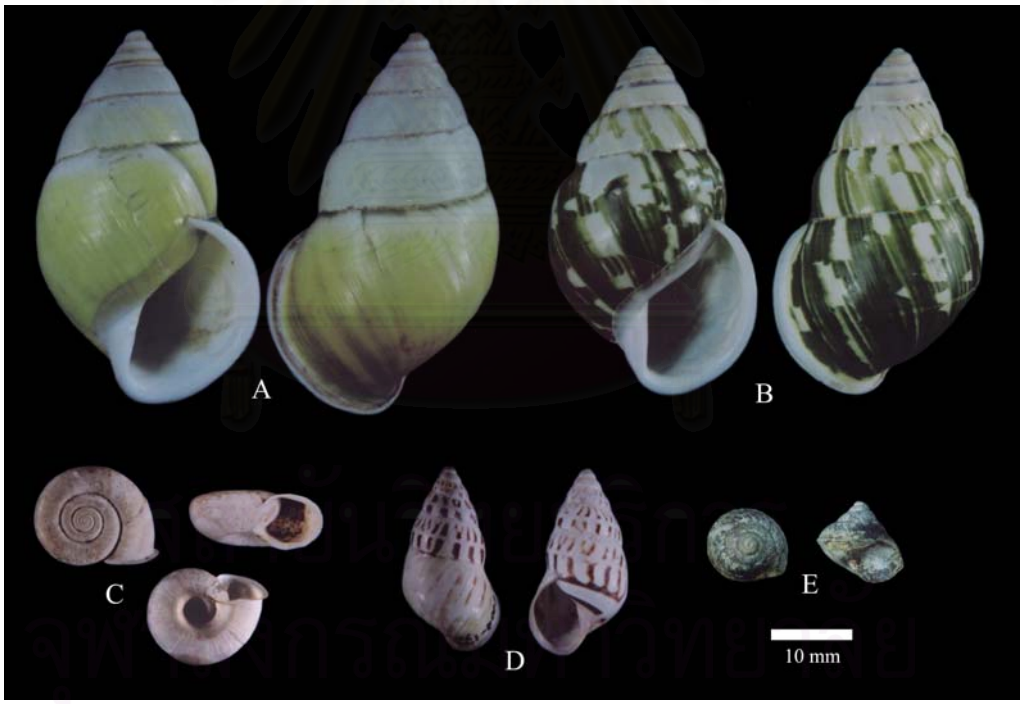


Figure 4.6 Shell shape of camaenid snails; A, *A. (A.) givenchyi*; B, *A. (A.) schomburgki dextrochlorus*; C, *C. (T.) tenella*; D, *A. (S.) zebrinus*; E, *G. (G.) capitium*.

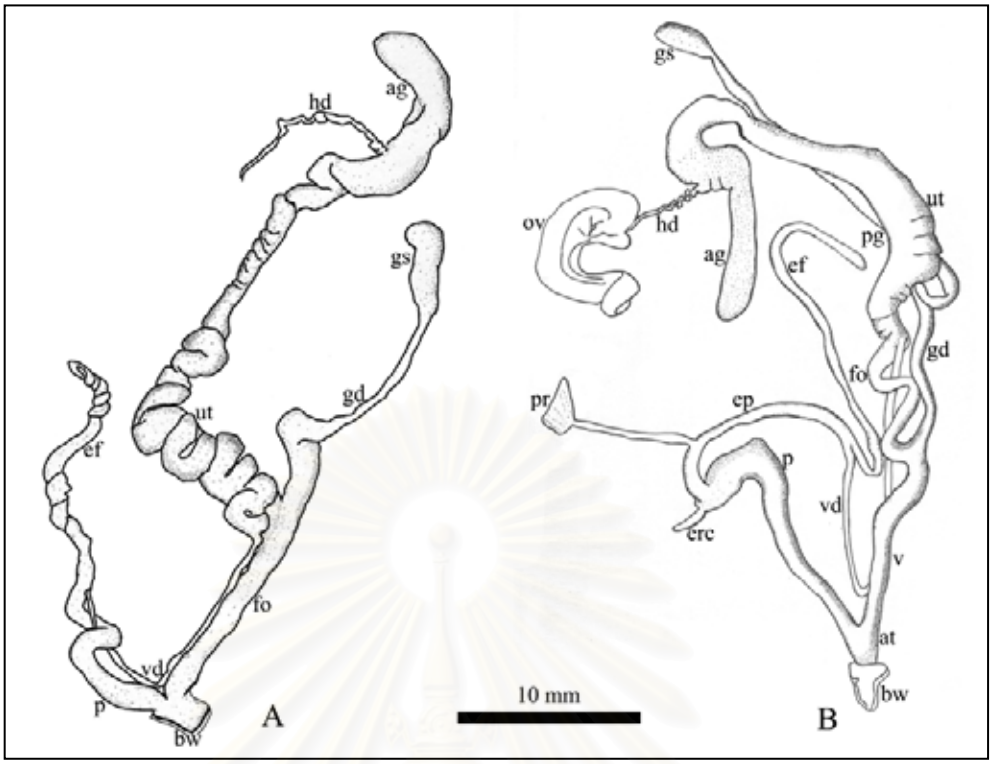


Figure 4.7 Genital systems of camaenid snails; A, *A. (A) givenchyi*; B, *C. (T.) tenella*.

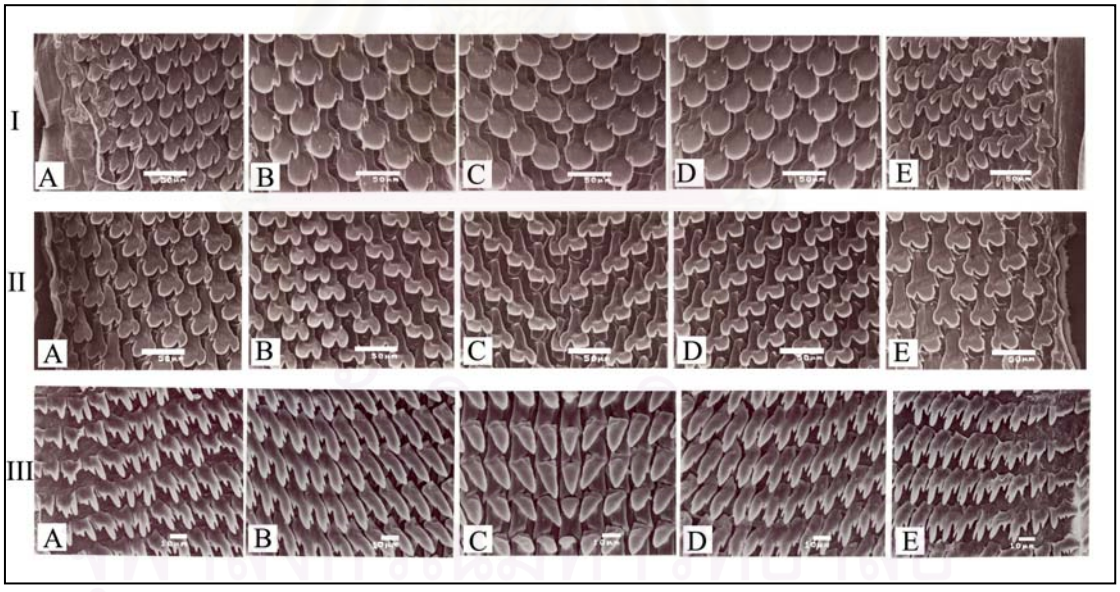


Figure 4.8 I, radula of *A. (A.) givenchyi*; II, radula of *A. (A.) schomburgki dextrochlorus*; III, radula of *C. (T.) tenella*; A, lateral teeth and marginal teeth; B, lateral teeth; C, central tooth and lateral teeth; D, lateral teeth; E, lateral teeth and marginal teeth.

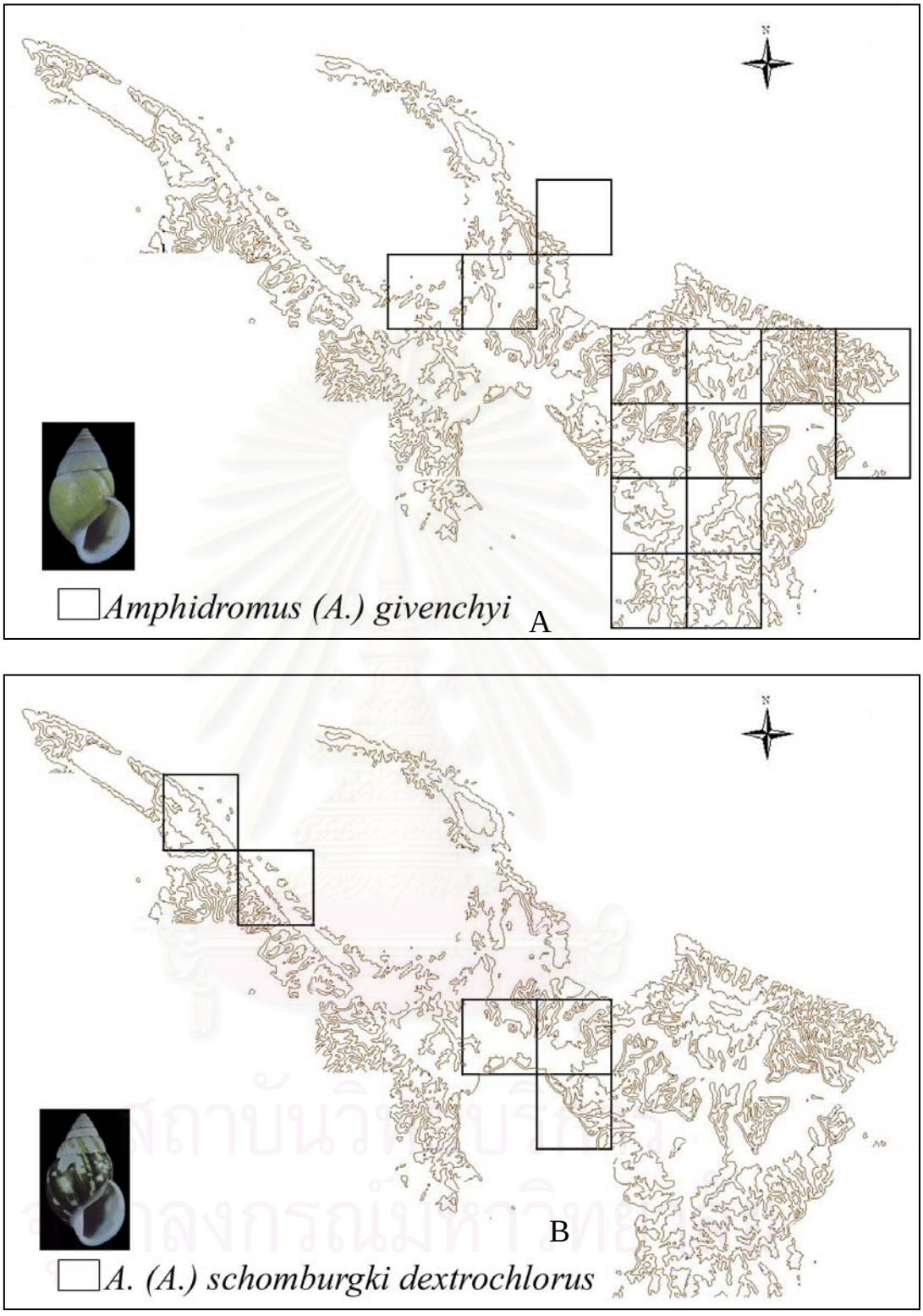


Figure 4.9 Distribution patterns of camaenid snails in 45 grids on the Phu Phan mountain range. A, *A. (A.) givenchyi*; B, *A. (A.) schomburgki dextrochlorus*.

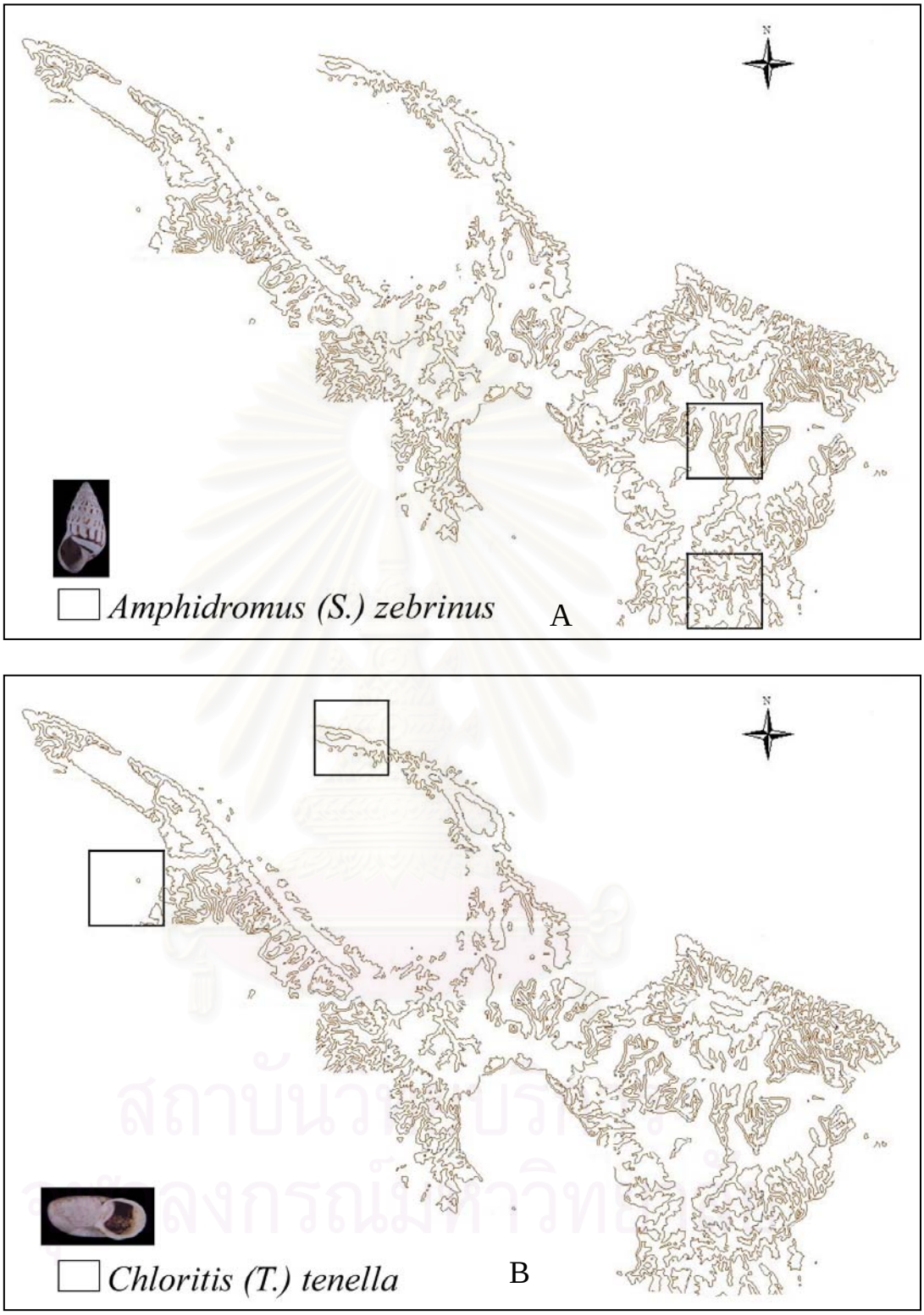


Figure 4.10 Distribution patterns of camaenid snails in 45 grids on the Phu Phan mountain range. A, *A. (S.) zebrinus*; B, *C. (T.) tenella*.

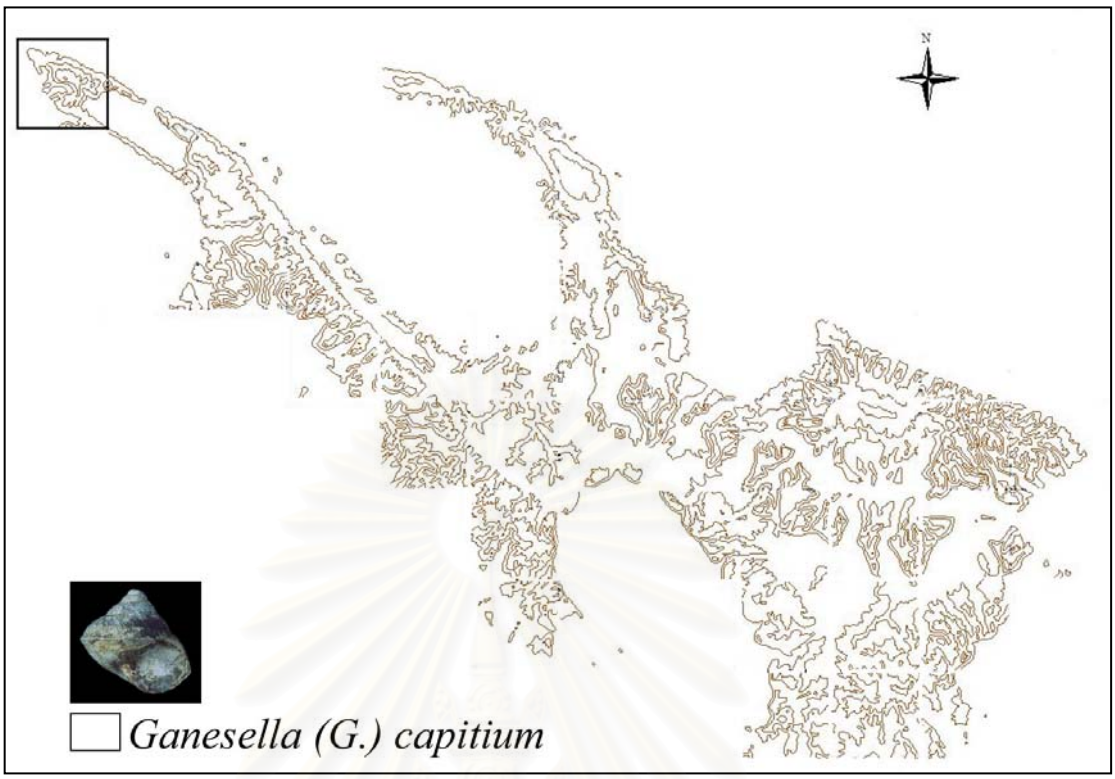


Figure 4.11 Distribution patterns of *G. (G.) capitium* in 45 grids on the Phu Phan mountain range.

Family Dyakiidae

***Quantula weinkauffiana* (Crosse& Fischer, 1863)**

(Figures 4.12B, 4.13A, 4.14I, 4.15B)

1863 *Quantula weinkauffiana* Crosse & Fischer, 11: 343-379. pls, 13-14

1894 *Ariophanta weinkauffiana inflata* Möllendorf, p. 149.

1959 *Quantula weinkauffiana* Zilch, 314 p.

Shell: Shell is 1.1-2.7 cm high and 1.7-3.6 cm wide, dextral, depress, solid, of 5-6 slightly convex whorls, last whorl with angled periphery. Shell lip neither expanded nor reflected. Perforate shell. Spire dome-shaped, apex slightly protruding. Color corneous above, basal side whitish around umbilicus. Embryonic whorls smooth. Later whorls with very weak radial wrinkles above and fine spiral striae, umbilicus dot-like.

Reproductive system: Vas deferens rather long, longer than epiphallus + penis, entering epiphallus terminally. Penis and ephiphallus rather short, without external boundary between these organs. Gameolytic duct rather large in lower part and rather small in the middle part, gametolytic sac rather large, ovate. Amatorial organ rather long, cylindrical. Gland of amatorial organ very large composed of several lobes, whose duct enter single long common duct.

Radula: Central tooth is tricuspid, elongate, smaller than first lateral. First lateral are also tricuspid, elongate, entocone very small and set nearer the mesoconal tip, ectocone very small. After twentieth lateral, entocones and ectocones reduced and lost in marginal teeth, marginal teeth are unicuspid, elongate, and rather small.

Habitat notes: The empty shells of *Q. weinkauffiana* were collected on ground surface or forest floor and the snails live on forest floor, rock, and undergrowth vegetation in dry dipterocarp forest, mixed deciduous forest and dry evergreen forest.

Distribution on the Phu Phan mountain range: The snails were found in 35 grids through the mountain range.

Word distribution: Vietnam, Malay Peninsula

***Phuphania globosa* Tumpeesuwan, Naggs & Panha, 2007**

(Figures 4.12A, 4.13B, 4.14II, 4.15A)

2007 *Phuphania globosa* Tumpeesuwan *et al*, 363-369.

Shell: Shell is 2.5-2.9 cm high and 3.2-3.4 cm wide, dextral, dextral, with 5-6 whorls, semiglobose, color fulvous above, below yellowish. Embryonic whorls smooth, subsequent whorls with fine radial growth line. Aperture large ovate, well oblique, lip neither expanded nor reflected. Umbilicus narrow. Animal: ground color brown, marked with black. The foot fringe is rather wide about 2 mm. the foot is compact, the sole undivided, and the caudal gland has no overhanging lobe. Shell lobes are entirely absent.

Reproductive system: Vas deferens rather long, thin, entering epiphallus subapically without sharp boundary. Epiphallus rather long, curved. Penis somewhat clavat, larger than epiphallus, penial retractor connecting mid section of epiphallus. Amatorial organ large, a thick-walled stoutly cylindrical sac, the organ consists of prepuce, inner surface of its prepuce with a few strong circular folds, Papilla of amatorial organ

minutely papillose, without thorn. Accessory glandular system over amatorial organ fused together as one large glandular covers the apical of amatorial organ and consists of 5 bundles of tubules entering to amatorial organ apically, free oviduct rather long. Elongate sac-like of gametolytic has a thin apical ligament and inserting on very lower part of prepuce of amatorial organ.

Radula: Central tooth is tricuspid, narrow and elongate, the first and the second admedians also tricuspid, narrow and elongate, the lateral teeth are bicuspid with tiny ectocone, narrow and elongate, the marginal teeth are unicuspid with groove, narrow and elongate.

Habitat notes: The empty shell were collected on ground surface or forest floor and the living snails live on under leaf litter, on small trees and forest floor in dry dipterocarp forest, dry evergreen forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 12 grids in the middle parts to the western parts of the mountain range.

Word distribution: Thailand

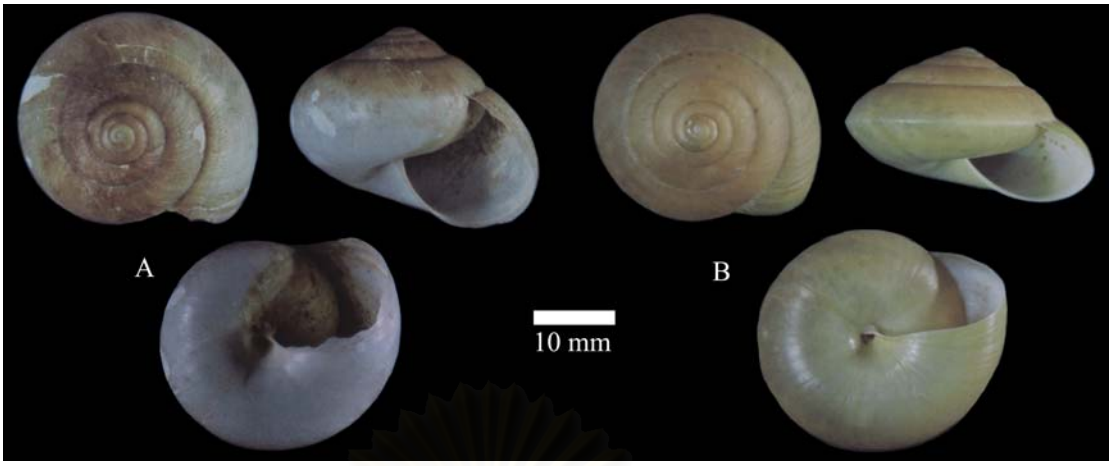


Figure 4.12 Shell shape of Dyakiid snails; A, *P. globosa*; B, *Q. weinkauffiana*.

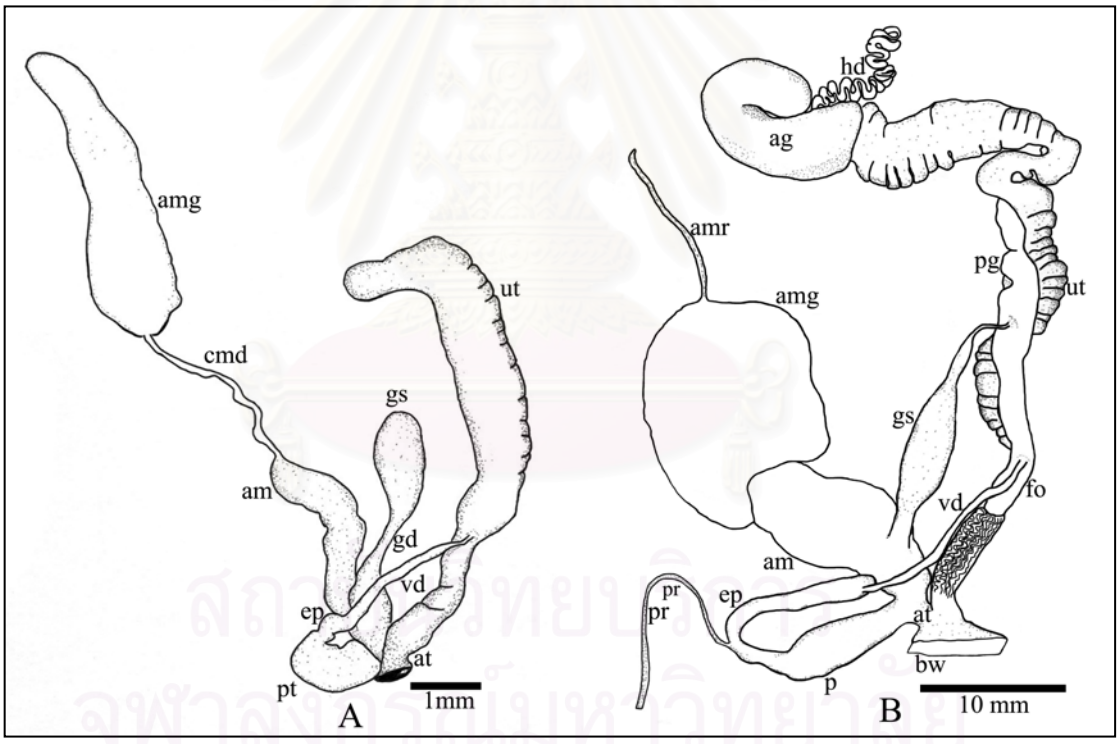


Figure 4.13 Genital systems of Dyakiid snails; A, *P. globosa*; B, *Q. weinkauffiana*.

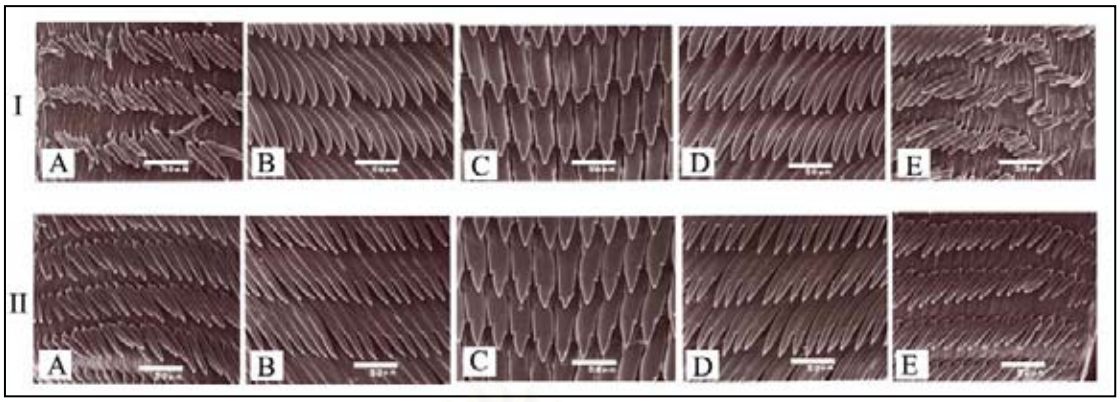
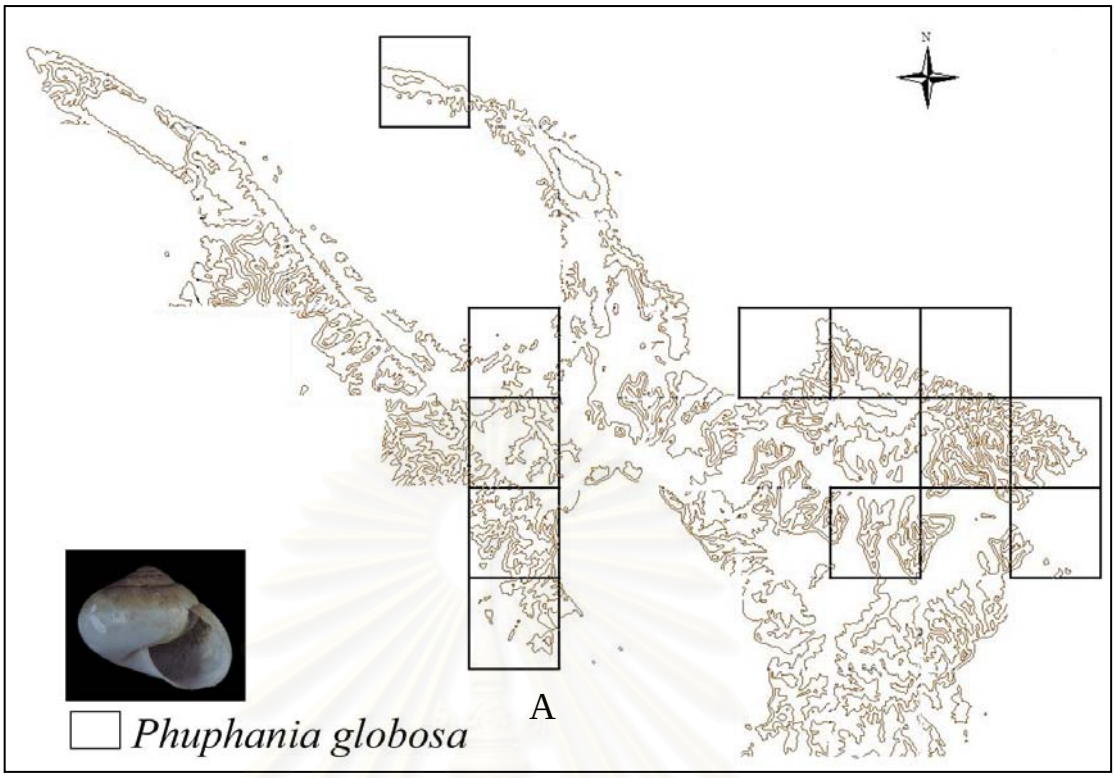


Figure 4.14 I, radula of *Q. weinkauffiana*; II, radula of *P. globosa*; A, lateral teeth and marginal teeth; B, lateral teeth; C, central tooth and lateral teeth; D, lateral teeth; E, lateral teeth and marginal teeth.



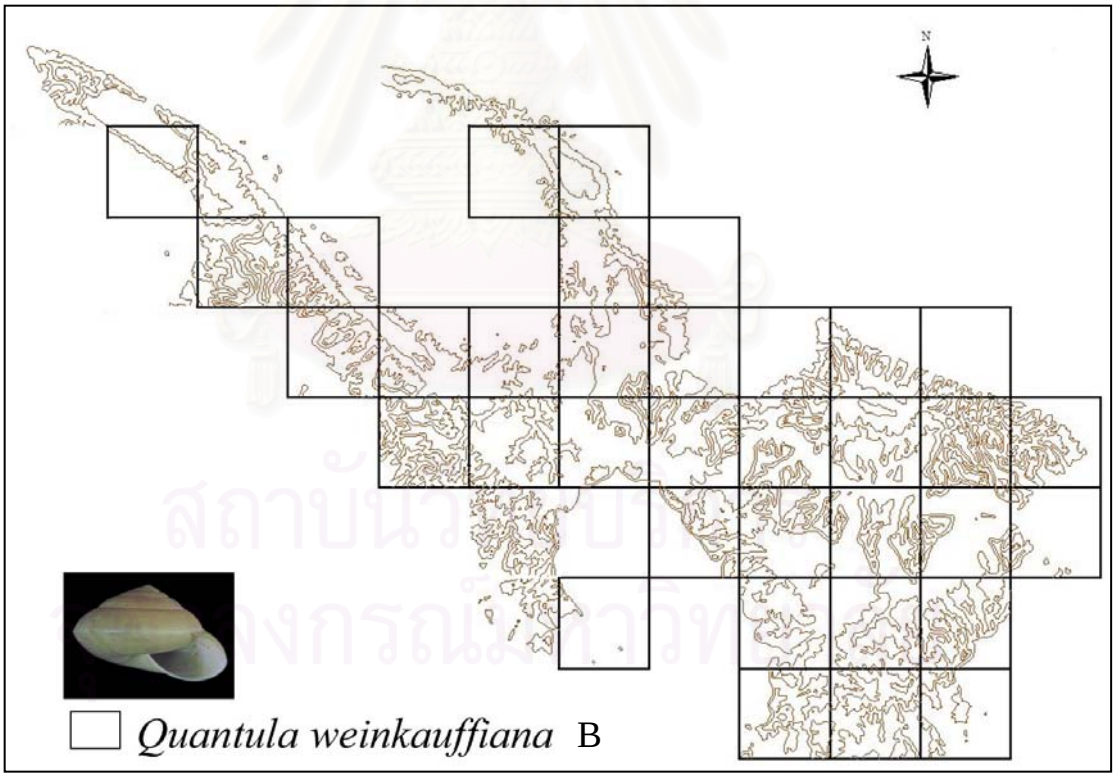


Figure 4.15 Distribution patterns of Dyakiid snails on the Phu Phan mountain range; A, *P. globosa*; B, *Q. weinkauffiana*.

Family Helicarionidae

Megaustenia siamensis (Haines, 1856)

(Figures 4.16A, 4.17A, 4.18I, 4.19A)

Type species: *Vitrina siamensis* Haines, 1856

1856 *Vitrina siamensis* Haines, 157-158, pl. 5

1867 *Vitrina siamensis* Martens, 68-69 pp.

1966 *Megaustenia siamensis* Solem, 78-84 pp.

Shell: Shell is 1.0-1.7 cm high and 2.2-2.9 cm wide, dextral, shell with few rapidly increasing whorls, very thin, glossy, with about 2 1/2-3 flattened whorls; last whorl widely rounded, slightly descending in front. Shell lip neither expanded nor reflected. Imperforate shell. Color corneous to yellowish. Embryonic whorl smooth, remaining surface with very fine spiral striae. Aperture large, widely ovate, with scarcely margins.

Reproductive system: Vas deferens a slender tube, long, thin, entering epiphallus subapically. Epiphallus moderately long, cylindrical. Penial retractor attached to short, uncoiled caecum. Penis very long, cylindrical. Amatorial organ very large, stoutly, ovate. Free oviduct rater short. Vagina rather short, cylindrical. Gametolytic duct very short, gametolytic sac rather large.

Radula: Central tooth is tricuspid, smaller than first lateral. First lateral are also tricuspid, longer than central tooth, entocone rather small and nearer the mesoconal tip, ectocone larger than entocone. After tenth lateral, entocones reduced and lost on marginal teeth. Marginal teeth are bicuspid, entcones and ectocones are the same size.

Habitat notes: The empty shell were collected from ground surface or forest floor and the hole of tree and the living snails were found on rock, undergrowth vegetation, sometime on small tree in dry dipterocarp forest, dry evergreen forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 14 grids in the middle parts to the eastern parts of the mountain range.

Word distribution: From Myanmar to South China and North Vietnam

Family Trochomorphidae

***Vitrinosis* sp.**

(Figures 4.16B, 4.18II, 4.19B)

1873 *Vitrinosis* Semper, 11-14 pp.

1897 *Helicarion* Möllendorf, 29, p. 58

1912 *Helicarion* Schepman 10, p. 229, pl. 10, fig. 1, 2

1959 *Vitrinosis* Zilch, 201-400 pp.

Shell: Depressed shell, dextral, shell with few rapidly increasing whorls, surface glossy, very thin, transparent, with about 4 ½ to 5, little convex, irregularly coiled. Shell color greenish, olive green. Shell sculpture with fine striae, suture shallow, margined, last whorl descending. Aperture very large, oblique, broadly lunar. Peristome not continuous, sharp, thin. Shell lip neither expanded nor reflected. Embryonic whorls smooth. Imperforate shell.

Radula: Central tooth is tricuspid. First lateral are also tricuspid, entocone rather small and nearer the mesoconal tip, ectocone also small, after tenth lateral, distinctly the ectocone and entocones. Marginal teeth are also tricuspid, entocones, mesocones and ectocones are the same size.

Habitat notes: The snails were collected on ground surface, on decaying wood and on vegetation in mixed deciduous forest and dry evergreen forest.

Distribution on the Phu Phan mountain range: The snails were found in 2 grids in the middle parts of the mountain range.

Word distribution: Philippines, Java, Bali, Lombok, Sumbava, Flores, Timor Island. 8-10 spp.

Family Durgellidae

***Durgella* Blanford, 1863**

1859 *Nanina levicula* Benson

1878 *Nanina levicula* Nevill

1966 *Durgella libas* Solem, 50-56 pp.

***Durgella* sp.**

(Figures 4.16C, 4.17C, 4.20A)

Shell: Shell very small, dextral, more or less vitrinoid, very thin, surface shining, radial sculpture, somewhat translucent, with 3-4 slightly convex whorls. Perforate shell. Color whitish, yellowish, usually with a brown band immediately above the periphery, rarely with a second band immediately below. Embryonic whorls smooth. Aperture ovate, quite oblique, with thin, sharp margin. Umbilicus narrow.

Reproductive system: Vas deferens very short, thin, entering epiphallus subapically. Epiphallus and penis very long, slender, cylindrical. Amatorial organ longer basal stalk and very long, cylindrical head. Free oviduct relatively long, somewhat cylindrical. Vagina rater short, cylindrical. Gametolytic duct with very short basal stalk, an extremely narrow neck, gametolytic sac rather small, thin-walled sac ovate.

Habitat notes: The empty shells of *Durgella* sp. were collected on ground surface or forest floor, the living snails live on bamboo leaves in mixed deciduous forest and dry evergreen forest.

Distribution on the Phu Phan mountain range: The snails were found in 2 grids in the middle parts of the mountain range.

Word distribution: East Himala, Assam, burma, Java, Bali, Sumbava, Flores, Timor Island. 8-10 spp.

Remarks: The species different from other species by having a brown band in each whorl and shell have a white color.

Family Parmarionidae

***Parmarion martensi* (Simroth, 1893)**

(Figures 4.16E, 4.17B, 4.20B)

1893 *Parmarion martensi* Simroth, 3, p. 107, pl. 7, fig. 8, pl. 8, fig. 22

1912 *Microparmarion jacobsoni* Schepmann, 10, p. 232.

1940 *Parmarion martensi* Hoffmann, 74, p. 32.

Shell: Animal slug like, with shell reduced to a cap-like structure. Shell completely enclosed by shell laps. Spire and most of body whorl calcified. No distinct coiling preserved. Tail relative small, slender with black in color, foot narrow. Caudal horn prominent slightly overhung. Caudal foss a transverse slit up under caudal horn. Mantle lobes and shell laps fused, completely covering shell and visceral hump.

Reproductive system: Vas deferens thin and enters from free oviduct to sub terminal epiphallus. Ephiphalic retractor caecum short, small. Penis large and short. Epiphallus very short. Vagina relative short, cylindrical. Gametoytic duct very short. Gametolytic sac very large, swollen. Free oviduct very short. Amatorial organ separate into two part, relative long stalk and very large the upper most of amatorial organ. Albumen gland curved.

Habitat: The snails live on forest floor, among fallen leaves, undergrowth vegetation, on stones, on tree trunks and shrub in mixed deciduous forest and dry evergreen forest.

Distribution on the Phu Phan mountain range: The snails were found in 2 grids in the middle parts of the mountain range.

Word distribution: Cambodia, Annam, Malaya, Sumatra, Java, Borneo.

Family Veronicellidae

***Semperula* Grimpe & Hoffmann, 1924**

***Semperula* sp.**

(Figures 4.16D, 4.18III, 4.21)

1867 *Semperula siamensis* Martens, P. 68, pl. 5, fig. 3 (*Vaginulus*)
1925 *Semperula siamensis* Hoffmann, 61, p. 179-181 and 256-257, pl. 8, fig. 58, 60-62, pl. 9, fig. 64, pl.10, fig. 71, pl. 11, 78-80.
1934 *Semperula siamensis* Hoffmann, 5, p. 257.
1966 *Semperula siamensis* Solem, p. 21

Animal: Animal oval, without shell. Both notum (dorsal surface) and hyponotum (ventral surface) dark grey, indistinctly marble with a cloudy, raticulate pattern. Footsole grey. Along the perinotum and in the mid-dorsal line there is a narrow light zone. Notum and hyponotum minutely granular.

Radula: Central tooth is unicuspid, very small, triangular, and smaller than first lateral. First lateral are also unicuspid, lateral and marginal teeth are not differences, so call latero-marginal teeth are also unicuspid.

Habitat notes: The snails were collected on the ground surface or forest floor, under stones, grass, undergrowth vegetation in mixed deciduous forest and dry evergreen forest.

Distribution on the Phu Phan mountain range: The snails were found in 2 grids in the middle parts of the mountain range.

Word distribution: Thailand, Cambodia

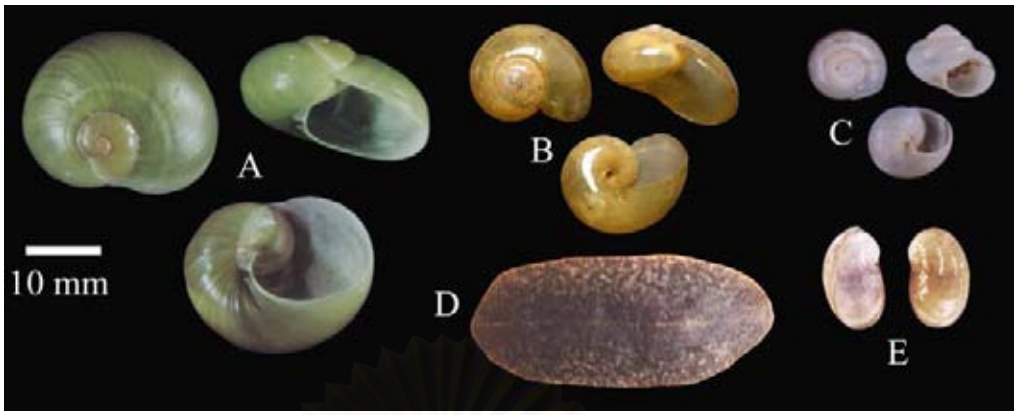


Figure 4.16 Shell shape of semi-slugs and slug; A, *M. siamensis*; B, *Vitrinopsis* sp.; C, *Durgella* sp.; D, *Semperula* sp.; E, *P. martensi*

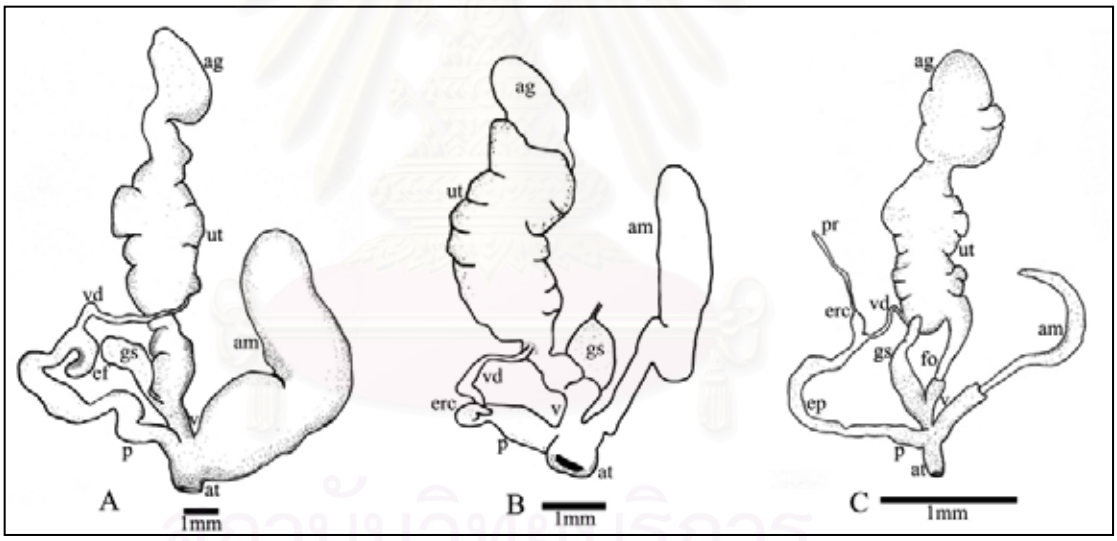


Figure 4.17 Genital system of semi-slugs and slug; A, *M. siamensis*; B, *P. martensi*; C, *Durgella* sp.

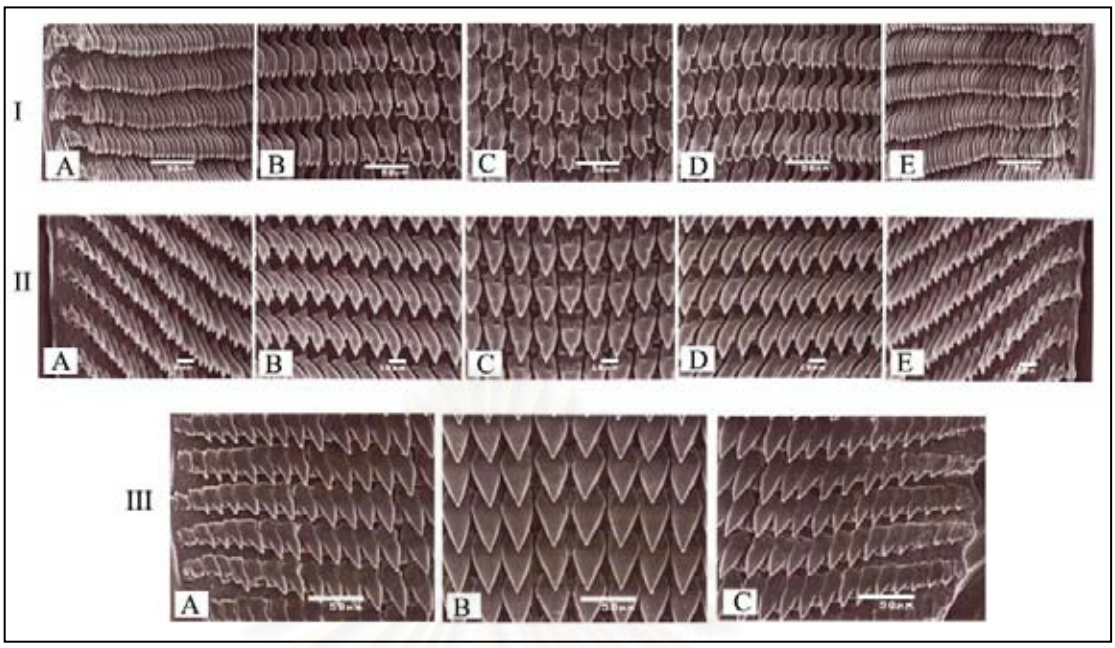


Figure 4.18 I, radula of *M. siamensis*; II, radula of *Vitrinopsis* sp.; A, lateral teeth and marginal teeth; B, lateral teeth; C, central tooth and lateral teeth; D, lateral teeth; E, lateral teeth and marginal teeth; III, radula of *Semperula* sp.; A; C lateral and marginal teeth; B, central tooth and marginal teeth

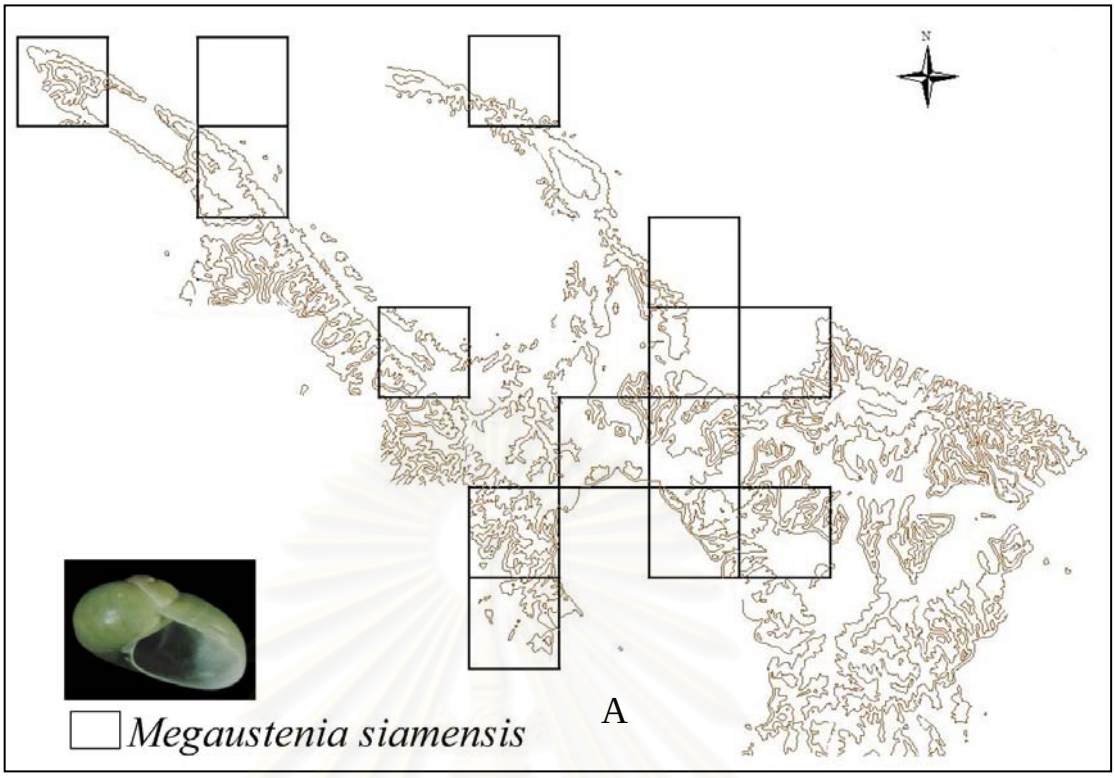
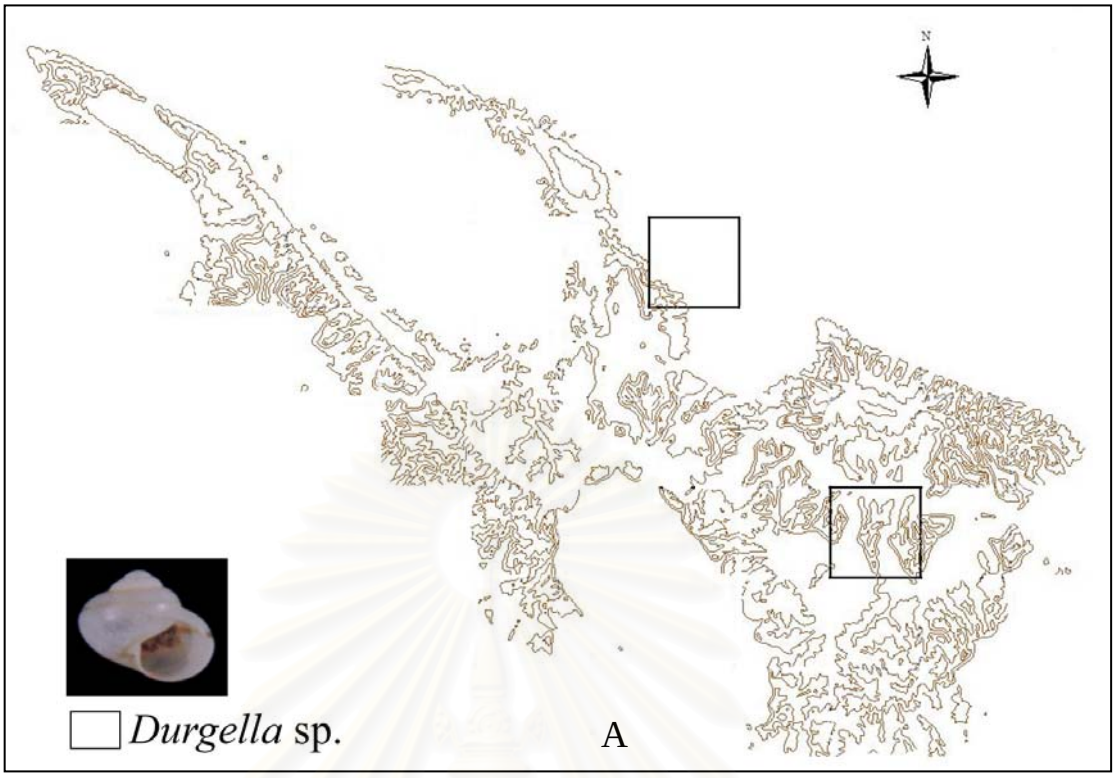


Figure 4.19 Distribution patterns of semi-slugs and slug; A, *M. siamensis*; B, *Vitrinopsis* sp. on the Phu Phan mountain range.



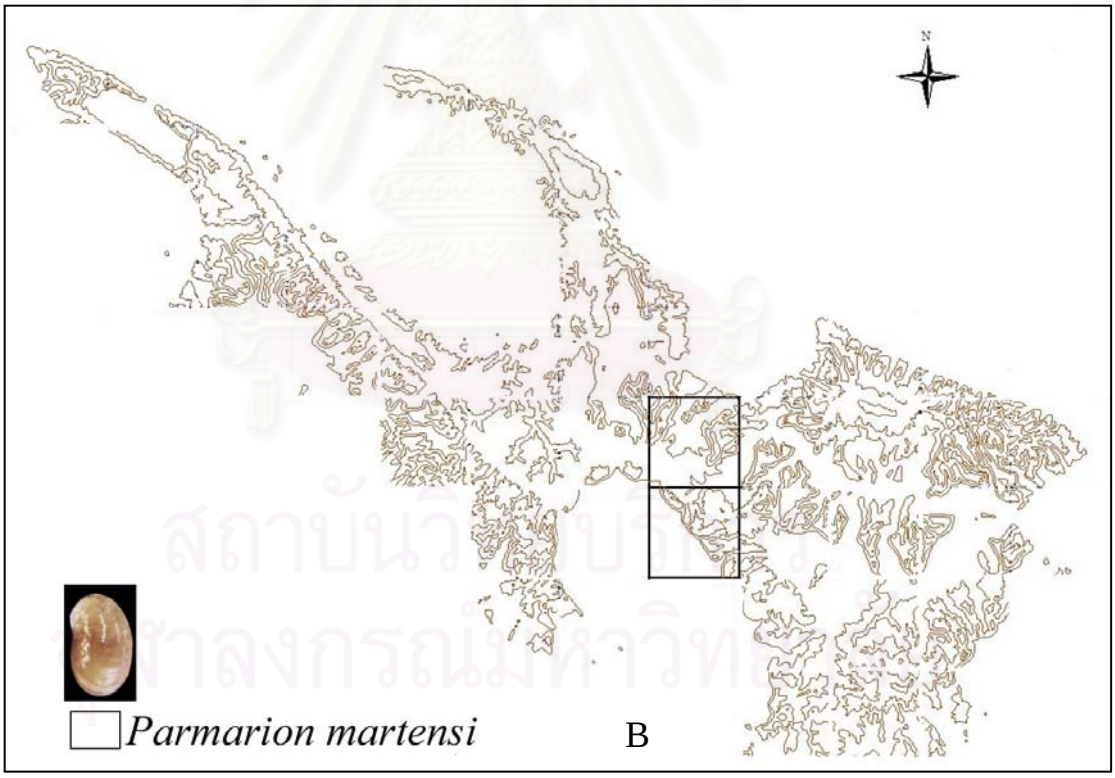


Figure 4.20 Distribution patterns of semi-slugs and slug; A, *Durgella* sp.; B, *P. martensi* on the Phu Phan mountain range.

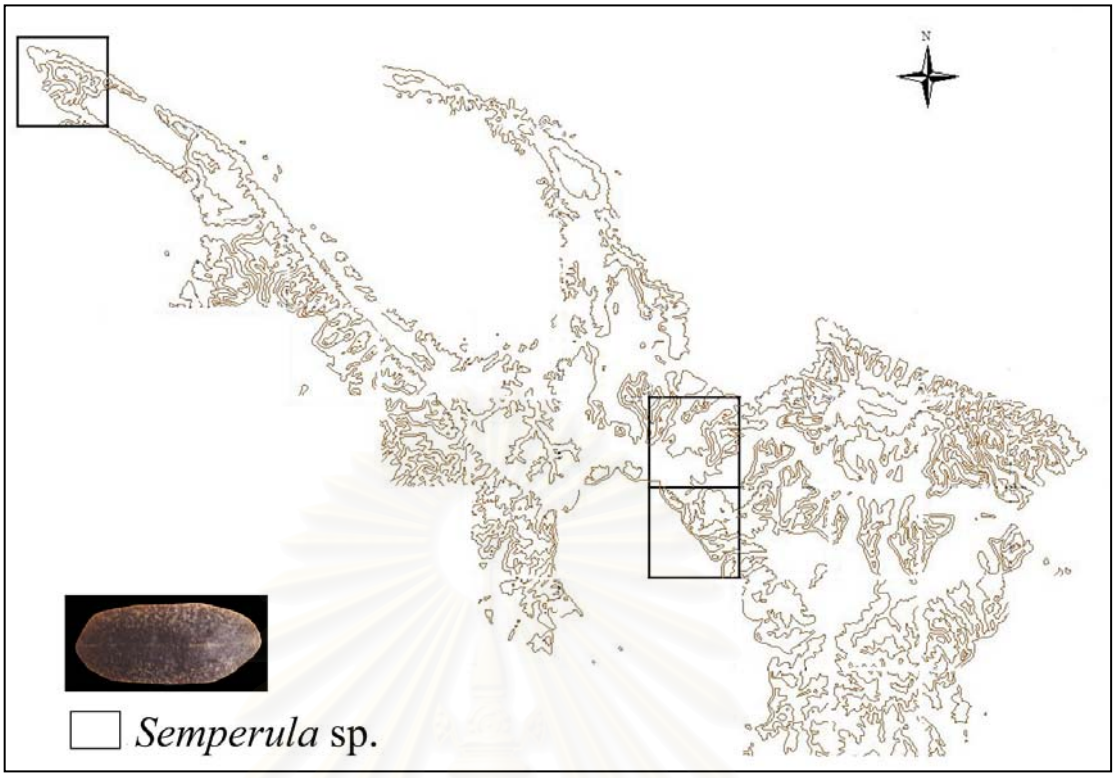


Figure 4.21 Distribution patterns of slug; *Semperula* sp. on the Phu Phan mountain range.

Family Ariophantidae

Hemiplecta distincta (L. Pfeiffer, 1850)

(Figures 4.22D, 4.23A, 4.24I, 4.25A)

1850 *Hemiplecta distincta* Pfeiffer, 69 pp.

1903 *Hemiplecta distincta* Blandford, 277-278 pp.

1919 *Hemiplecta distincta* Godwin-Austen, 199-202 pp.

Shell: Shell is 2.8-4.5 cm high and 3.6-6.8 cm wide, dextral, depressed-subglobose, moderately thin to solid, subopaque, a little translucent, of about 5-6 slightly convex whorls. Shell lip neither expanded nor reflected. Last whorl scarcely descending just before aperture. Color yellowish, with light band above periphery; lower edge of band distinct, upper blurred. Embryonic whorls smooth, rest whorls with weak irregular radial wrinkles, spiral wavy lines. Aperture ample, quit oblique, with scarcely thickened margins; columnellar margin a little dilated. Umbilicus narrow, perspective cylindrical.

Reproductive system: Vas deferens rather long, slender, thin, entering epiphallus apically. Flagellum sac-like. Epiphallus shorter than penis, with uncoiled caecum supplied with terminal retractor. Penis very long, longer than epiphallus, cylindrical, with proximal swelling. Amatorial organ very large, long, cylindrical. Free oviduct rater short. Vagina also rather short, cylindrical. Gametolytic duct and sac rather large.

Radula: Central tooth is unicuspid, rather small, and smaller than first lateral. First lateral to thirtieth are also unicuspid. After thirtieth lateral are bicuspid, entocones larger than ectocones. Marginal teeth are also bicuspid.

Habitat notes: The adult snails live on forest floor, small tree, and undergrowth vegetation, however the juvenile snails live on tree trunk in three forest types including to dry dipterocarp forest, dry evergreen forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 45 grids through the mountain range.

Word distribution: Malaya, Greater Sunda Islands, Philippines.

***Hemiplecta danae* (L. Pfeiffer, 1862)**

(Figures 4.22A, 4.25B)

1862 *Hemiplecta danae* Pfeiffer

Shell: Shell is 2.2-2.4 cm high and 3.3-3.4 cm wide, dextral, depress, solid, perforate shell, shell lip neither expanded nor reflected, with about 6-7 slightly whorls. Shell with many, slowly increasing whorls. Shell sculpture with striae, periostracum brown. Aperture descending in front.

Habitat notes: The empty shells were collected on ground surface or forest floor in dry dipterocarp forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 4 grids in the middle parts to the eastern parts of the mountain range.

Word distribution: Indochina, Maldives, Moluccas, Indonesia, New Guinea. 20 spp.

Remarks: It closed to *Q. weinkauffiana* in having a sharp keel surrounds the body whorl, but this species different from the species by having a small shell, stronger peripheral keel and have whorl more than *Q. weinkauffiana*. In this study we found only empty shell and shell fragment, so the detail of reproductive anatomy and radula were not studied.

***Sarika resplendens* (Philippi, 1846)**

(Figures 4.22C, 4.23C, 4.24II, 4.26A)

1846 *Sarika resplendens* Philippi, 3: 191-192 pp.

1867 *Sarika resplendens* Marten, p 72, pl. 12, fig 6.

Shell: Shell is 0.9-1.4 cm high and 1.9-2.4 cm wide, dextral, strongly depressed-shell, conic, thin, translucent, shining, fragile, with about 6-7 slightly convex whorls. Shell lip neither expanded nor reflected. Perforate shell. Last whorl not descending. Color light-yellow, light-grey or shell colorless. Embryonic whorl smooth, polished. Aperture widely lunate, only slightly oblique, with simple, sharp margins; columellar margin a little reflexed. Umbilicus tiny.

Reproductive system: Vas deferens rather long, entering epiphallus subapically. Flagellum rather long with distinct axial thread. Epiphallus shorter than penis, with uncoiled caecum supplied with terminal retractor. Penis longer than epiphallus, clavate to subcylindrical. Amatorial organ large. Free oviduct short, somewhat expanded. Vagina short to very short. Gametolytic duct rather long, gametolytic sac rather large.

Radula: Central tooth is tricuspid, smaller than first lateral. First lateral are also tricuspid, entocone very small and set nearer the mesoconal tip, ectocone very small. After tenth lateral, are bicuspid, entocones set nearer mesoconal tip, lost in marginal teeth, marginal teeth are bicuspid.

Habitat notes: The empty shells of *S. resplendens* were collected on ground surface or forest floor, the living snails were found on the dead leaves and undergrowth vegetation in dry dipterocarp forest, mixed deciduous forest and dry evergreen forest.

Distribution on the Phu Phan mountain range: The snails were found in 13 grids through the mountain range.

Word distribution: Thailand

***Cryptozona siamensis* (L. Pfeiffer, 1856)**

(Figures 4.22B, 4.23B, 4.24III, 4.26B)

1856 *Cryptozona siamensis* Pfeiffer, 32-36 pp.

Shell: Dextral, depress, solid, of 6-8 slightly convex whorls. Shell lip neither expanded nor reflected. Last whorl scarcely descending just before aperture. Perforate shell. The upper side is a rather pale rust-red; immediately above the periphery this color finishes up sharply and abruptly with a narrow band of rather deeper tint; and the under side is entirely a pale yellowish- white. The upper side of the whorls, under a lens, is seen to be covered with extremely fine and close pararell axial ridges, which are cut at moderate intervals with shallow spiral grooves.

The base of the shell shows very little sculpture of any kind. Embryonic whorls smooth, rest whorls with weak irregular radial wrinkles, spiral wavy lines. Aperture ample, quit oblique, with scarcely thickened margins; columellar margin a little dilated. Shell sculpture with striae, shell with many, slowly increasing whorls. Umbilicus narrow, open.

Reproductive system: Vas deferens rather long, thin, entering epiphallus subapically. Flagellum rather long with distinct axial thread. Epiphallus shorter than penis, with uncoiled caecum supplied with terminal retractor. Penis very long, longer than epiphallus, cylindrical. Amatorial organ large, long, cylindrical, lower part larger than upper part. Free oviduct rater long, somewhat cylindrical. Vagina rather short, cylindrical. Gametolytic duct very long, cylindrical, gametolytic sac rather small.

Radula: Central tooth is tricuspid, rather small, and smaller than first lateral. First lateral are also tricuspid, larger than central tooth, entocone rather small and near the mesoconal tip. After tenth lateral, mesocones reduced and set nearer mesoconal tip, lost on marginal teeth. Marginal teeth are bicuspid.

Habitat notes: The empty shell were collected on ground surface or forest floor, the living snails live on ground surface or forest floor, undergrowth vegetation, and small trees in dry dipterocarp forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 2 grids in the middle parts of the mountain range.

Family Zonitidae

***Oxychilus* sp.**

(Figures 4.22F, 4.24IV, 4.27A)

Shell: Shell dextral, strongly depressed-shell, conic, very thin, translucent, shining, fragile, with about 4-6 slightly convex whorls. Shell lip neither expanded nor reflected. Perforate shell. Last whorl not descending. Dark red in color. Embryonic whorl smooth, polished. Aperture widely lunate, only slightly oblique, with simple, sharp margins; columellar margin a little reflexed. Umbilicus relative tiny.

Radula: Central tooth asymmetric tricuspid, smaller than the first lateral teeth, lateral teeth tricuspid, endocone smallest, set nearer the central tip, ectocone larger than endocone. Marginal teeth bicuspid, endocone larger than ectoocone.

Habitat notes: The snails were collected under leaf litter, ground surface and undergrowth vegetation in dry dipterocarp forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 5 grids in the middle parts to the western parts of the mountain range.

Family Subulinidae

***Prosopeas* sp.**

(Figures 4.22E, 4.27B)

Shell: Shell is 1.0-1.3 cm high and 0.3-0.35 cm wide, dextral, high-turreted, with numerous whorls, rather solid. Yellowish or brownish, hardly or not transparent. Vertical striation distinct, in fresh specimens as close, thread-like ribs. The top whorls are not sculptured differently, spiral striae very weak. Suture distinct, not margined, umbilicus closed. Aperture somewhat oblique. Irregularly oval, pointed above, rounded below. Peristome not continuous, the free margin sharp, not thickened or reflected. Columellar margin slightly reflexed and adnate.

Habitat notes: The snails were collected under leaf litter, under dead wood, under rock, which surrounding dry diperocarp forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 3 grids in the middle parts of the mountain range.

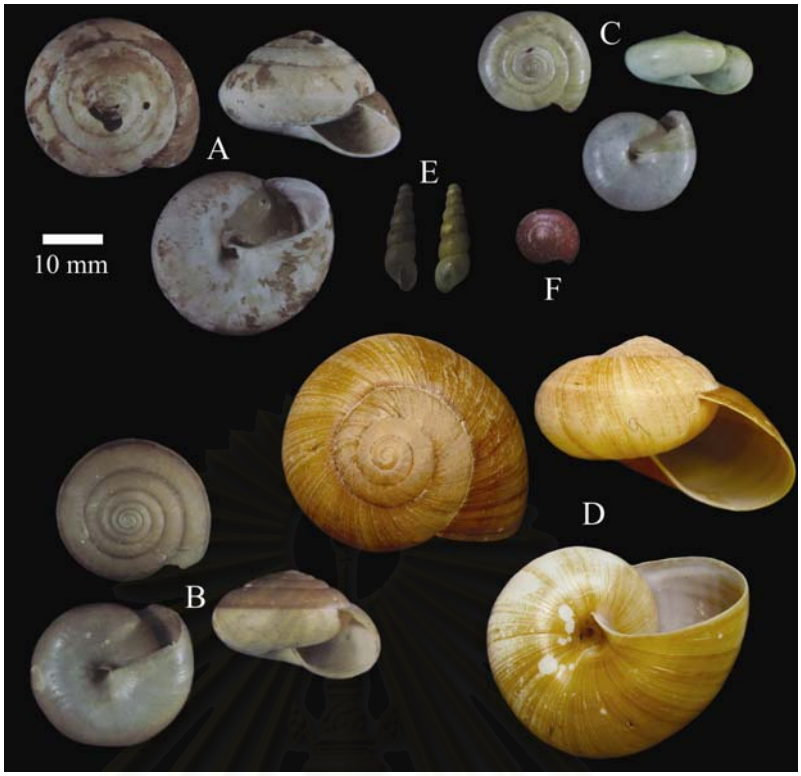


Figure 4.22 Shell shape of land snails; A, *H. danae*; B, *C. siamensis*; C, *S. resplendens*; D, *H. distincta*; E, *Prosopeas* sp.; F, *Oxychilus* sp.

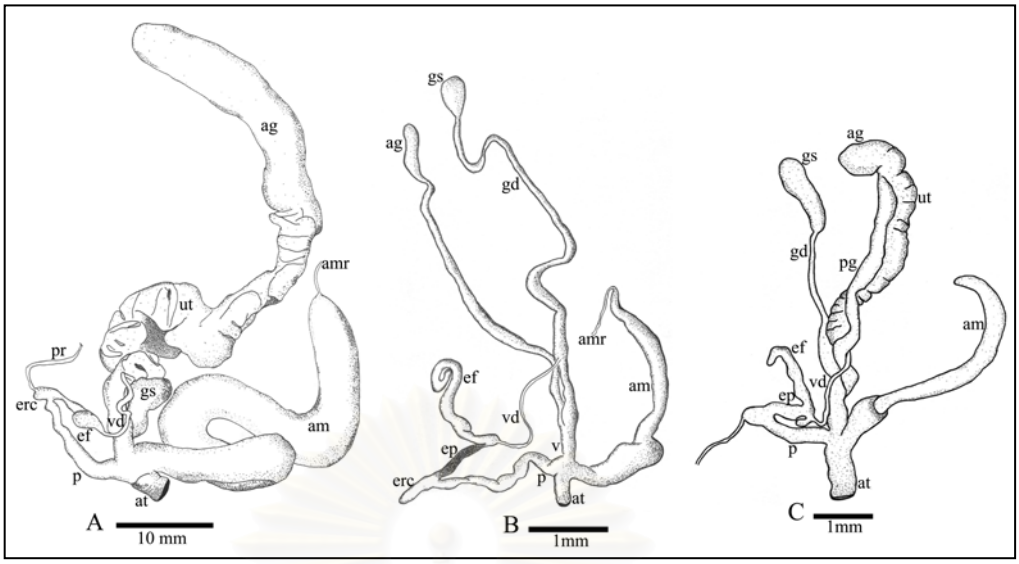


Figure 4.23 Genital systems of land snails; A, *H. distincta*; B, *C. siamensis*; C, *S. resplendens*.

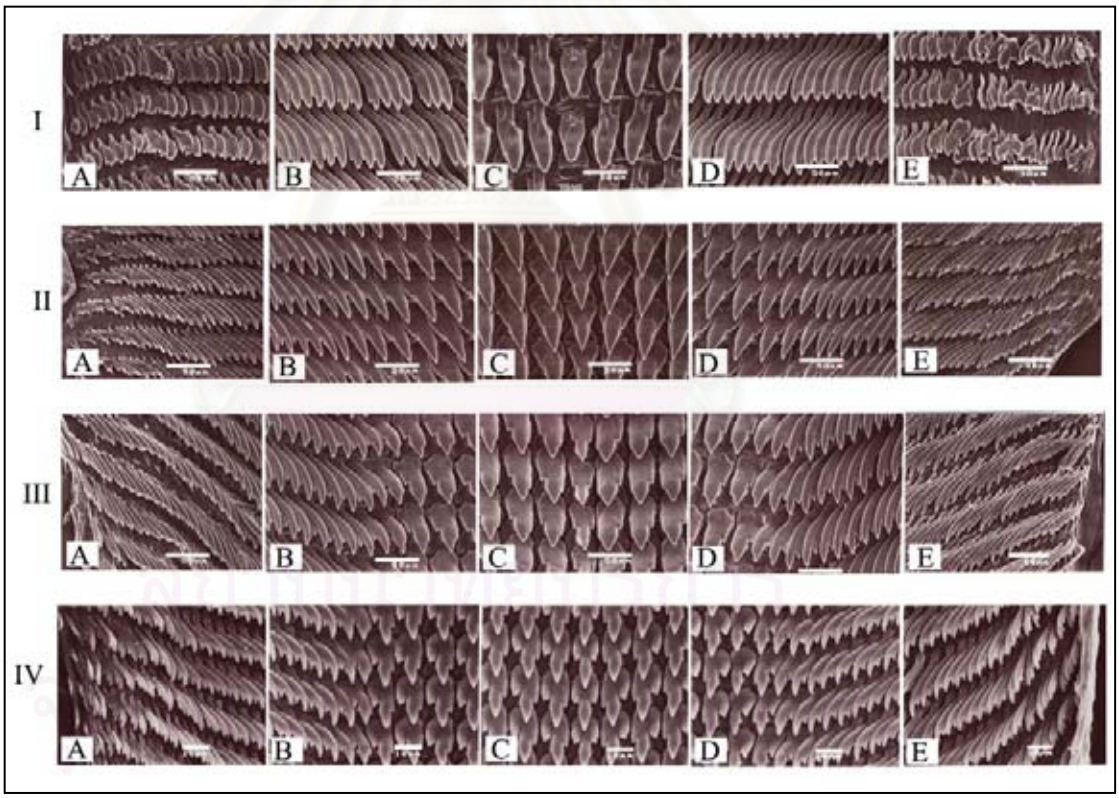
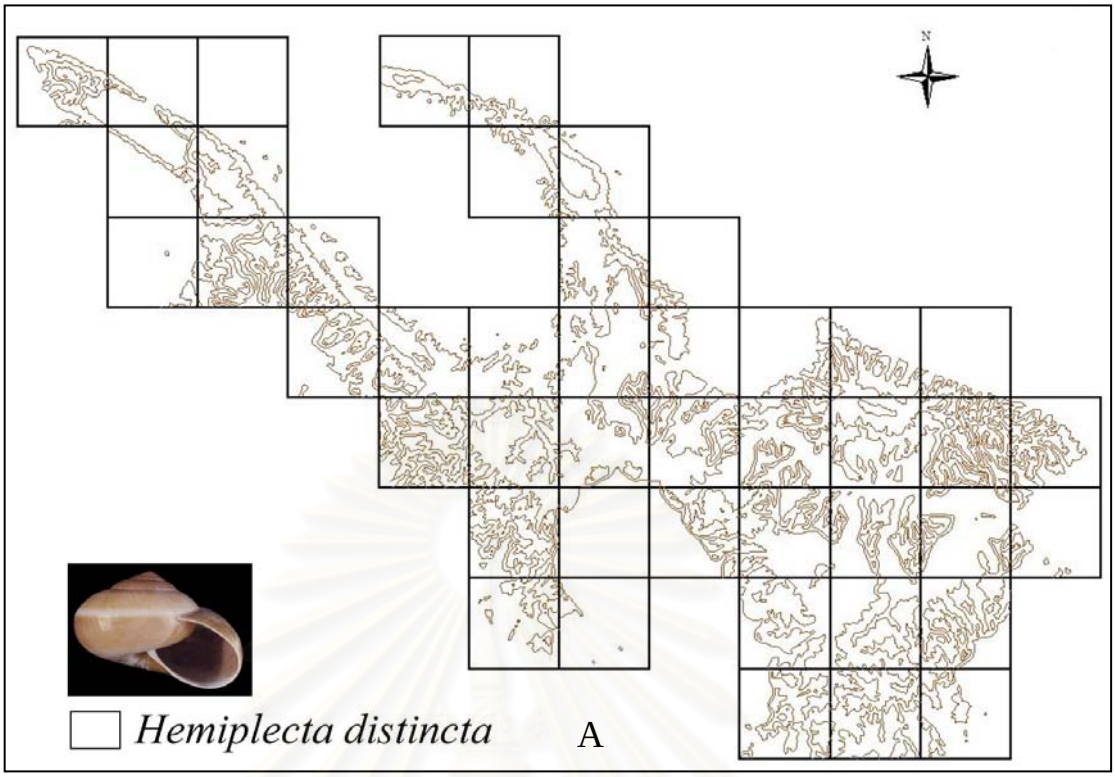


Figure 4.24 I, radula of *H. distincta*; II, radula of *S. resplendens*; III, radula of *C. siamensis*; IV, radula of *Oxychilus* sp.; A, lateral teeth and marginal teeth; B, lateral teeth; C, central tooth and lateral teeth; D, lateral teeth; E, lateral teeth and marginal teeth.



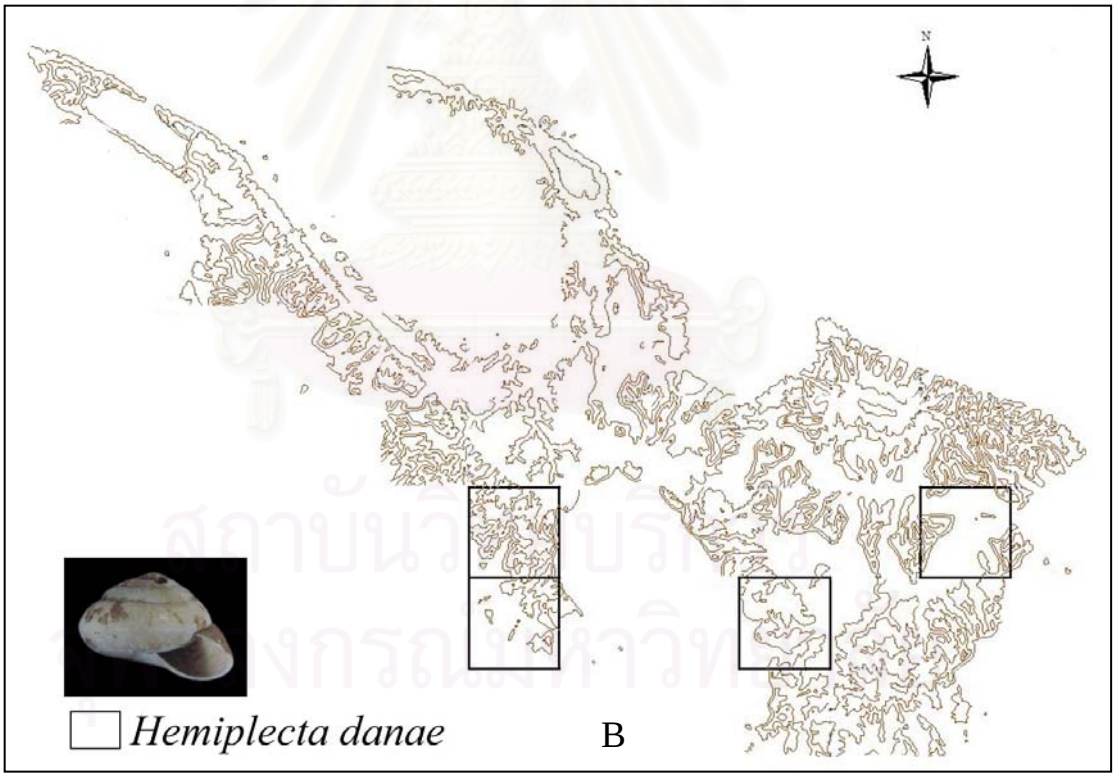


Figure 4.25 Distribution patterns of land snails on the Phu Phan mountain range; A, *H. distincta*; B, *H. danae*.

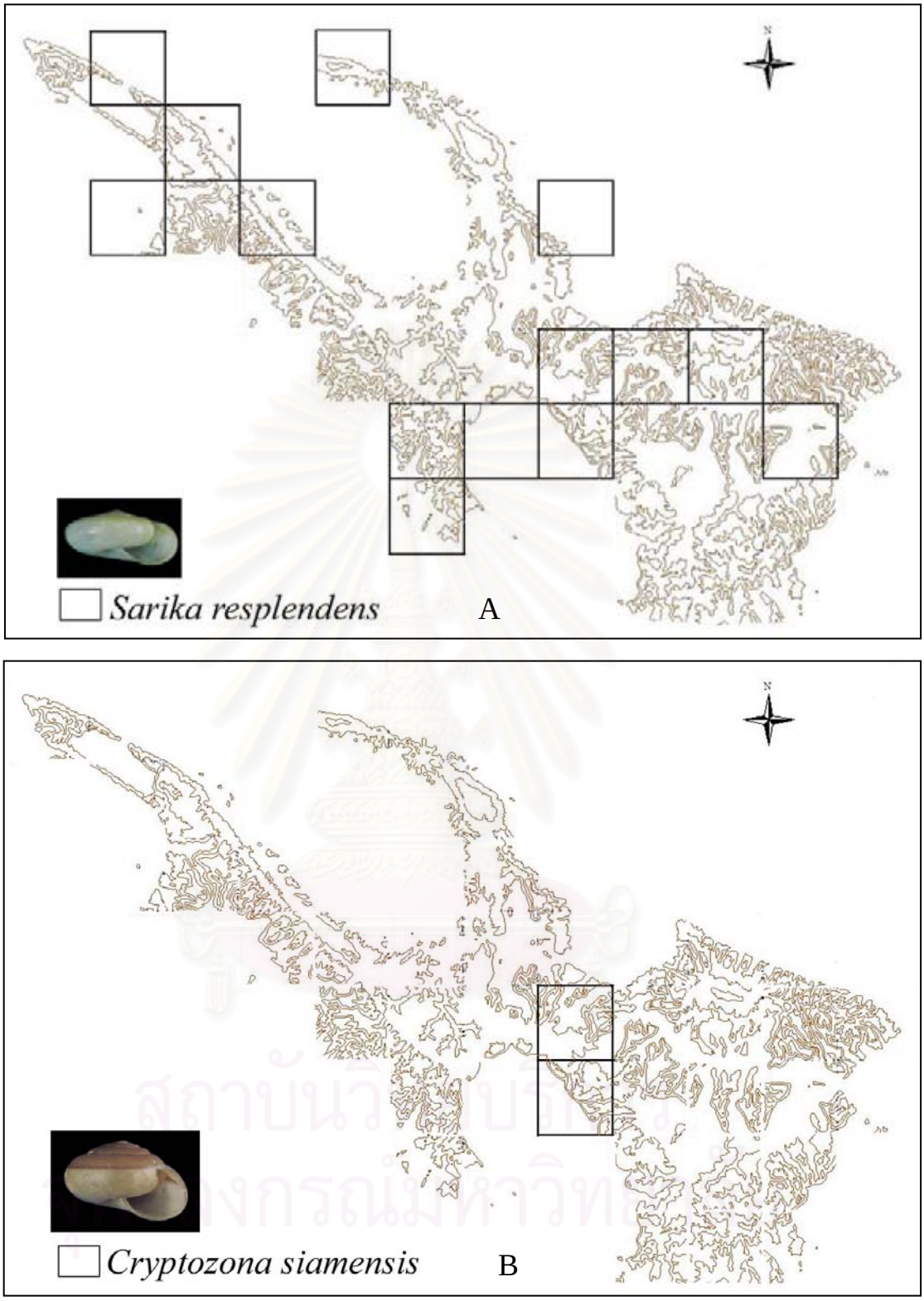
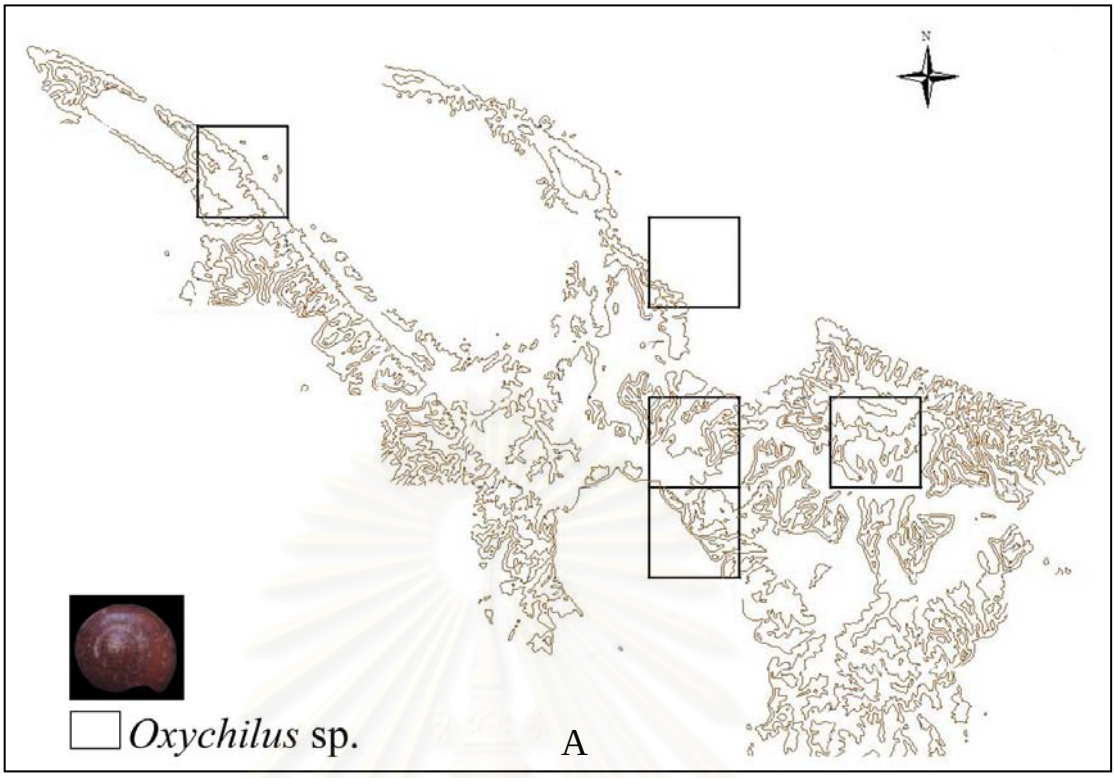


Figure 4.26 Distribution patterns of land snails on the Phu Phan mountain range; A, *S. resplendens*; B, *C. siamensis*.



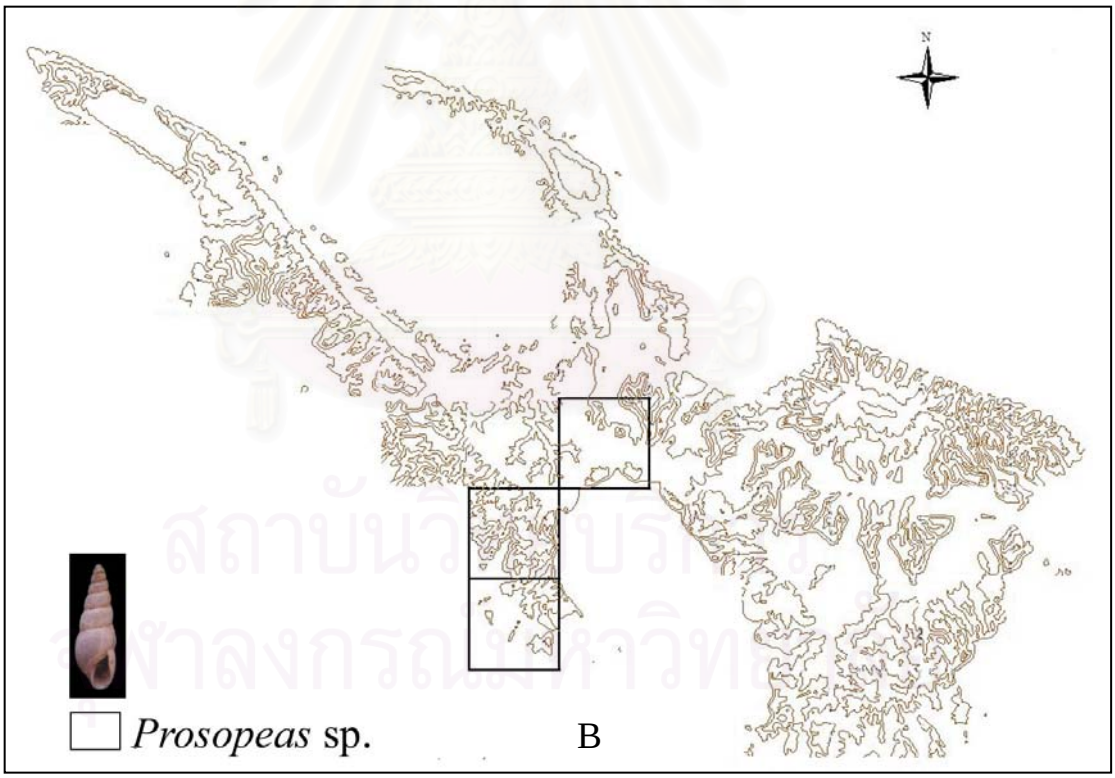


Figure 4.27 Distribution patterns of land snails on the Phu Phan mountain range; A, *Oxychilus* sp.; B, *Prosopeas* sp.

Family Bulimulidae

Pseudobuliminus (Giardia) siamensis (Redfield, 1853)

(Figures 4.28C, 4.29A, 4.30I, 4.31A)

1853 *Pseudobuliminus (Giardia) siamensis* Redfield, 15-16 pp.

1960 *Pseudobuliminus (Giardia) siamensis* Zilch

1966 *Pseudobuliminus (Giardia) siamensis* Solem, p. 104

2003 *Pseudobuliminus (Giardia) siamensis* Schileyko

Shell: Shell is 2.0-2.7 cm high and 0.8-0.9 cm wide, sinistral, elongate-ovate, shining, of 7-9 slightly convex whorls. Last whorl rounded, not deflected. Shell lip expanded. Color (pale) corneous. Embryonic whorls smooth. Aperture irregularly ovate, slightly oblique, with shortly reflexed, thin margins; columellar margin straight, well expanded. Shell sculpture with striae. Umbilicus narrowly open.

Reproductive system: Vas deferens very long, thin, entering epiphallus subapically. Flagellum very long. There is no distinct external boundary between epiphallus and penis. Penial retractor attached to middle part of epiphallus. Amatorial organ missing. Free oviduct rater long, somewhat cylindrical. Vagina very long, cylindrical. Gametolytic duct very long, cylindrical in lower part, upper part slender tube, gametolytic sac rather small, ovate.

Radula: Central tooth is unicuspid, triangular, smaller than first lateral. First lateral are bicuspid, larger than central tooth, entocone very small and set nearer the mesoconal tip, ectocone rather small. After twentieth lateral are tricuspid, entocones set nearer mesoconal tip, marginal teeth are tricuspid, ectocones have three cusps.

Habitat notes: The snail lives on undergrowth vegetation, on decaying wood, on tree trunks, on shrub in three forest types dry dipterocarp forest, dry evergreen forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 22 grids in through the mountain range.

Word distribution: Thailand, Vietnam 2-3 spp.

Family Bradybaenidae

***Thaitropis* sp.**

(Figures 4.28B, 4.29B, 4.30II, 4.31B)

1862 *Helix goniochila* Pfeiffer

2003 *Thaitropis goniochila* schileyko, p. 1632.

Shell: Shell is 0.5-1.6 cm high and 0.9-1.3 cm wide, dextral, obesely lentiform, of about 5-6 moderately convex whorls. Lip expanded. Last whorl scarcely deflected, with rounded, cord-like peripheral keel. Umbilicate shell. Color light-corneous to whitish. Embryonic whorls with exceptionally delicate spiral striae. Latter whorls finely irregularly, radial striated above. Aperture irregularly ovate, moderately oblique, with thin, shortly reflexed margins; small, smoothed. Umbilicus broad, shallow.

Reproductive system: Vas deferens long, thin, entering epiphallus apically. Epiphallus thin-walled, there is no distinct external boundary between epiphallus and penis. Penial retractor attached to proximal part of epiphallus. Amatorial organ missing. Free oviduct rater short. Vagina

very long, cylindrical. Gametolytic duct very long, somewhat swallen basally, gametolytic sac rather small, globular.

Radula: Central tooth is tricuspid, smaller than first lateral. First lateral are also tricuspid, entocone very small and set nearer the mesoconal tip, ectocone is also very small. After tenth lateral are tricuspid, ectocones have three small cusps, marginal teeth are tricuspid, entocones and ectocones have three to five small cusps.

Habitat notes: The empty shell were collected on ground surface or forest floor and the living snails live on ground surface or forest floor, on shrub, on small tree and undergrowth vegetation in dry dipterocarp forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 7 grids in the middle parts to the western parts of the mountain range.

Word distribution: Thailand 2 spp.

Family Achatinidae

***Achatina (Lissachatina) fulica* (Bowdich, 1822)**

(Figures 4.28A, 4.29C, 4.30III, 4.32A)

1822 *Achatina (Lissachatina) fulica* Bowdich, 1, pl, 13, fig. 3.

Shell: Elongate shell, dextral, very large, solid, pyramidal with produced spire and rounded base, with about 7 slightly convex whorls. Shell with flattened whorls. Shell lip not expanded, not deflected. Ground color light yellow or fawn, ornated with irregular brown or

mauve a greenish-yellow epidermis. With soft luster, little or not transparent. Coarsely striated in vertical direction. Embryonic whorls smooth. Aperture irregularly ovate, slightly oblique, with shortly reflexed, thin margins; columellar margin straight, shell surface sculptured with prominent, wrinkles. Imperforate shell. The last whorls round, not shouldered, suture slightly deep.

Animal: The pneumostome opens at the right side of a mantle rim lining the anterior margin of the shell. Within it are the anus and kidney aperture. There is a single genital pore placed near the right eye-bearing tentacle.

Reproductive system: Vas deferens thin and enters from free oviduct to distal epiphallus. Penial retractor muscle relative long, insert proximally near penis. Penis relative long, slender. Epiphallus relative long equal in length to penis, cylindrical. Vagina relative long, slender, cylindrical. Gametoytic duct relative long, gametolytic sac relative long, cylindrical. Free oviduct relative long. Albumen gland relative small.

Radula: Central tooth is unicuspid, rather small. First lateral teeth are tricuspid, larger than central tooth, distinctly entoocone and ectocone. After fourth lateral, mesocones reduced and set nearer mesoconal tip, lost on marginal teeth.

Habitat notes: The empty shell was collected on ground surface or forest floor, the living snails were found on shrub and small trees which surrounding plantation in dry dipterocarp forest and mixed deciduous forest.

Distribution on the Phu Phan mountain range: The snails were found in 2 grids in the middle parts to the eastern parts of the mountain range.

Word distribution: Tropical and subtropical Africa and adjacent islands, tropical Asia, Malaysian and Pacific islands

Family Trochomorphidae

***Trochomorpha* Albers, 1850**

***Trochomorpha* sp.**

(Figures 4.28D, 4.32B)

1850 *Trochomorpha* Albers, 1850

Shell: Shell dextral, strongly depressed-shell, conic, very thin, translucent, shining, fragile, with about 4-6 slightly convex whorls. Shell lip neither expanded nor reflected. Perforate shell. Last whorl not descending. Dark red in color. Embryonic whorl smooth, polished. Aperture widely lunate, only slightly oblique, with simple, sharp margins; columellar margin a little reflexed. Umbilicus relative tiny.

Habitat notes: The empty shells were collected from ground in dry dipterocarp forest. In this study we found only empty shell and shell fragment, so the detail of reproductive anatomy and radula were not studied.

Distribution on the Phu Phan mountain range: The snails were found in 1 grid in the eastern parts of the mountain range.

Word distribution: South and East Asia, Malay Archipelago, various Pacific Islands.

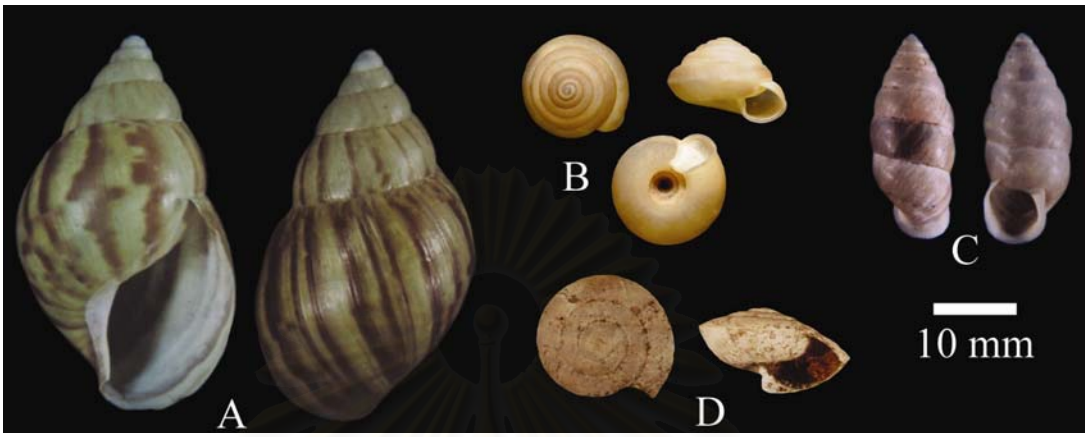


Figure 4.28 Shell shape of land snails; A, *A. (L.) fulica*; B, *Thaitropis* sp.; C, *P. (G.) siamensis*; D, *Trochomorpha* sp.

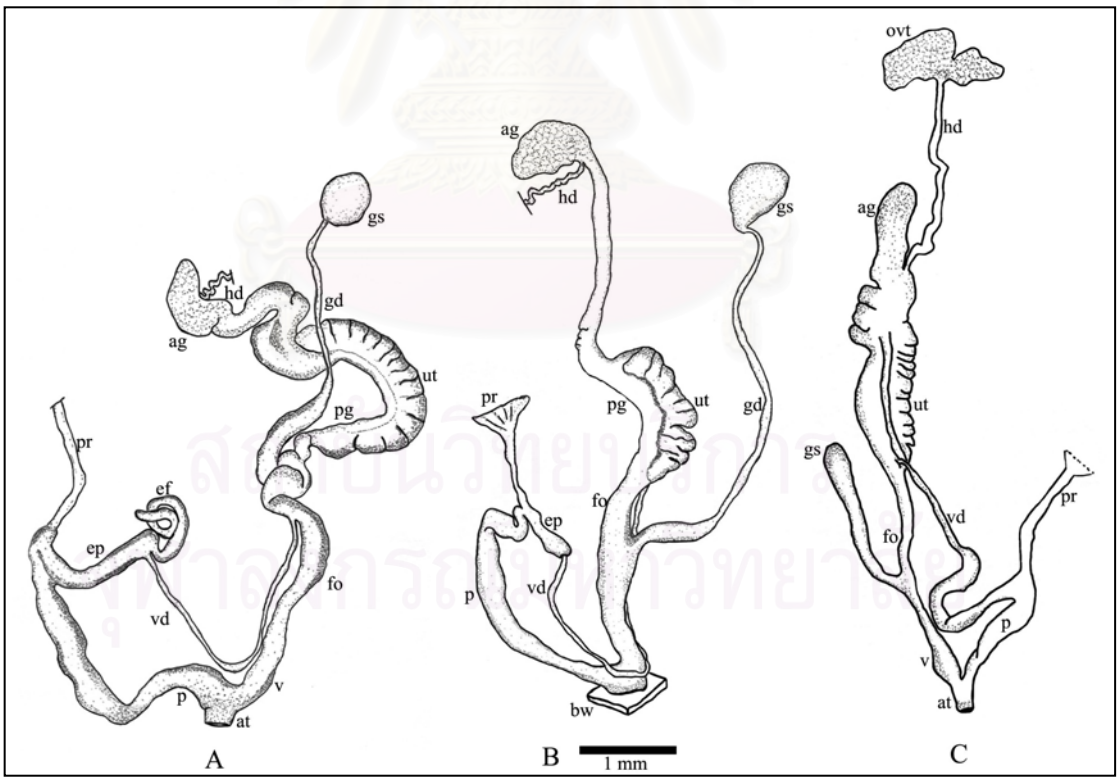


Figure 4.29 Genital systems of land snails; A, *P. (G.) siamensis*; B, *Thaitropis* sp.; C, *A. (L.) fulica*.

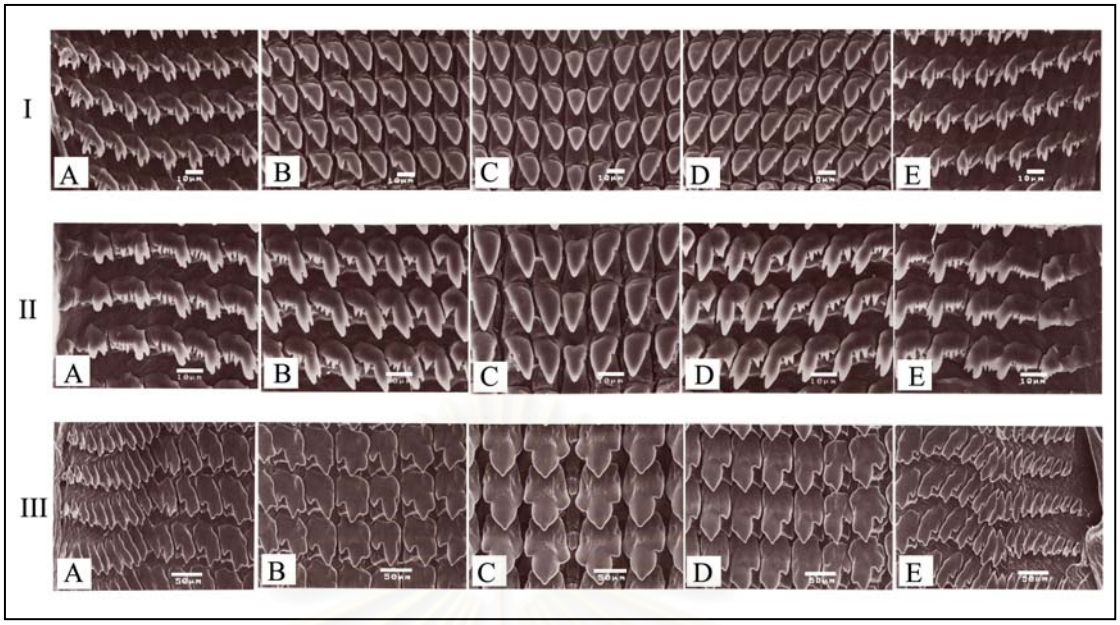
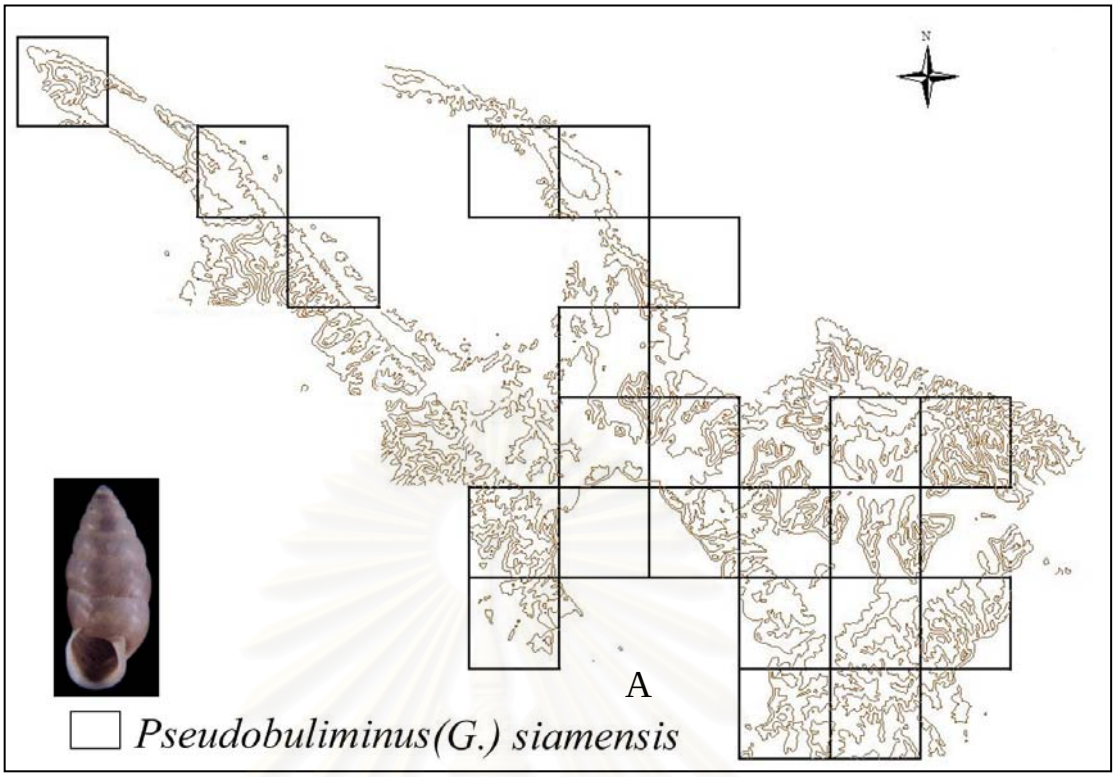


Figure 4.30 I, radula of *P. (G.) siamensis*; II, radula of *Thaitropis* sp.; III, radula of *A. (L.) fulica*; A, lateral teeth and marginal teeth; B, lateral teeth; C, central tooth and lateral teeth; D, lateral teeth; E, lateral teeth and marginal teeth.



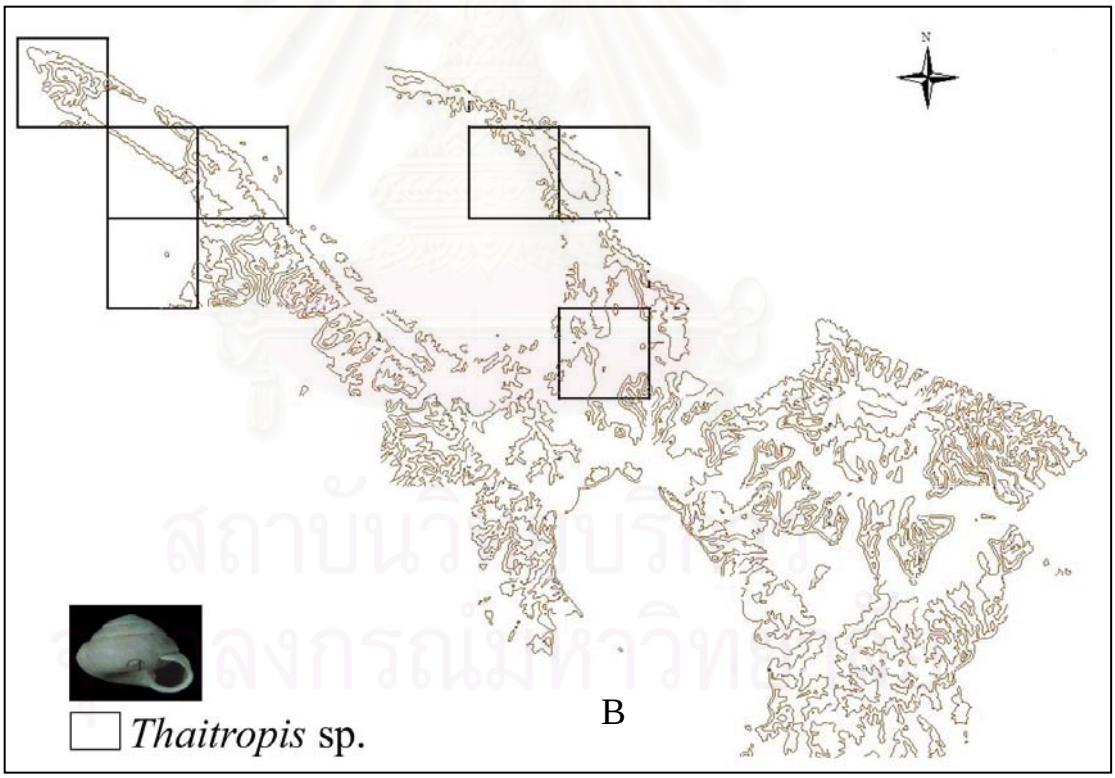
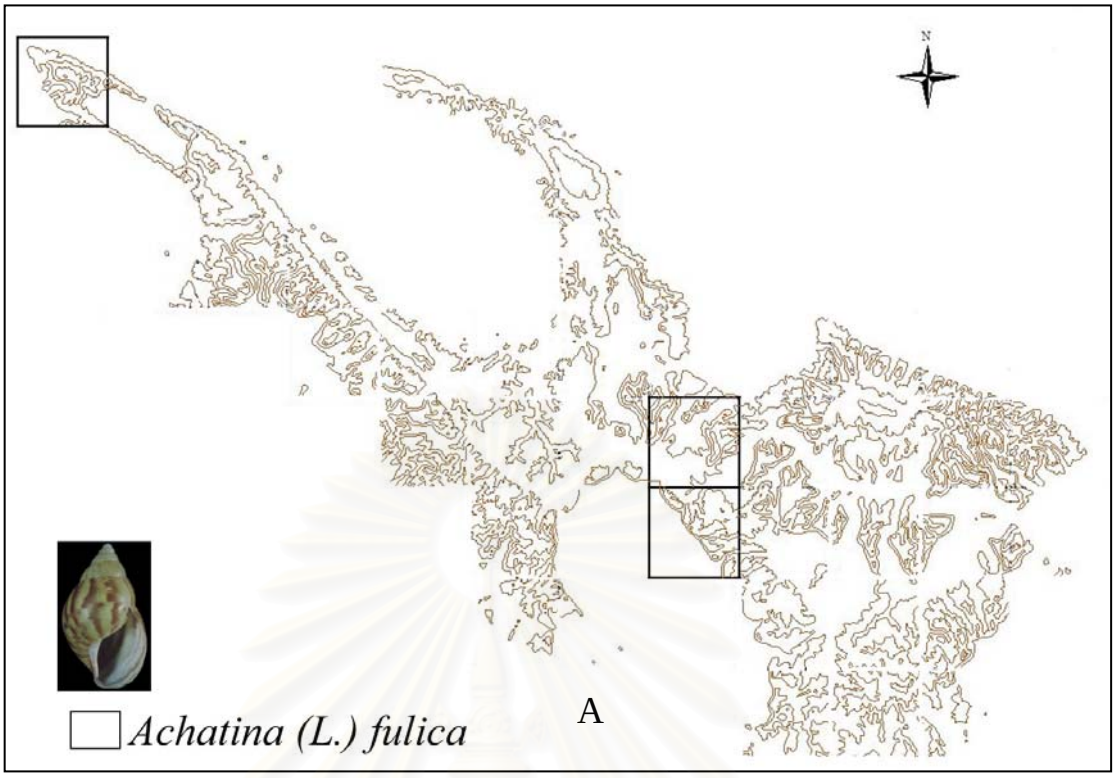


Figure 4.31 Distribution patterns of land snails on the Phu Phan mountain range; A, *P. (G.) siamensis*; B, *Thaitropis* sp.



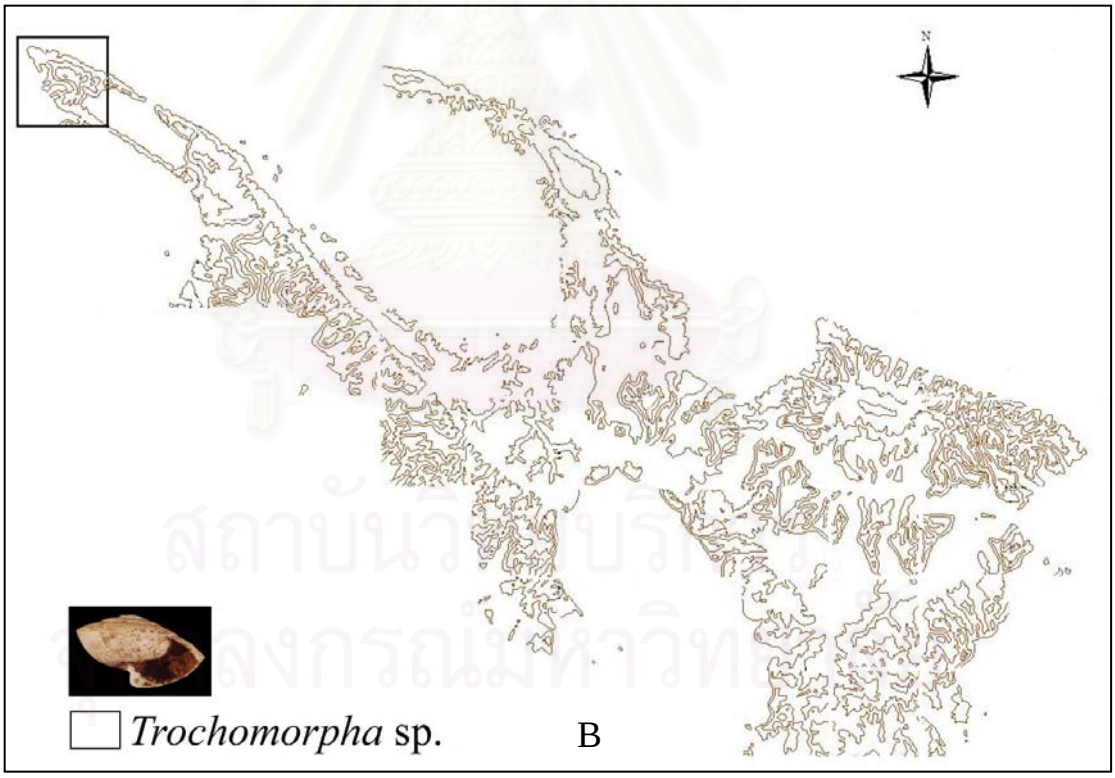


Figure 4.32 Distribution patterns of land snails on the Phu Phan mountain range; A, *A. (L.) fulica*; B, *Trochomorpha* sp.

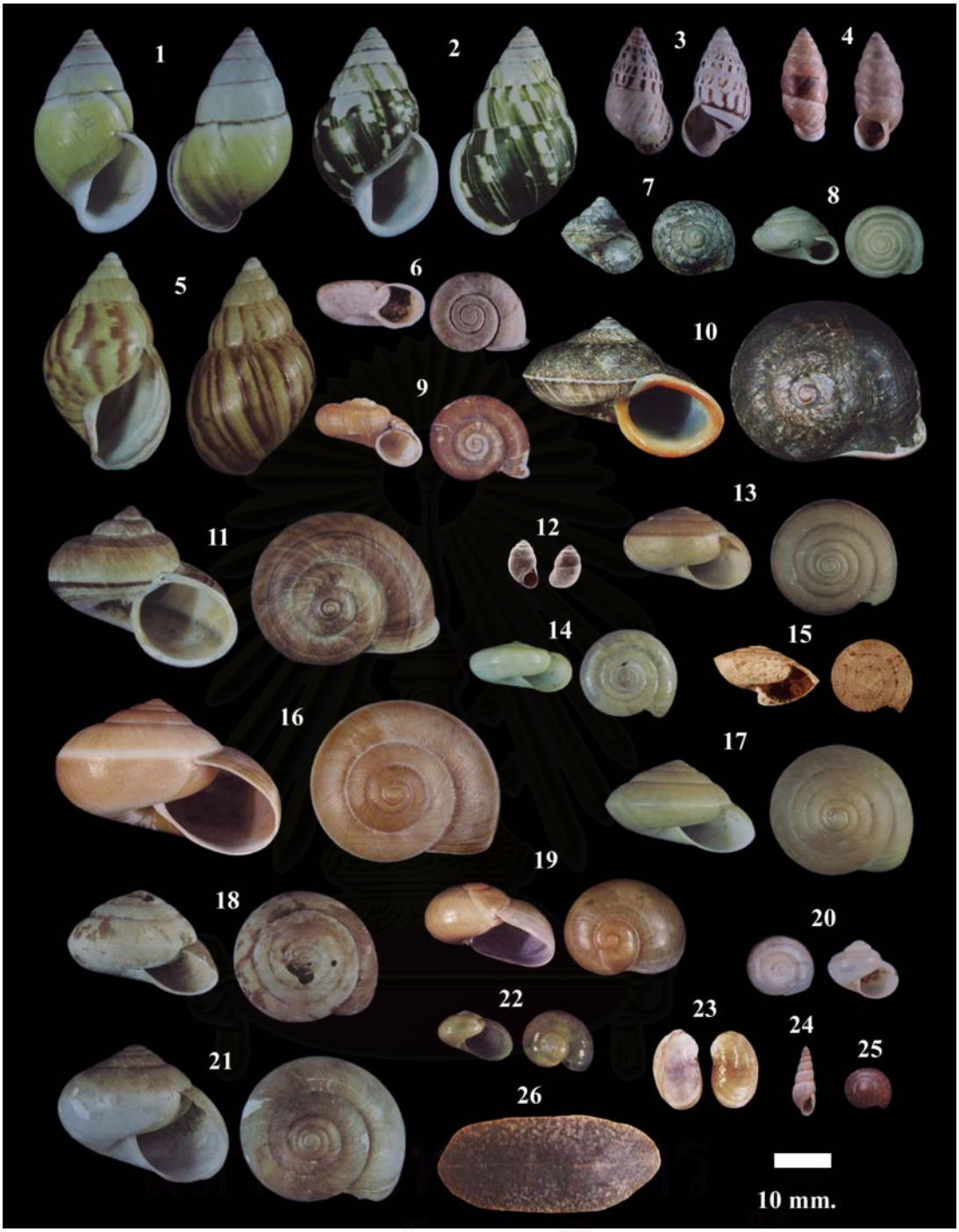


Figure 4.33 Land snails on the Phu Phan mountain range.1, *A. (A.) givenchyi*; 2, *A. (A.) schomburgki dextrochlorus*; 3, *A. (S.) zebrinus*; 4, *P. (G.) siamensis*; 5, *A. (L.) fulica*; 6, *C. (T.) tenella*; 7, *G. (G.) capitium*; 8, *Thaitropis* sp.; 9, *C. (S.) hinlapensis*; 10, *Cyclophorus* sp.; 11, *C. consociatus*; 12, *Pupina* sp.; 13, *C. siamensis*; 14, *S. resplendens*; 15, *Trochomorpha* sp.; 16, *H. distincta*; 17, *Q. weinkauffiana*; 18, *H. danae*; 19, *M. siamensis*; 20, *Durgella* sp.; 21, *P. globosa*; 22, *Vitrinopsis* sp.; 23, *P. martensi*; 24, *Prosopeas* sp.; 25, *Oxychilus* sp.; 26, *Semperula* sp.

Distribution patterns of land snails on the Phu Phan mountain range

Table 4.2 Land snails in three forest types; dry dipterocarp forest, mixed deciduous forest and dry evergreen forest.

Species/ forest types	**Dry dipterocarp forest (DDF)**	**Mixed deciduous forest (MDF)**	**Dry evergreen forest (DEF)**
1. *Cyclophorus consociatus*	√	√	√
2. *Cyclophorus* sp.		√	√
3. *Cyclotus (Siphonocyclotus) hinlapensis*	√	√	√
4. *Pupina* sp.		√	
5. *Amphidromus (Amphidromus) givenchyi*	√	√	√
6. *Amphidromus (Amphidromus) schomburgki dextrochlorus*		√	
7. *Amphidromus (Syndromus) zebrinus*	√	√	
8. *Chloritis (Trichochloritis) tenella*	√		
9. *Ganesella (Ganesella)capitium*	√		
10. *Quantula weinkauffiana*	√	√	√
11. *Phuphania globosa*	√	√	√
12. *Megaustenia siamensis*	√	√	√
13. *Vitrinopsis* sp.		√	
14. *Durgella* sp.		√	
15. *Parmarion martensi*		√	
16. *Semperula* sp.	√	√	
17. *Hemiplecta distincta*	√	√	√
18. *Hemiplecta danae*		√	√
19. *Sarika resplendens*	√	√	√
20. *Cryptozona siamensis*		√	
21. *Oxychilus* sp.		√	
22. *Prosopeas* sp.		√	√
23. *Pseudobuliminus (Giardia) siamensis*	√	√	√
24. *Thaitropis* sp.	√	√	
25. *Trochomorpha* sp.	√		
26. *Achatina (Lissachatina) fulica*	√	√	
Species richness	**16**	**23**	**12**

Alpha, gamma, and beta (α, γ and β) diversity in three forest types on the Phu Phan mountain range are show below.

alpha diversity was 17

gamma diversity was 26

beta diversity was 1.529

Beta diversity was low indicating the difference in species between forest types was low.

Distribution patterns of land snails were overlaid with three forest type from GIS data (scale 1:250,000). They are shown in figures 4.34-4.39. According to GIS data, some grids show one forest type, whereas others show two or three forest types. However, the field observation give more delicate information than GIS data, such as grid 7 *Pupina* sp. was collected from mixed deciduous forest, whereas the map show only one forest type dry dipterocarp forest. The map from GIS data is the country scale, which it is too large when use with small area such as Phu Phan range. Therefore, in the western part of Phu Phan, dry evergreen forest occurs only along the stream, and mixed deciduous forest occurs as transition zone of former one and dry dipterocarp forest which it is too small area and can not present on the map scale 1:250,000. From above reason, the distribution patterns map of land snails, which overlay with three forest types data cannot used in most species for example *Pupina* sp. and *Amphidromus (Amphidromus) schomburgki dextrochlorus*. The distribution map can used in some species such as *Ganesella (Ganesella) capitium* and *Trochomorpha* sp. occurred only in dry dipterocarp forest from field studied and the map show the two species occurred only in dipterocarp forest.

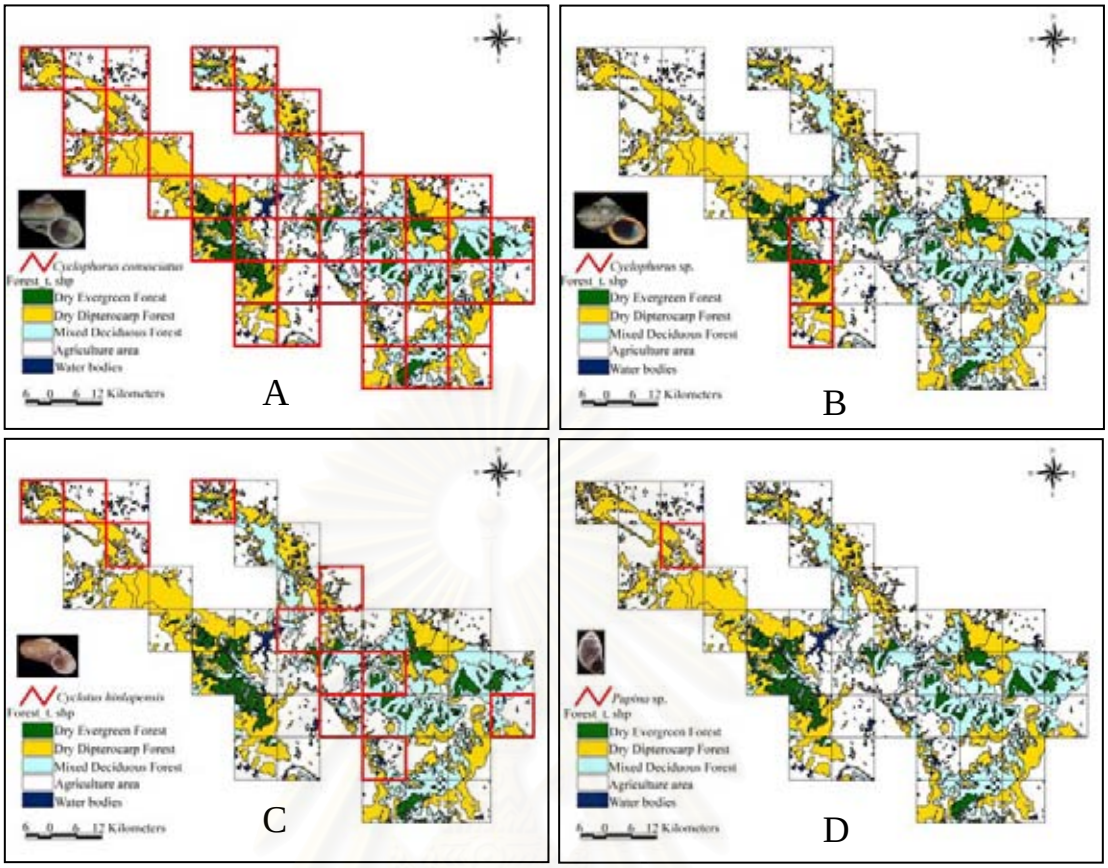


Figure 4.34 Distribution maps of land operculate snails in three forest types on the Phu Phan mountain range. A, *C. consociatus*; B, *Cyclophorus* sp.; C, *C. (S.) hinlapensis*; D, *Pupina* sp.

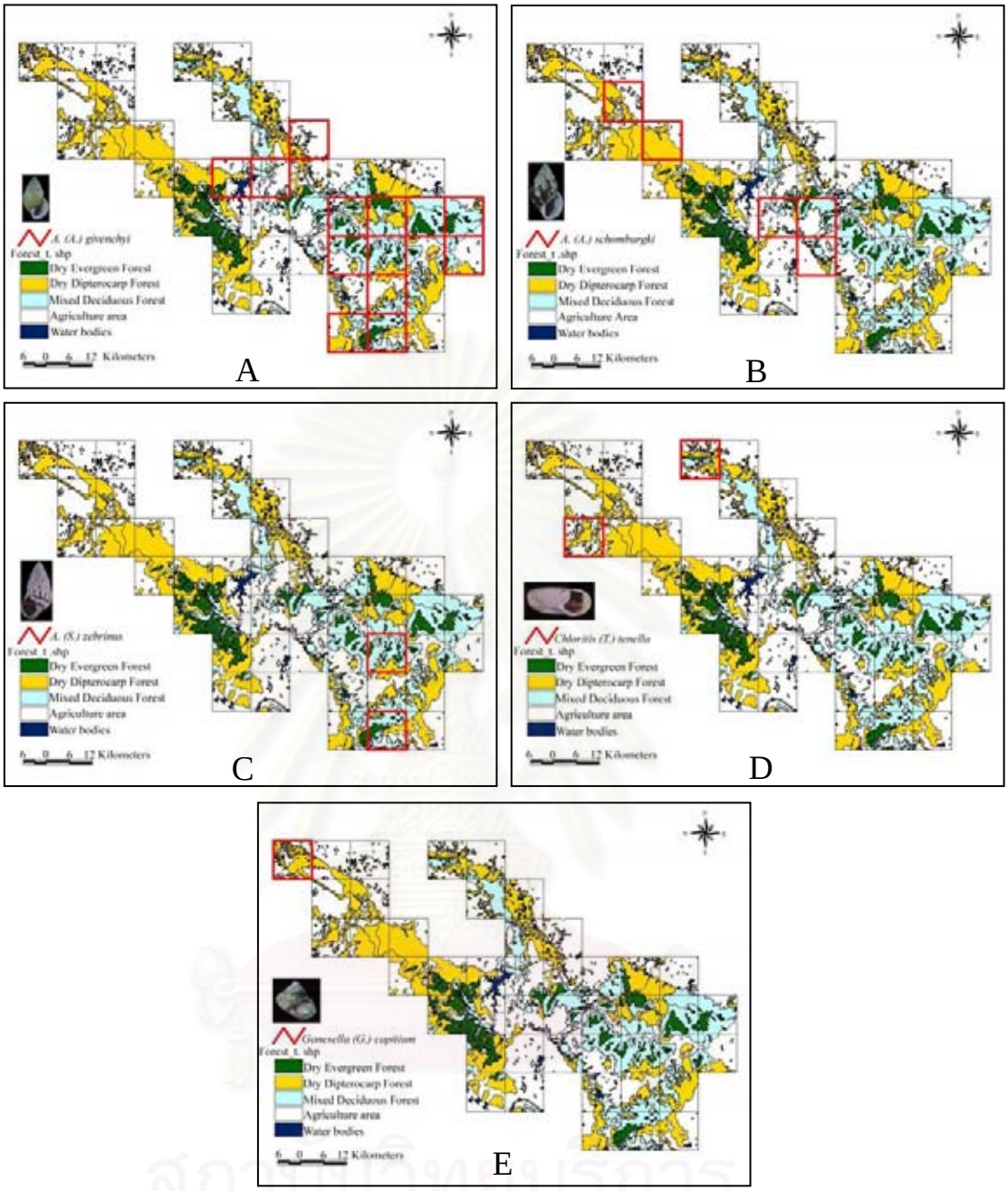


Figure 4.35 Distribution maps of camaenid snails in three forest types on the Phu Phan mountain range. A, *A. (A.) givenchyi*; B, *A. (A.) schomburgki dextrochlorus*; C, *A. (S.) zebrinus*; D, *C. (T.) tenella*; E, *G. (G.) capitium*.

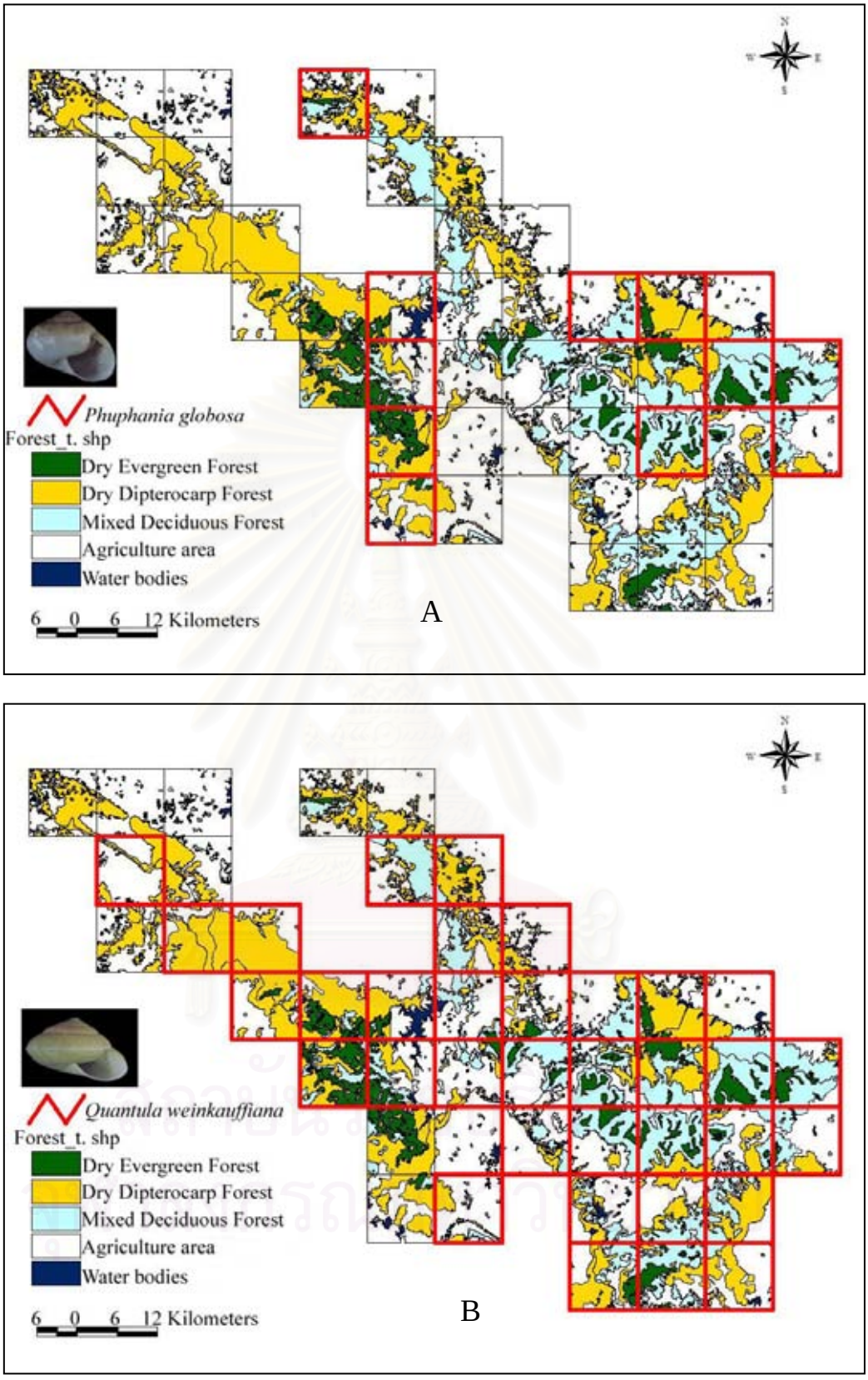


Figure 4.36 Distribution maps of dyakiid snails in three forest types on the Phu Phan mountain range. A, *P. globosa*; B, *Q. weinkauffiana*.

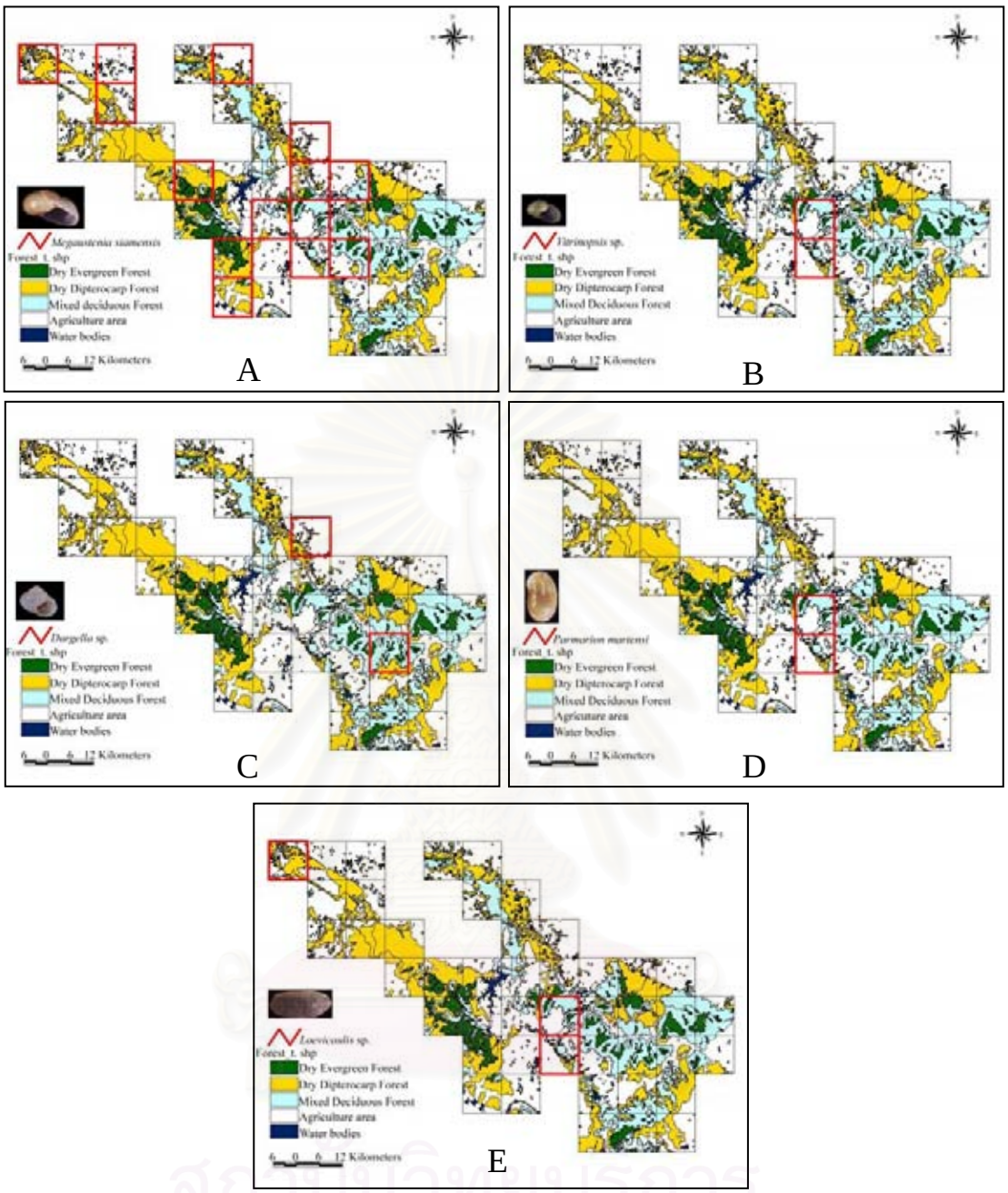


Figure 4.37 Distribution maps of semi-slugs and slug in three forest types on the Phu Phan mountain range. A, *M. siamensis*; B, *Vitrinopsis* sp.; C, *Durgella* sp.; D, *P. martensi*; E, *Semperula* sp.

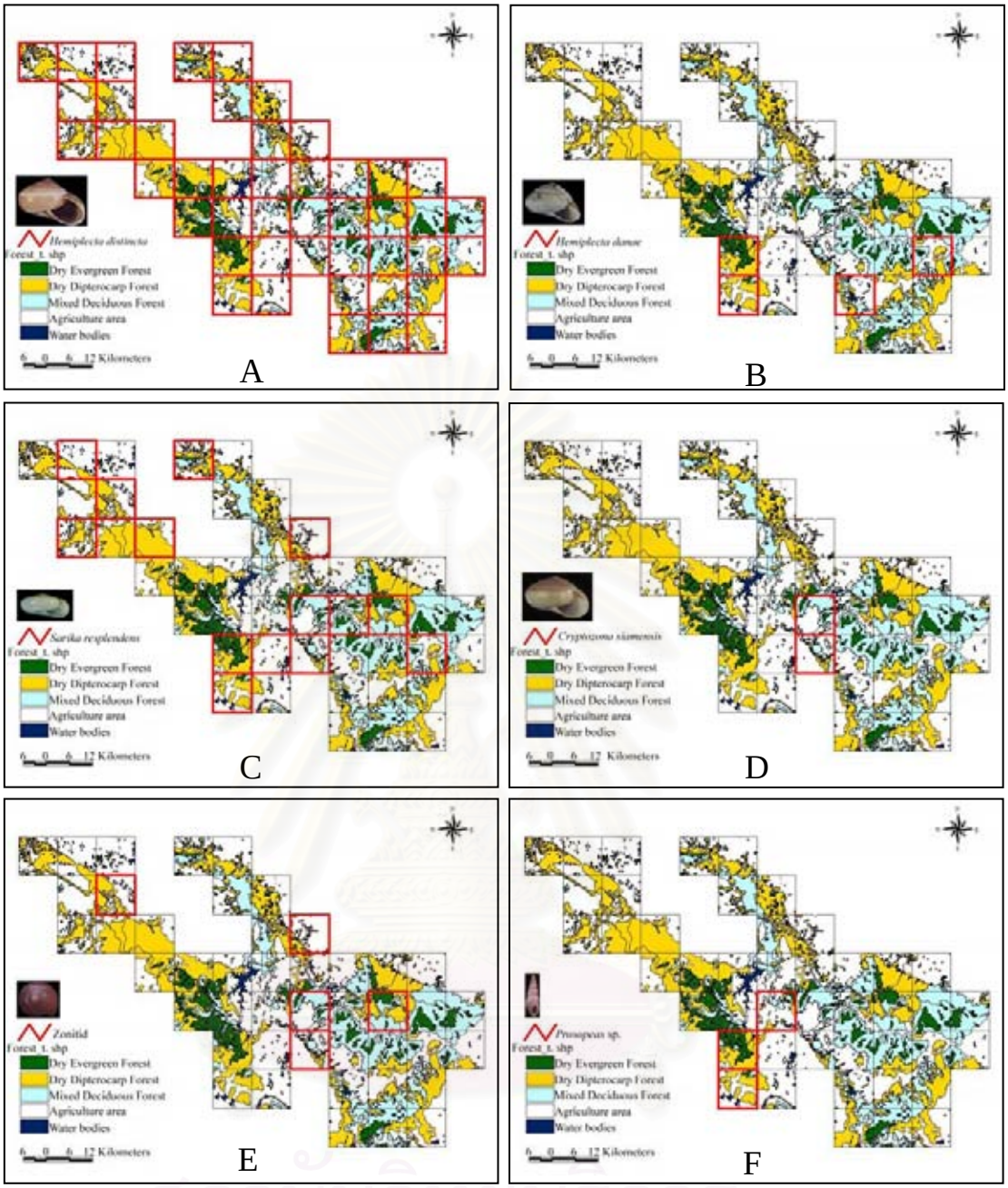


Figure 4.38 Distribution maps of land snails in three forest types on the Phu Phan mountain range. A, *H. distincta*; B, *H. danae*; C, *S. resplendens*; D, *C. siamensis*; E, *Oxychilus* sp.; F, *Prosopeas* sp.

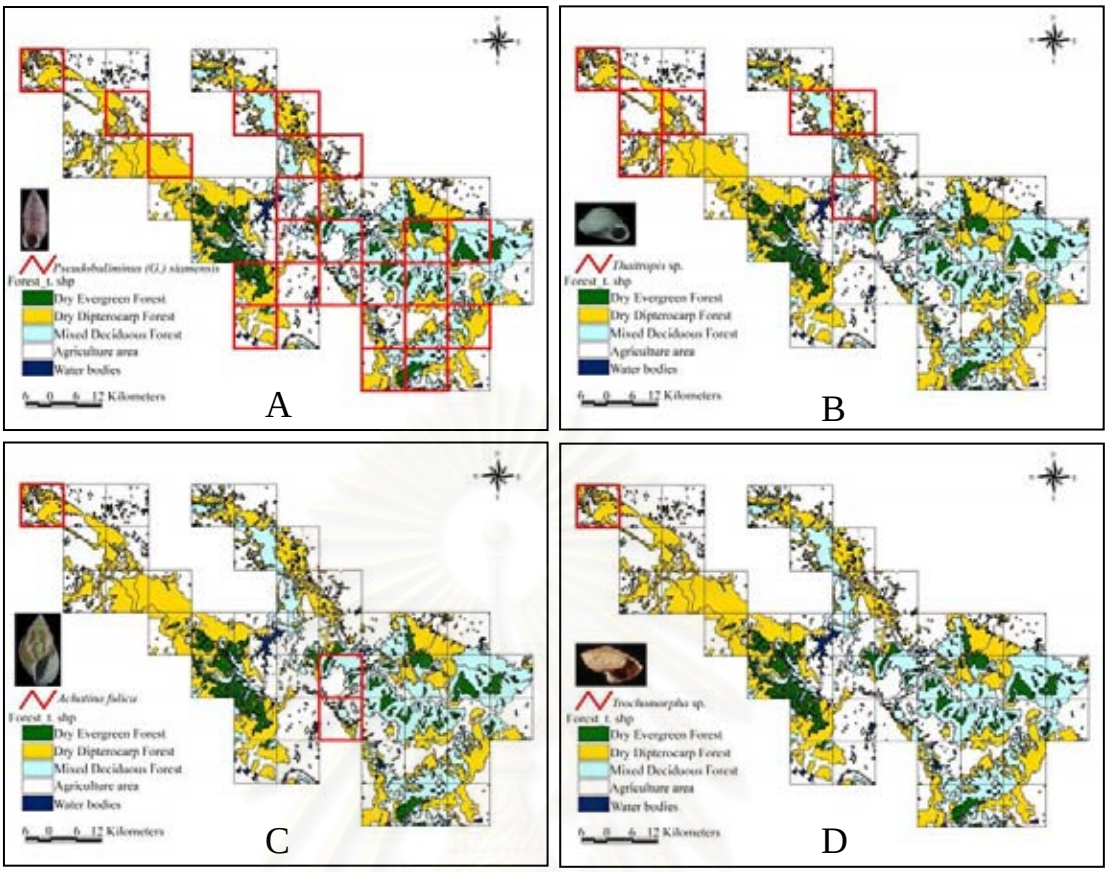


Figure 4.39 Distribution maps of land snails in three forest types. A, *P. (G.) siamensis*; B, *Thaitropis* sp.; C, *A. (L.) fulica*; D, *Trochomorpha* sp.

Ecological study

A total of 3,446 specimens (live snails, empty shell and shell fragments) of twenty-six species/ morphospecies were collected during the sampling on the Phu Phan mountain range, the number of specimens per plot range from 36 to 166 specimens, the average number of specimens per plot was 76.57 (±33.60). The number of species per plot range from 3 to 14 species, the average number of species per plot was 5.59 (±2.78).

Sampling the snails in dry dipterocarp forest yielded between 39 and 114 specimens per plot. In total, 1,225 specimens were collected, representing 16 species, the average number of specimens per plot was 61 (±17). In mixed deciduous forest, number of specimens per plot ranged from 36 to 166, for a total 1,734 belonging to 23 species, the average number of specimens per plot was 91 (±41). In dry evergreen forest, the number of specimens per plot range from 48 to 127, for a total 487 belonging to 12 species, the average number of specimens per plot was 81 (±30).

The total number of species per plot was significantly higher in mixed deciduous forest. In mixed deciduous forest, the average number of species per plot was 7.05 (±3.34), in dry dipterocarp forest, the average number of species per plot was 4.75 (±1.83), and in dry evergreen forest, the average number of species per plot was 5.66 (±1.96).

Table 4.3 Land snails in 45 grids on the Phu Phan mountain range.

Species/ forest types	**Number of individuals in each grid**														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. *Cyclophorus consociatus*	32	23	23	22	22	25	24	19	20	14	23	23	18	26	32
2. *Cyclophorus* sp.															
3. *Cyclotus (Siphonocyclotus) hinlapensis*	9	4		6			6							8	
4. *Pupina* sp.							12								
5. *Amphidromus (Amphidromus) givenchyi*	12	8	16	13	24	16	17	8	8	9	15	8	9	17	6
6. *Amphidromus (Amphidromus) schomburgki dextrochlorus*															
7. *Amphidromus (Syndromus) zebrinus*	8	9		9			16			3		8		18	
8. *Chloritis (Trichochloritis) tenella*															
9. *Ganesella (Ganesella)capitium*	15		8		9		9	5						9	
10. *Quantula weinkauffiana*														16	
11. *Phuphania globosa*							9					3			
12. *Megaustenia siamensis*															
13. *Vitrinopsis* sp.	6														
14. *Durgella* sp.				12						3					
15. *Parmarion martensi*															
16. *Semperula* sp.	3														
17. *Hemiplecta distincta*														2	
18. *Hemiplecta danae*							2							2	
19. *Sarika resplendens*	13					12	14	5	5	12					
20. *Cryptozona siamensis*															
21. *Oxychilus* sp.	4														
22. *Prosopeas* sp.															
23. *Pseudobuliminus (Giardia) siamensis*	8						17	8	8			7		9	
24. *Thaitropis* sp.	4														
25. *Trochomorpha* sp.						9	9	12	12		22	12	12	18	17
26. *Achatina (Lissachatina) fulica*				6											
total	114	44	47	68	55	62	135	57	53	41	60	61	39	125	55

Table 4.4 Land snails in 45 grids on the Phu Phan mountain range (continue).

Species/ forest types	Number of individuals in each grid														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. *Cyclophorus consociatus*	25	19	29	29	22	17	14	19	24	18	34	24	34	23	13
2. *Cyclophorus* sp.									23						
3. *Cyclotus (Siphonocyclotus) hinlapensis*			8								9	5			
4. *Pupina* sp.															
5. *Amphidromus (Amphidromus) givenchyi*	12	9	15	17	9	14	19	8	16	11	13	16	15	15	9
6. *Amphidromus (Amphidromus) schomburgki dextrochlorus*															
7. *Amphidromus (Syndromus) zebrinus*											22	17	14		
8. *Chloritis (Trichochloritis) tenella*											14				
9. *Ganesella (Ganesella)capitium*	8			8	6					16	16				
10. *Quantula weinkauffiana*		16	32									42	58	5	6
11. *Phuphania globosa*										12	9				
12. *Megaustenia siamensis*															
13. *Vitrinopsis* sp.															
14. *Durgella* sp.											3				
15. *Parmarion martensi*															
16. *Semperula* sp.															
17. *Hemiplecta distincta*															
18. *Hemiplecta danae*											3		2		
19. *Sarika resplendens*			31												
20. *Cryptozona siamensis*										3					
21. *Oxychilus* sp.											8				
22. *Prosopeas* sp.											4				
23. *Pseudobuliminus (Giardia) siamensis*			22							14	8		19	8	
24. *Thaitropis* sp.											2				
25. *Trochomorpha* sp.	19	16	21	23	12	22	23	21	23	17	16	23	24	15	22
26. *Achatina (Lissachatina) fulica*		11			4	3	2		16					5	2
total	64	71	158	77	53	56	58	48	102	91	161	127	166	71	52

Table 4.5 Land snails in 45 grids on the Phu Phan mountain range (continue).

Species/ forest types	Number of individuals in each grid														
	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
1. *Cyclophorus consociatus*	15	23	17	16	25	12	25	22	6	27	28	19	16	27	9
2. *Cyclophorus* sp.	12							9							
3. *Cyclotus (Siphonocyclotus) hinlapensis*			9				3			7					
4. *Pupina* sp.															
5. *Amphidromus (Amphidromus) givenchyi*	8	15	11	12	20	4	8	8	4	12	15	9	8	9	12
6. *Amphidromus (Amphidromus) schomburgki dextrochlorus*	3					2		2		2					
7. *Amphidromus (Syndromus) zebrinus*	12	11	9			15		8							
8. *Chloritis (Trichochloritis) tenella*			8												
9. *Ganesella (Ganesella)capitium*	15		6	8				9							
10. *Quantula weinkauffiana*			14	5	8		7				3		3	5	
11. *Phuphania globosa*															
12. *Megaustenia siamensis*					8									29	
13. *Vitrinopsis* sp.															
14. *Durgella* sp.			1												
15. *Parmarion martensi*															
16. *Semperula* sp.															
17. *Hemiplecta distincta*					2										
18. *Hemiplecta danae*			1		2										
19. *Sarika resplendens*															
20. *Cryptozona siamensis*	2							2							
21. *Oxychilus* sp.															
22. *Prosopeas* sp.															
23. *Pseudobuliminus (Giardia) siamensis*	7	9	12	12	9			14		17	9	12	11	8	
24. *Thaitropis* sp.			2												
25. *Trochomorpha* sp.			18	12	22	23	12		26	15	22	23	21	12	24
26. *Achatina (Lissachatina) fulica*	13				13		2	6							
total	87	58	113	65	109	56	57	80	36	80	77	69	59	90	45

Local diversity or alpha diversity (α diversity) is the number of species in small area of homogeneous habitat.

Regional diversity or gamma diversity (γ diversity) is the total number of species observed in all habitats within geographic area.

α, γ and β diversity in 45 grids on the Phu Phan mountain range.

$$\alpha \text{ diversity} = \frac{263}{26} = 5.84$$

$$\gamma \text{ diversity} = 26$$

$$\beta \text{ diversity} = 4.45$$

β diversity was high indicating the greater the difference in species between grids. Grids differing in vegetation had characteristics species assemblages, indicating a degree of habitat specialization.

Table 4.6 Summary of the number of specimens, richness and diversity at 45 grids of land snail in three forest types.

grid	forest types	no. of specimens	no. of species	Shannon Weiner Index	Dominance Index
1	dry dipterocarp forest	114	11	2.1672	0.1422
2	dry dipterocarp forest	44	4	1.1926	0.3564
3	dry dipterocarp forest	47	3	1.0179	0.3843
4	dry dipterocarp forest	68	6	1.6836	0.2054
5	dry dipterocarp forest	55	3	1.0246	0.3772
6	dry dipterocarp forest	62	4	1.3138	0.2877
7	mixed deciduous forest	135	11	2.1787	0.1221
8	dry dipterocarp forest	57	6	1.6724	0.2102
9	dry dipterocarp forest	53	5	1.4976	0.2481
10	dry dipterocarp forest	41	5	1.4420	0.2611
11	dry dipterocarp forest	60	3	1.0820	0.3438
12	mixed deciduous forest	61	6	1.6170	0.2308
13	dry dipterocarp forest	39	3	1.0579	0.3609
14	mixed deciduous forest	125	10	1.9093	0.1185
15	mixed deciduous forest	55	3	0.9197	0.4459
16	dry dipterocarp forest	64	4	1.3015	0.2915
17	dry diterocarp forest	71	5	1.5751	0.2132
18	mixed deciduous forest	158	7	1.8714	0.1618
19	mixed deciduous forest	77	4	1.2974	0.2906
20	mixed deciduous forest	53	5	1.4444	0.2709
21	dry dipterocarp forest	56	4	1.2323	0.3118
22	dry dipterocarp forest	58	4	1.1915	0.3240
23	dry evergreen forest	48	3	1.0271	0.3758
24	dry evergreen forest	102	5	1.5933	0.2062
25	mixed deciduous forest	91	7	1.8626	0.1616
26	mixed deciduous forest	161	14	2.3903	0.1097
27	dry evergreen forest	127	6	1.6477	0.2132
28	mixed deciduous forest	166	7	1.6988	0.2134
29	dry evergreen forest	71	6	1.6417	0.2168
30	dry evergreen forest	52	5	1.3885	0.2862
31	dry evergreen forest	87	9	2.0617	0.1364
32	mixed deciduous forest	58	4	1.3209	0.2841
33	mixed deciduous forest	113	14	2.3704	0.1061
34	dry dipterocarp forest	65	6	1.7359	0.1839
35	mixed deciduous forest	109	9	1.9615	0.1594
36	mixed deciduous forest	56	5	1.3559	0.2927
37	mixed deciduous forest	57	6	1.4951	0.2754
38	mixed deciduous forest	80	9	1.8456	0.0910
39	mixed deciduous forest	36	3	0.7777	0.5617
40	mixed deciduous forest	80	6	1.8364	0.2695
41	dry dipterocarp forest	77	5	1.4217	0.2669
42	mixed deciduous forest	63	4	1.3232	0.2809
43	dry dipterocarp forest	59	5	1.4571	0.2559
44	dry dipterocarp forest	90	6	1.6007	0.2325
45	dry dipterocarp forest	45	3	1.0096	0.3955

Table 4.7 Land snail diversity and abundance in three forest types.

Ecological Indices of species compositions	**Dry dipterocarp forest (DDF)**	**Mixed deciduous forest (MDF)**	**Dry evergreen forest (DEF)**
Replicates/plots	20	19	6
Species richness	16	23	12
Mean species/plot	4.75±1.83	7.05±3.34	5.66±1.96
Species range in plots	3-11	3-14	3-9
Mean snail per plot	61±17	91±41	81±30
Specimens total	1,225	1,734	487
Species diversity index	1.3838	1.6566	1.5600
Index of dominance	0.2826	0.2340	0.2391
Similarity index between DDF and MDF	0.400		
Similarity index between DDF and DEF	0.391		
Similarity index between MDF and DEF	0.406		

Species diversity (Shannon Weiner Index) was highest in mixed deciduous forest (1.6566), the second was found in dry evergreen forest (1.5600) and species diversity index was lowest in dry diptercarp forest (1. 3838).

The highest similarity index between dry dipterocarp forest and mixed deciduous forest was 0.406 indicates the highest number of snail species coexistence in both habitats. The lowest similarity index between dry dipterocarp forest and dry evergreen forest was 0.391 indicates the lowest number of snail species coexistence in both habitats may be the microhabitats between two areas are more different.

The low- spire species

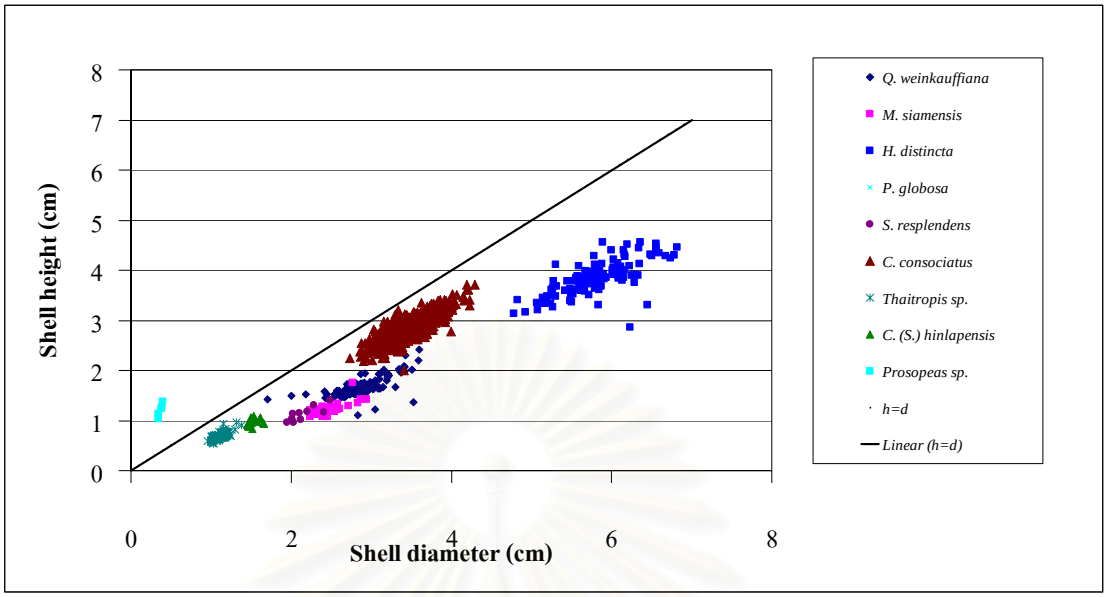


Figure 4.40 Distribution of h (shell height) against d (shell diameter) for the ground snails in the Phu Phan mountain range. Each symbol gives h and d for adult shells, the oblique line (h=d) served as a reference guide.

Fig 4.40 shows the h, d scatters for the ground snails. All are wholly or predominantly within the lower scatter, however the tiny snail *Prosopeas* sp. has tall-spired shells. The scatters indicates an essentially bimodal shell-shape distribution pattern as Cain (1978) presented among ground dwellers, the fauna strongly dominated by snails with rather flat shells (h<d). The line of shell height equal shell diameter indicates the predominance of taxa possessing rather flat shells. The flat shell shape predominates in the ground habitats, forest floor, undergrowth vegetations and rocks.

The high- spire species

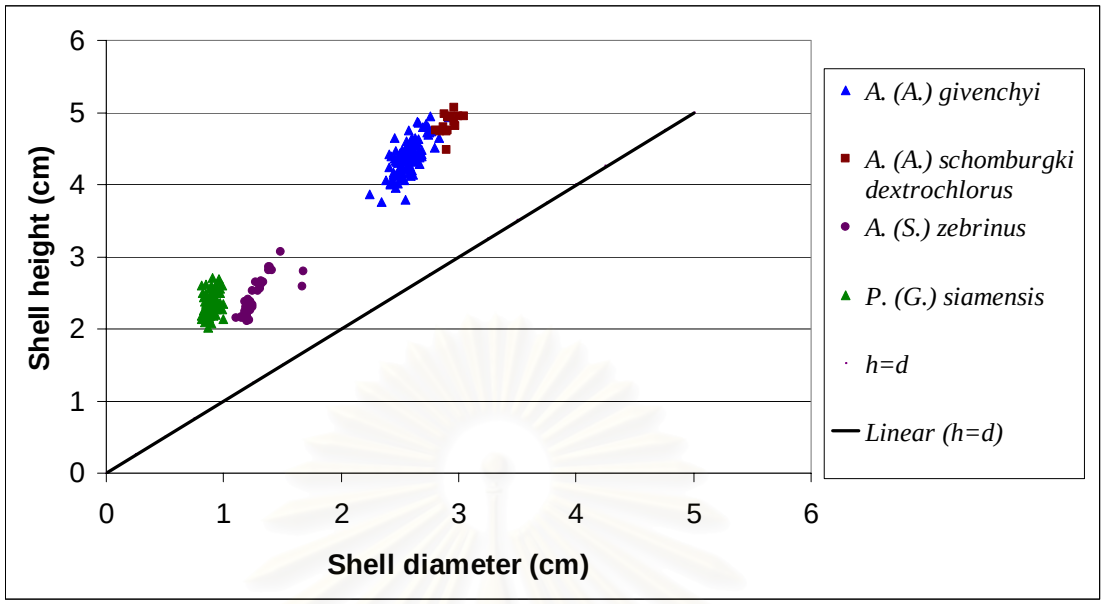


Figure 4.41 Distribution of h (shell height) against d (shell diameter) for the tree snails in the Phu Phan mountain range. Each symbol gives h and d for adult shells, the oblique line (h=d) served as a reference guide.

Fig 4.41 shows the h, d scatters for the tree snails. All are wholly or predominantly within the higher scatter. The scatter indicates an essentially unimodal shell-shape distribution pattern among snails in tree habitats, the fauna is strongly dominated by snails with rather tall-spired shells (h>d). The line height equal diameter indicates the predominance of taxa possessing rather height spire shell. The snails have shell in which the height exceeds the diameter.

Habitat relationship

The relationships between shell shape and height above ground of land snails was show below (Fig. 4.35).

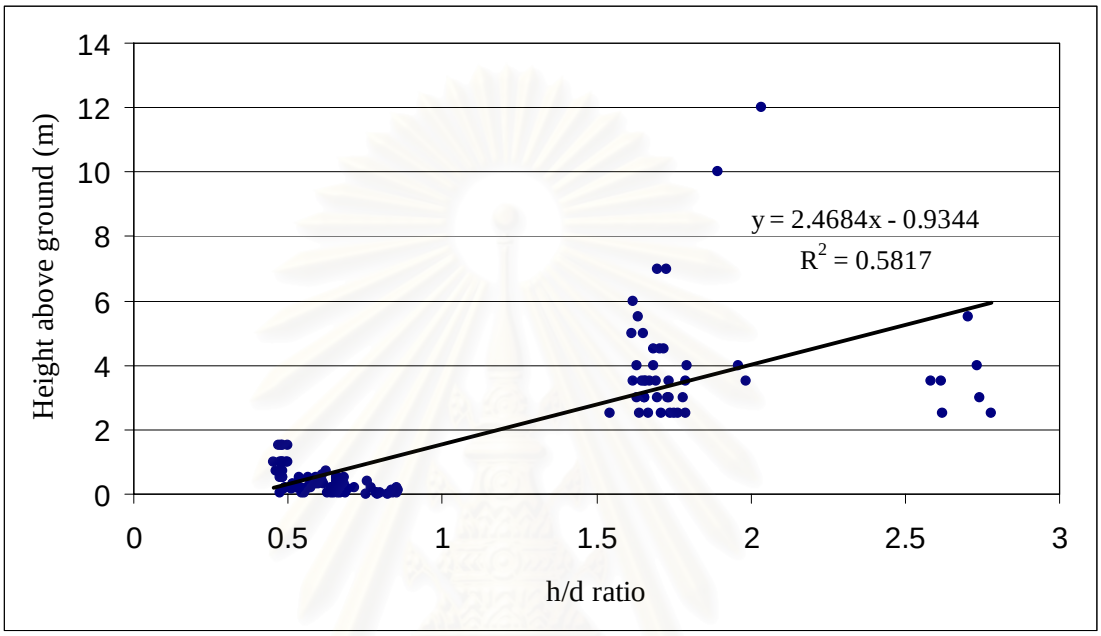


Figure 4.42 Shell shape and vertical distribution (high from ground level) of some land snails on the Phu Phan mountain range.

There was a significant positive correlation between shell shape and vertical distribution of land snails on the Phu Phan mountain range, from Fig. 4.45 shows the higher value of h/d ratio when the high vertical distribution increase (R^2 of a fitted linear trendline = 0.5817; $P < 0.05$). Mostly the snails which have rather flat shell (h/d ratio < 1) live on forest floor, ground habitats, undergrowth vegetations and rocks, and the snails have a tall shell (h/d >1) live or found mostly on tree habitats.

CHAPTER V

DISCUSSIONS

5.1 Taxonomy of land snails on the Phu Phan mountain range

Two subclasses, 15 families, 22 genera, and 26 species of land snails on the mountain range were collected and identified which including *Cyclophorus consociatus, Cyclophorus* sp., *Cyclotus* (*Siphonocyclotus*) *hinlapensis*, *Pupina* sp., *Amphidromus* (*Amphidromus*) *schomburgki dextrochlorus, A.* (*A.*) *givenchyi, A.* (*Syndromus*) *zebrinus., Chloritis* (*Trichochloritis*) *tenella, Ganeslla* (*Ganesella*) *capitium, Quantula weinkauffiana, Phuphania globosa, Megaustenia siamensis, Parmarion martensi, Vitrinopsis* sp., *Durgella* sp., *Semperula* sp., *Hemiplecta distincta, H. danae, Cryptozona siamensis, Sarika resplendens, Prosopeas* sp., *Oxichilus* sp., *Pseudobulimius* (*Giardia*) *siamensis, Achatina* (*Lissachatina*) *fulica, Thaitropis* sp. and *Trochomorpha* sp. One species *Phuphania globosa* was described as a new genus and new species (Tumpeesuwan *et al.,* 2007) indicated the northernmost distribution of the Dyakiidae. The separation of *Phuphania* from ancestor like *Bertia* might have arisen following uplift of the Khorat Plateau from the Thailand and Cambodian lowlands in the Early Tertiary. This would have allowed time for *Phuphania* to become adapted to the unique dry climatic pattern that became established on the Phu Phan mountain range. Sixteen individuals of *Pupina* sp. were collected at only one plot in mixed deciduous forest thought out the year 2004 to 2006 of collecting period. The apparently represent the first records for this genus in the Khorat Plateau.

Fifteen snail families were identified, of which the three most prominent in species richness are Ariophantidae (4 species), Camaenidae (5 species) and Cyclophoridae (3 species) this results are agree with to the checklist of land pulmonate snails by Panha (1996), the camaenid and ariophantid taxa proved to be abundant, diverse and Schilthuzen and Hendrikus (2001) showed that three families (Cyclophoridae, Ariophantidae, and Camaenidae) are common families of land snails in Southeast Asia.

The unique character of land snails on the Phu Phan mountain range

Comparison land snail faunas composition among three rock type mountains including limestone, granite and sandstone mountain are discussed. The land snail faunas in limestone mountain was studied at Doi Chiang Dao (Solem, 1966) which the unique taxa are *Dioryx bacca* and *Chlamalyceaeus* aff. *fimbricatus* (Family Cyclophoridae). The land snail faunas in granite mountains were studied at Doi Sutep (Solem, 1966) and Phliu National Park (Panha, 1997), which no unique taxon. The land snail faunas in sandstone mountains in the present study shows the absent of *Plectopylis* (Family Plectopylidae) which occurred in both limestone mountain and granite mountains, and the unique character is the absent of micro-snails. However, this comparison is different in the sampling method and the study areas are far from each others. The best comparison should be study land snail faunas composition in different rock type mountains in the adjacent areas of same latitude and also same the sampling methods. Schilthuizen *et al.*, (2003) studied abundance and diversity of land snails on limestone hills and non-limestone habitats in Sabah, Borneo Malaysia. Their study showed that limestone habitats do indeed support higher land snail densities than those of a non-limestone

substrate. The diversity on limestone areas is not much higher than non-limestone substrate.

5.2 Distribution patterns of land snails on the Phu Phan mountain range

5.2.1 Distribution patterns of land snails in 45 grids

Two species *Cyclophorus consociatus* and *Hemiplecta distincta* were collected from 45 grids throughout the mountain range. Two species *Sarika resplendens* and *Megaustenia siamensis* occurred in 14 of 45 grids throughout the mountain range. Three species *Ganesella (Ganesella) capitium, Pupina* sp. and *Trochomorpha* sp. were found in only one grid. Six species *Amphidromus (Syndromus) zebrinus, Chloritis (Trichochloritis) tenella, Cryptozona siamensis, Durgella* sp., *Parmarion martensi,* and *Vitrinopsis* sp. were collected from 2 grids. Four species *Achatina (Lissachatina) fulica, Cyclophorus* sp., *Prosopeas* sp. and *Semperula* sp. occurred in 3 grids on the mountain range. *Amphidromus (Amphidromus) schomburgki dextrochlorus* and *Oxychilus* sp. were collected from 5 of 45 grids. *Amphidromus (Amphidromus) givenchyi* occurred in 13 of 45 grids, *Cyclotus (Siphonocyclotus) hinlapensis* were found in 11 of 45 grids, *Hemiplecta danae* occurred in 4 of 45 grids, *Phuphania globosa* were found in 12 of 45 grids, *Pseudobuliminus (Giardia) siamensis* were collected from 22 of 45 grids through the mountain range. *Quantula weinkauffiana* occurred in 35 of 45 grids through the mountain range, *Thaitropis* sp. were collected from 7 of 45 grids in the middle parts to eastern parts of the mountain range.

Whittaker's index (Whittaker, 1975) was calculated as an estimate of between grids (beta) diversity. A value of unity indicates perfect correspondence of faunas between grids, and increasing values indicates increasing differentiation.

α diversity = 5.84, γ diversity = 26 and β diversity = 4.45

In this study have high beta diversity, this result agree with Gary *et al.,* in 1999 the beta diversity was 3.54). The high beta diversity indicates a level of habitat or niche specificity. The beta diversity was high and site occupancy per species was low, indicating they are difference species among grids (Whittaker, 1975).

5.2.2 Distribution patterns of land snails in three forest types

Ten species restrict to one forest type, whereas 16 species occurred among forest types. Nine species *C. consociatus*, *C. (S.) hinlapensis*, *Q. weinkauffiana*, *P. globosa*, *M. siamensis*, *H. distincta*, *S. resplendens*, *A. (A.) givenchyi* and *P. (G.) siamensis* were found in three forest types; dry dipterocarp forest, mixed deciduous forest and dry evergreen forest. Four species were found both in dry dipterocarp forest and mixed deciduous forest which including *A. (S.) zebrinus*, *Thaitropis* sp., *Semperula* sp. and *A. (L.) fulica*. Three species occurred both in mixed deciduous forest and dry evergreen forest such as *Cyclophorus* sp., *Prosopeas* sp., and *H. danae*. Three species *C. (T.) tenella*, *G. (G.) capitium* and *Trochomorpha* sp. occurred only in dry dipterocarp forest and three species were collected from a few grids in the mountain range and they occurred in the western parts of the mountain range. Seven species which including *Pupina* sp., *A. (A.) schomburgki dextrochlorus*, *Vitrinopsis* sp., *P. martensi*, *Durgella* sp., *C. siamensis*, and *Oxichilus* sp. were found only in mixed deciduous forest.

The distribution patterns of land snails in three forest types on the Phu Phan mountain range show that both common species and rare species. Some species is rare species such as *Pupina* sp. occurred only in mixed deciduous forest, however they were found only one plot in mixed

deciduous but they absent in other mixed deciduous forest. This result suggests that this species is narrow niche. The snails were collected from under leaf litter and under the soil in mixed deciduous forest. Some species such as *C. consociatus* and *H. distincta* are common and widespread. These two species were recorded in all 45 grids and were also found in both wet and dry season. It probable that these species have broad niche, in this study they occurred in various microhabitats such as ground surface, under leaf litter, on decaying plants, on rocks and on shrub. Shell of these snails is very solid, it may be retard breakdown of empty shell in the soil and they probably consume much calcium nutrient from the vegetation. These two species are edible snail, which were consumed by people in northeastern Thailand (Panha, 1994) and the snails occur in the wild and are gathered by villagers for consumption and for sale.

5.3 Comparison of the species composition of land snails in three forest types

In the study of abundance of snails, species composition, Shannon Weiner index, Index of dominance and similarity index of land snails were compared among the three forest types including dry dipterocarp forest, mixed deciduous forest and dry evergreen forest. A total of 3,446 specimens of twenty-six species were collected during the sampling on the mountain range, the number of specimens per plot range from 36 to 166 specimens, the average number of specimens per plot was 76.57 (±33.60). The number of species per plot range from 3 to 14 species, the average number of species per plot was 5.59 (±2.78).

Sampling in dry dipterocarp forest, the number of specimens per plot range from 39 to 114 specimens. In total, 1,225 specimens were

collected, representing 16 species, the average number of specimens (abundance) per plot was 61 (±17). In mixed deciduous forest, number of specimens per plot ranged from 36 to 166, for a total 1,734 belonging to 23 species, the average number of specimens per plot being 91 (±41). In dry evergreen forest, the number of specimens per plot range from 48 to 127, for a total 487 belonging to 12 species, the average number of specimens per plot was 81 (±30).

The highest abundance was recorded in dry evergreen forest, this forest located beside water and tree species in this forest are mainly evergreen, while some shed leaves during the dry season (Bunyavejchewin, 1986). This results suggest that the highest abundance is probable that the leaves or molds and fungi growing upon fallen leaves are directly associated with snails in food chain relationship. Food is a very important factor in determining the abundance of snails (Burch, 1955). The microhabitats in this forest types are leaf litter, tree trunk, dead plant and decaying wood. The dry evergreen forest locates beside the water. Getz (1974) concluded there was positive correlation between snail abundance and moisture regime.

The total number of species (species richness) per plot was significantly higher in mixed deciduous forest. In mixed deciduous forest, the average number of species per plot was 7.05 (±3.34), in dry dipterocarp forest, the average number of species per plot was 4.75 (±1.83), and in dry evergreen forest, the average number of species per plot was 5.66 (±1.96). The highest species richness of land snails was found in mixed deciduous forest, the forest is transitional forest type found between dry dipterocarp uplands and dry evergreen areas located next to water and the forest has more diverse forest type and more layer than dry evergreen forest and dry dipterocarp forest. Mwinzi (2003)

showed the highest species richness of plant was recorded in mixed forest 84 woody species. Getz (1974) showed that there was a positive correlation between snail diversity and diversity of dominant tree species. Getz and Uetz (1994) concluded that there was a significant positive correlation of species diversity of snails and tree leaf litter diversity. In this forest have various microhabitats such as leaf litter, mosses, bamboo trunk, bamboo leaves, rotten logs, and decaying wood. Coney *et al* (1986) showed that microhabitat difference were significantly more important for more species than any other factors.

The lowest abundance and species richness of snails were recorded in dry dipterocarp forest. The forest is a deciduous broad-leaved forest community type occurring in dry sites (Sahunalu and Dhanmanonta, 1995). Chantaranothai (2001) showed the dry dipterocarp can be divided into three dominance type *Shorea obtuse-Sindora siamensis* type, *Shorea obtuse-Dipterocarp obtusifolius* type and *Dipterocarus tubuculatus-Parinari anamense* type. The undergrowth and the forest floor are generally composed of tree sapling, dwarf bamboo-like grass *Arundinaria pusilla* and Cycads *Cycas siamensis* (Lamotte *et al.*, 1998). The low snail density and species richness in the dry dipterocarp forest was effect by the fire. This is important factor for land snails mortality and shell breakdown. The burning suddenly changes the tree structure and microhabitats. Fire is a principle factor controlling the dry dipterocarp forest and is believed to be the most important factor for maintaining the forest structures and species composition (Lamotte *et al*., 1998). In this forest types has a few microhabitats and locates in dry sites, both microhabitats and moisture correlate with snails abundance and species richness (Gezt, 1974 and Coney *et al*, 1986).

The highest snail diversity is represented in mixed deciduous forest (Shannon-Weiner Index=1.6566), the second and the lowest species diversity index are represented in dry evergreen forest and dry dipterocarp forest (Shannon-Weiner Index=1.5600 and 1.3838). This result agrees with land snail diversity study in Kenya, which the greatest snails diversity was concentrated within the mixed forest (Lange and Mwinzi, 2003). Mixed deciduous forest is more diverse vegetation than dry dipterocarp forest and dry evergreen forest, because the mixed deciduous forest is a transitional stage in succession from dry dipterocarp forest to dry evergreen forest. The study from the Sakaerat Environmental Research station represent that the mixed deciduous forest contains 84 woody species, whereas the dry evergreen forest and dry dipterocarp forest contain 48 and 37 species respectively (Lamotte *et al*., 1998). The trees in mixed deciduous forest are generally taller and the forest possess more layer than the other forest types (Bunyavejchewin, 1986). The greatest diversity of woody species and more forest layer of the mixed deciduous forest provide great habitat diversity, which greater habitat diversity positively correlates with greater resource gradient length and greater available niche space of snails (Tattersfield, 1996). The different types of vegetation are important factors determining the compositions of the snail fauna.

The similarity index, tools for comparing the similarity between two community samples. By the similarity measurement, the similarity index between mixed deciduous forest and dry evergreen forest was 0.406 shows the most similar snail species composition. The similarity index between them indicates 40.6% of the number of snail species coexistence in both habitats. It is possible that the mixed deciduous forest may consist of some similar microhabitat types occurring in dry

evergreen forest. The microhabitats between two areas are slightly different. The microhabitats were found both in the two forest types are under leaf litter, decaying wood and bamboo trunk. The similarity index between mixed deciduous forest and dry dipterocarp forest was 0.400. The similarity index between them indicates 40% of the number of snail species coexistence in both habitats. It is possible that the mixed deciduous forest may consist of some similar microhabitat types occurring in dry dipterocarp forest. The microhabitats between two areas are slightly different. The microhabitats were found both in the two forest types are under leaf litter. The similarity index between dry dipterocarp forest and dry evergreen forest was 0.391 indicates that about 39% of the number of snail species coexistence in both habitats. The microhabitats between two areas are slightly different.

The three forest types have low indices of dominance 0.2826, 0.2340 and 0.2391 in dry dipterocarp forest, mixed deciduous forest and dry evergreen forest respectively. The low index value implies that there is no dominant snail species exist in three forest types probably reflex many microhabitats, many food supply, low competition, and low predation in all three forest types. However, the highest dominance index in dry dipterocarp forest might be interpreted that some species is slightly dominance.

5.4 Relationships between shell shape (h/d ratio) and vertical distribution

In this study, the field clearly shows signs of considerable ecological specialization. Representatives of certain genera (*Achatina, Hemiplecta*, *Chloritis*, *Cryptozona, Megaustenia*, *Parmarion*, *Phuphania, Quantula*, *Sarika, Thaitropis*, and *Vitropsis*) were found on ground, low vegetation, foot and lower portions of large trees, while others genera

(*Amphidromus* and *Pseudobuliminus*) were only seen high in the trees. Finally Subulinidae, Cyclophoridae and Pupinidae were mostly seen alive in leaf litter and soil litter.

Mostly the snails which have rather flat shell (h/d ratio < 1) live on ground dweller habitats, undergrowth vegetations, forest floor and mostly the snails which have a tall shell or high spired shells (h/d >1) live on tree habitats. Figure 4.40 show the h, d scatters for ground snails. All are predominantly within the lower scatter indicates low spire shell (Cain, 1978), however in *Prosopeas* sp. is higher scatter or high spired shells. This result suggests that ecological explanations might account for the bimodality, with shell shape tied evolutionally to niche characteristics. They may be taking different food. Few species are food specialists. Food generalist may avoid competition by feeding preferentially on surface of different habitats, and that shell shape is at least partly adapted for locomotion at different angles (Cain, 1977a). Figure 4.41 show the h, d scatters for tree snails. All are predominantly within the higher scatter indicates high spired shell (Cain, 1978).

It was significant positive correlation between shell shape and habitat height of land snails on the mountain range, the shell shape (h/d ratio) increases with vertical distribution or height above ground level (R^2 of a fitted linear trendline = 0.5817; $P < 0.05$). This suggests that the shell shape of land snails is important factors for live in the microhabitat, may be the shell shape is suitable for foraging and reproductive activity. Further studies should be able to circumscribe the ecological niches of various species and the degree of niche overlap.

CHAPTER VI

CONCLUSIONS

1. Fifteen families, 22 genera, and 26 species of land snails on the Phu Phan mountain range were collected and identified.

2. *Phuphania globosa* was described and identified for the new genus and new species

3. Three prominent families in species richness are the Ariophantidae (4 species), Camaenidae (5 species) and Cyclophoridae (3 species).

4. *Cyclophorus consociatus* and *Hemiplecta distincta* are common and widespread species.

5. Ten species restrict in only one forest type, whereas 16 species occur among forest types. Nine species *Cyclophorus consociatus*, *Cyclotus (Siphonocyclotus) hinlapensis*, *Quatula weinkauffiana*, *Phuphania globosa*, *Megaustenia siamensis*, *Hemiplecta distincta*, *Sarika resplendens*, *Amphidromus (Amphidromus) givenchyi* and *Pseudobuliminus (Giardia) siamensis* were found in three forest types including to dry dipterocarp forest, mixed deciduous forest and dry evergreen forest. Four species were found in two forest type dry dipterocarp forest and mixed deciduous forest including *Amphidromus (Syndromus) zebrinus*, *Thaitropis* sp., *Semperula* sp. and *Achatina (Lissachatina) fulica*. Three species occurred in two forest type mixed deciduous forest and dry evergreen forest such as *Cyclophorus* sp., *Prosopeas* sp., and *Hemiplecta danae*. Three species *Chloritis (Trichochloritis) tenella*, *Ganesella (Ganesella) capitium* and *Trochomorpha* sp. were recorded only in dry dipterocarp forest. Seven species which including *Pupina* sp., *Amphidromus (Amphidromus)*

schomburgki dextrochlorus, *Vitrinopsis* sp., *Parmarion martensi*, *Durgella* sp., *Cryptozona siamensis*, and *Oxichilus* sp. were recorded only in mixed deciduous forest.

6. The 3,446 specimens (live snails, empty shell and shell fragments) of snails were collected on the mountain range, the number of specimens per plot range from 36 to 166 individuals (76.57±33.60). The average number of species per plot range from 3 to 14 species (5.59±2.78).

7. The abundance of snails was highest in dry evergreen forest (81 ±30) and the highest species richness of land snails was recorded in mixed deciduous forest (7.05 ±3.34).

8. The highest snail diversity (Shannon Weiner Index) was recorded in mixed deciduous forest (1.6566), the second was found in dry evergreen forest (1.5600) and the lowest diversity was found in dry dipterocarp forest (1.3838).

9. The highest similarity index between mixed deciduous forest and dry evergreen forest was 0.406. The second similarity index was recorded between dry dipterocarp forest and dry evergreen forest (0.400). The lowest similarity index (0.391) was found between dry dipterocarp forest and dry evergreen forest.

10. The highest index of dominance species was 0.2826 in dry dipterocarp forest, the second index of dominance species was 0.2340 in mixed deciduous forest and the lowest index of dominance species was 0.2391 in dry evergreen forest.

11. Mostly the snails which have rather flat shell (h/d ratio < 1) live on ground surface, forest floor, undergrowth vegetations, and the snails have a tall shell (h/d >1) live on tree habitats.

12. It was significant positive correlation between shell shape and habitat height of land snails on the mountain range, the shell shape (h/d

ratio) increases with vertical distribution or height above ground (R^2 of a fitted linear trendline = 0.5817; $P < 0.05$).

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APPENDICES

APPENDIX I

SPECIMENS COLLECTION

COLL. NO.	CUMZ	SCIENTIFIC NAME	LOCALITY	HABITAT	DATE	COLLECTOR	SPECIMENS	
							SHELL	WET
PPM 2004-001	001601	*Quantula weinkauffiana*	GRID 16	Ground	14/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-002	001602	*Amphidromus (Amphidromus) givenchyi*	GRID 22	under bamboo	13/5/2004	C. Tumpeesuwan	40D	-
PPM 2004-003	001603	*Quantula weinkauffiana*	GRID 22	Ground	13/5/2001	C. Tumpeesuwan	43 D	-
PPM 2004-004	001604	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 22	Litter, ground	13/5/2004	C. Tumpeesuwan	2D	-
PPM 2004-005	001605	*Pseudobuliminus (Giardia) siamensis*	GRID 22	Tree, ground	13/5/2004	C. Tumpeesuwan	8S	-
PPM 2004-006	001606	*Megaustenia siamensis*	GRID 22	Rock, ground	13/5/2004	C. Tumpeesuwan	11D	-
PPM 2004-007	001607	*Cyclophorus consociatus*	GRID 22	Litter, ground	13/5/2004	C. Tumpeesuwan	31D	-
PPM 2004-008	001608	*Hemiplecta distincta*	GRID 22	Ground	13/5/2004	C. Tumpeesuwan	12D	-
PPM 2004-009	001609	*Amphidromus (Amphidromus) givenchyi*	GRID 21	under bamboo	13/5/2004	C. Tumpeesuwan	60D	-
PPM 2004-010	001610	*Pseudobuliminus (Giardia) siamensis*	GRID 21	Shrub, ground	13/5/2004	C. Tumpeesuwan	5S	-
PPM 2004-011	001611	*Sarika resplendens*	GRID 21	Ground	13/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-012	001612	*Quantula weinkauffiana*	GRID 21	Ground	13/5/2004	C. Tumpeesuwan	5D	-
PPM 2004-013	001613	*Cyclophorus consociatus*	GRID 21	Ground	13/5/2004	C. Tumpeesuwan	25D	-
PPM 2004-014	001614	*Hemiplecta distincta*	GRID 21	Ground	13/5/2004	C. Tumpeesuwan	5D	-
PPM 2004-015	001615	*A. (A.) schomburgki dextrochlorus*	GRID 6	Ground	27/4/2004	C. Tumpeesuwan	5D	-
PPM 2004-016	001616	*Thaitropis* sp.	GRID 6	Ground	27/4/2004	C. Tumpeesuwan	60D	-
PPM 2004-017	001617	*Pupina* sp.	GRID 6	Litter, ground	27/4/2004	C. Tumpeesuwan	4D	8D
PPM 2004-018	001618	*Sarika resplendens*	GRID 6	Ground	27/4/2004	C. Tumpeesuwan	3D	-
PPM 2004-019	001619	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 6	Litter, ground	27/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-020	001620	*Pseudobuliminus (Giardia) siamensis*	GRID 6	Ground	27/4/2004	C. Tumpeesuwan	12D	-
PPM 2004-021	001621	*Megaustenia siamensis*	GRID 6	Rock, ground	27/4/2004	C. Tumpeesuwan	9D	-
PPM 2004-022	001622	*Cyclophorus consociatus*	GRID 6	Litter, ground	27/4/2004	C. Tumpeesuwan	40D	-
PPM 2004-023	001623	*Hemiplecta distincta*	GRID 6	Ground	27/4/2004	C. Tumpeesuwan	20D	-
PPM 2004-024	001624	*Hemiplecta distincta*	GRID 17	Ground	23/4/2004	C. Tumpeesuwan	5D	-
PPM 2004-025	001625	*Cyclophorus consociatus*	GRID 17	Litter, ground	23/4/2004	C. Tumpeesuwan	9D	-
PPM 2004-026	001626	*Phuphania globosa*	GRID 17	Ground	23/4/2004	C. Tumpeesuwan	3D	-
PPM 2004-027	001627	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 17	Ground	23/4/2004	C. Tumpeesuwan	3D	-
PPM 2004-028	001628	*Hemiplecta distincta*	GRID 5	Ground	24/4/2004	C. Tumpeesuwan	2D	-
PPM 2004-029	001629	*Cyclophorus consociatus*	GRID 5	Ground	24/4/2004	C. Tumpeesuwan	14D	-
PPM 2004-030	001630	*Pseudobuliminus (Giardia) siamensis*	GRID 5	Ground	24/4/2004	C. Tumpeesuwan	8S	-
PPM 2004-031	001631	*Megaustenia siamensis*	GRID 5	Ground	24/4/2004	C. Tumpeesuwan	2D	-
PPM 2004-032	001632	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 5	Ground	24/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-033	001633	*Sarika resplendens*	GRID 5	Ground	24/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-034	001634	*Cyclophorus consociatus*	GRID 26	Ground	10/5/2004	C. Tumpeesuwan	30D	-
PPM 2004-035	001635	*Quantula weinkauffiana*	GRID 26	Ground	10/5/2004	C. Tumpeesuwan	10D	-
PPM 2004-036	001636	*Phuphania globosa*	GRID 26	Ground	10/5/2004	C. Tumpeesuwan	10D	-
PPM 2004-037	001637	*Hemiplecta distincta*	GRID 26	Ground	10/5/2004	C. Tumpeesuwan	8D	-

COLL. NO.	CUMZ	SCIENTIFIC NAME	LOCALITY	HABITAT	DATE	COLLECTOR	SPECIMENS	
							SHELL	WET
PPM 2004-038	001638	*Quantula weinkauffiana*	GRID 25	Ground	10/5/2004	C. Tumpeesuwan	10D	-
PPM 2004-039	001639	*Hemiplecta distincta*	GRID 25	Ground	10/5/2004	C. Tumpeesuwan	4D	-
PPM 2004-040	001640	*Cyclophorus consociatus*	GRID 25	Ground	10/5/2004	C. Tumpeesuwan	21D	-
PPM 2004-041	001641	*Phuphania globosa*	GRID 25	Ground	10/5/2004	C. Tumpeesuwan	2D	-
PPM 2004-042	001642	*Hemiplecta distincta*	GRID 3	Ground	25/4/2004	C. Tumpeesuwan	19D	-
PPM 2004-043	001643	*Cyclophorus consociatus*	GRID 3	Ground	25/4/2004	C. Tumpeesuwan	9D	-
PPM 2004-044	001644	*Quantula weinkauffiana*	GRID 3	Ground	25/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-045	001645	*Thaitropis* sp.	GRID 3	Ground	25/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-046	001646	*Cyclophorus consociatus*	GRID 3	Ground	24/4/2004	C. Tumpeesuwan	2D	-
PPM 2004-047	001647	*Hemiplecta distincta*	GRID 19	Ground	8/5/2004	C. Tumpeesuwan	13D	-
PPM 2004-048	001648	*Quantula weinkauffiana*	GRID 19	Ground	8/5/2004	C. Tumpeesuwan	3D	-
PPM 2004-049	001649	*Cyclophorus consociatus*	GRID 19	Ground	8/5/2004	C. Tumpeesuwan	7D	-
PPM 2004-050	001650	*Pseudobuliminus (Giardia) siamensis*	GRID 19	Ground	8/5/2004	C. Tumpeesuwan	3S	-
PPM 2004-051	001651	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 19	Ground	8/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-052	001652	*Thaitropis* sp.	GRID 19	Ground	8/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-053	001653	*Oxychilus* sp.	GRID 19	Ground	8/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-054	001654	*Ganesella (Ganesella) capitium*	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-055	001655	*Hemiplecta distincta*	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	20D	-
PPM 2004-056	001656	*Cyclophorus consociatus*	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	90D	-
PPM 2004-057	001657	*Sarika resplendens*	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	2D	-
PPM 2004-058	001658	*Pseudobuliminus (Giardia) siamensis*	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	6S	-
PPM 2004-059	001659	*Thaitropis* sp.	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	6D	-
PPM 2004-060	001660	*Cyclophorus consociatus*	GRID 8	Ground	7/5/2004	C. Tumpeesuwan	20D	-
PPM 2004-061	001661	*Hemiplecta distincta*	GRID 8	Ground	7/5/2004	C. Tumpeesuwan	6D	-
PPM 2004-062	001662	*Quantula weinkauffiana*	GRID 8	Ground	7/5/2004	C. Tumpeesuwan	4D	-
PPM 2004-063	001663	*Pseudobuliminus (Giardia) siamensis*	GRID 8	Ground	7/5/2004	C. Tumpeesuwan	3S	-
PPM 2004-064	001664	*Thaitropis* sp.	GRID 8	Ground	7/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-065	001665	*A. (A.) schomburgki*	GRID 8	under bamboo	7/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-066	001666	*Cyclophorus consociatus*	GRID 23	Ground	13/5/2004	C. Tumpeesuwan	3D	-
PPM 2004-067	001667	*Hemiplecta distincta*	GRID 23	Ground	13/5/2004	C. Tumpeesuwan	4D	-
PPM 2004-068	001668	*Quantula weinkauffiana*	GRID 23	Ground	13/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-069	001669	*Megaustenia siamensis*	GRID 23	Ground	13/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-070	001670	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 23	Ground	13/5/2004	C. Tumpeesuwan	2D	-
PPM 2004-071	001671	*Sarika resplendens*	GRID 22	Ground	13/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-072	001672	*Hemiplecta distincta*	GRID 20	Ground	13/5/2004	C. Tumpeesuwan	2D	-
PPM 2004-073	001673	*Cyclophorus consociatus*	GRID 20	Ground	13/5/2004	C. Tumpeesuwan	4D	-
PPM 2004-074	001674	*Quantula weinkauffiana*	GRID 20	Ground	13/5/2004	C. Tumpeesuwan	3D	-

COLL. NO.	CUMZ	SCIENTIFIC NAME	LOCALITY	HABITAT	DATE	COLLECTOR	SPECIMENS	
							SHELL	WET
PPM 2004-075	001675	*Cyclophorus consociatus*	GRID 18	Ground	23/4/2004	C. Tumpeesuwan	10D	-
PPM 2004-076	001676	*Hemiplecta distincta*	GRID 18	Ground	23/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-077	001677	*Megaustenia siamensis*	GRID 18	Ground	23/4/2004	C. Tumpeesuwan	4D	-
PPM 2004-078	001678	*Cyclophorus consociatus*	GRID 24	Ground	13/5/2004	C. Tumpeesuwan	3D	-
PPM 2004-079	001679	*Quantula weinkauffiana*	GRID 24	Ground	13/5/2004	C. Tumpeesuwan	6D	-
PPM 2004-080	001680	*Phuphania globosa*	GRID 24	Ground	13/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-081	001681	*Cyclophorus consociatus*	GRID 9	Ground	7/5/2004	C. Tumpeesuwan	9D	-
PPM 2004-082	001682	*Hemiplecta distincta*	GRID 9	Ground	7/5/2004	C. Tumpeesuwan	8D	-
PPM 2004-083	001683	*Quantula weinkauffiana*	GRID 9	Ground	7/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-084	001684	*Megaustenia siamensis*	GRID 9	Ground	7/5/2004	C. Tumpeesuwan	11D	-
PPM 2004-085	001685	*Sarika resplendens*	GRID 4	Ground	25/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-086	001686	*Pseudobuliminus (Giardia) siamensis*	GRID 4	Ground	25/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-087	001687	*Thaitropis* sp.	GRID 4	Ground	25/4/2004	C. Tumpeesuwan	33D	-
PPM 2004-088	001688	*Hemiplecta distincta*	GRID 4	Ground	25/4/2004	C. Tumpeesuwan	6D	-
PPM 2004-089	001689	*Quantula weinkauffiana*	GRID 13	Ground	12/5/2004	C. Tumpeesuwan	6D	-
PPM 2004-090	001690	*Phuphania globosa*	GRID 13	Ground	12/5/2004	C. Tumpeesuwan	4D	-
PPM 2004-091	001691	*Cyclophorus consociatus*	GRID 13	Ground	12/5/2004	C. Tumpeesuwan	38D	-
PPM 2004-092	001692	*Pseudobuliminus (Giardia) siamensis*	GRID 13	Ground	12/5/2004	C. Tumpeesuwan	14S	-
PPM 2004-093	001693	*Thaitropis* sp.	GRID 13	Ground	12/5/2004	C. Tumpeesuwan	6D	-
PPM 2004-094	001694	*Sarika resplendens*	GRID 13	Ground	12/5/2004	C. Tumpeesuwan	5D	-
PPM 2004-095	001695	*Amphidromus (Amphidromus) givenchyi*	GRID 13	Ground	12/5/2004	C. Tumpeesuwan	4D	-
PPM 2004-096	001696	*Hemiplecta distincta*	GRID 13	Ground	12/5/2004	C. Tumpeesuwan	16D	-
PPM 2004-097	001697	*Cyclophorus consociatus*	GRID 27	Ground	12/5/2004	C. Tumpeesuwan	5D	-
PPM 2004-098	001698	*Hemiplecta distincta*	GRID 27	Ground	12/5/2004	C. Tumpeesuwan	14D	-
PPM 2004-099	001699	*Quantula weinkauffiana*	GRID 27	Ground	12/5/2004	C. Tumpeesuwan	4D	-
PPM 2004-100	001700	*Pseudobuliminus (Giardia) siamensis*	GRID 27	Ground	12/5/2004	C. Tumpeesuwan	6S	-
PPM 2004-101	001701	*Megaustenia siamensis*	GRID 27	Ground	12/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-102	001702	*Cyclophorus consociatus*	GRID 12	Ground	14/5/2004	C. Tumpeesuwan	23D	-
PPM 2004-103	001703	*Pseudobuliminus (Giardia) siamensis*	GRID 12	Ground	14/5/2004	C. Tumpeesuwan	3S	-
PPM 2004-104	001704	*Megaustenia siamensis*	GRID 12	Ground	14/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-105	001705	*Sarika resplendens*	GRID 12	Ground	14/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-106	001706	*Quantula weinkauffiana*	GRID 12	Ground	14/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-107	001707	*Phuphania globosa*	GRID 12	Ground, shrub	14/5/2004	C. Tumpeesuwan	-	3D
PPM 2004-108	001708	*Quantula weinkauffiana*	GRID 12	Ground	14/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-109	001709	*Cyclophorus consociatus*	GRID 14	Ground	14/5/2004	C. Tumpeesuwan	18D	-
PPM 2004-110	001710	*Hemiplecta distincta*	GRID 14	Ground	14/5/2004	C. Tumpeesuwan	3D	-
PPM 2004-111	001711	*Phuphania globosa*	GRID 14	Ground	14/5/2004	C. Tumpeesuwan	3D	-

COLL. NO.	CUMZ	SCIENTIFIC NAME	LOCALITY	HABITAT	DATE	COLLECTOR	SPECIMENS	
							SHELL	WET
PPM 2004-112	001712	*Quantula weinkauffiana*	GRID 14	Ground	14/5/2004	C. Tumpeesuwan	3D	-
PPM 2004-113	001713	*Cyclophorus consociatus*	GRID 15	Litter, ground	14/5/2004	C. Tumpeesuwan	-	15D
PPM 2004-114	001714	*Sarika resplendens*	GRID 15	Ground	14/5/2004	C. Tumpeesuwan	1D	-
PPM 2004-115	001715	*Pseudobuliminus (Giardia) siamensis*	GRID 15	Ground	14/5/2004	C. Tumpeesuwan	5S	-
PPM 2004-116	001716	*Hemiplecta distincta*	GRID 2	Ground	9/10/2003	C. Tumpeesuwan	9D	-
PPM 2004-117	001717	*Cyclophorus consociatus*	GRID 2	Ground	9/10/2003	C. Tumpeesuwan	6D	-
PPM 2004-118	001718	*Sarika resplendens*	GRID 2	Ground	9/10/2003	C. Tumpeesuwan	2D	-
PPM 2004-119	001719	*Hemiplecta distincta*	GRID 28	Ground	28/10/2003	C. Tumpeesuwan	2D	-
PPM 2004-120	001720	*Megaustenia siamensis*	GRID 28	Ground	28/10/2004	C. Tumpeesuwan	10D	-
PPM 2004-121	001721	*Cyclophorus consociatus*	GRID 28	Ground	28/10/2004	C. Tumpeesuwan	12D	-
PPM 2004-122	001722	*Prosopeas* sp.	GRID 28	Ground	28/10/2004	C. Tumpeesuwan	3D	-
PPM 2004-123	001723	*Quantula weinkauffiana*	GRID 28	Ground	28/10/2004	C. Tumpeesuwan	10D	-
PPM 2004-124	001724	*Cyclophorus consociatus*	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	10D	-
PPM 2004-125	001725	*Megaustenia siamensis*	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-126	001726	*Pseudobuliminus (Giardia) siamensis*	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	1D	-
PPM 2004-127	001727	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 1	Ground	30/4/2004	C. Tumpeesuwan	4D	-
PPM 2004-128	001728	*Durgella* sp.	GRID 22	Tree	19/6/2004	C. Tumpeesuwan	-	1D
PPM 2004-129	001729	*Phuphania globosa*	GRID 34	Shrub, ground	7/10/2004	C. Tumpeesuwan	-	20D
PPM 2004-130	001730	*Sarika resplendens*	GRID 1	Shrub, ground	6/10/2004	C. Tumpeesuwan	-	1D
PPM 2004-131	001731	*Pseudobuliminus (Giardia) siamensis*	GRID 28	Tree trunk	7/10/2004	C. Tumpeesuwan	-	10D
PPM 2004-132	001732	*Quantula weinkauffiana*	GRID 30	Shrub, ground	4/10/2004	C. Tumpeesuwan	-	2D
PPM 2004-133	001733	*Cyclophorus consociatus*	GRID 30	Ground	4/10/2004	C. Tumpeesuwan	-	1D
PPM 2004-134	001734	*Quantula weinkauffiana*	GRID 31	Shrub, ground	4/10/2004	C. Tumpeesuwan	-	2D
PPM 2004-135	001735	*Quantula weinkauffiana*	GRID 29	Ground	4/10/2004	C. Tumpeesuwan	-	3D
PPM 2004-136	001736	*Cyclophorus consociatus*	GRID 33	Ground	7/10/2004	C. Tumpeesuwan	-	1D
PPM 2004-137	001737	*Quantula weinkauffiana*	GRID 32	Ground	4/10/2004	C. Tumpeesuwan	-	1D
PPM 2004-138	001738	*Oxychilus* sp.	GRID 30	Ground	4/10/2004	C. Tumpeesuwan	-	2D
PPM 2004-139	001739	*Semperula* sp.	GRID 28	Tree	30/7/2004	C. Tumpeesuwan	-	4D
PPM 2004-140	001740	*Cryptozona siamensis*	GRID 28	Shrub, ground	30/7/2004	C. Tumpeesuwan	1D	10
PPM 2004-141	001741	*Parmarion siamensis*	GRID 28	Shrub	30/7/2004	C. Tumpeesuwan	-	6D
PPM 2004-142	001742	*Semperula* sp	GRID 1	Tree trunk	16/5/2004	C. Tumpeesuwan	-	1D
PPM 2004-143	001743	*Phuphania globosa*	GRID 13	Ground	30/7/2004	C. Tumpeesuwan	-	1D
PPM 2004-144	001744	*Hemiplecta distincta*	GRID 14	Ground	28/4/2004	C. Tumpeesuwan	-	1D
PPM 2004-145	001745	*Cyclophorus* sp.	GRID 32	Litter, ground	30/10/2003	C. Tumpeesuwan	-	8D
PPM 2004-146	001746	*Cyclophorus consociatus*	GRID 13	Ground	28/4/2004	C. Tumpeesuwan	-	10D
PPM 2004-147	001747	*Sarika resplendens*	GRID 13	Ground	16/5/2004	C. Tumpeesuwan	-	9D
PPM 2004-148	001748	*Quantula weinkauffiana*	GRID 28	Ground	28/10/2003	C. Tumpeesuwan	-	3D

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							SHELL	WET
PPM 2004-149	001749	*Achatina (Lissachatina) fulica*	GRID 28	Ground	28/10/2003	C. Tumpeesuwan	-	1D
PPM 2004-150	001750	*Phuphania globosa*	GRID 13	Ground	10/5/2004	C. Tumpeesuwan	-	1D
PPM 2004-151	001751	*Hemiplecta distincta*	GRID 13	Ground	10/5/2004	C. Tumpeesuwan	-	2D
PPM 2004-152	001752	*Sarika resplendens*	GRID 6	Ground	17/5/2004	C. Tumpeesuwan	-	2D
PPM 2004-153	001753	*Thaitropis* sp.	GRID 6	Ground	17/5/2004	C. Tumpeesuwan	-	3D
PPM 2004-154	001754	*Semperula* sp.	GRID 28	Ground	30/7/2004	C. Tumpeesuwan	-	1D
PPM 2004-155	001755	*Pseudobuliminus (Giardia) siamensis*	GRID 22	Ground	30/7/2004	C. Tumpeesuwan	-	3S
PPM 2004-156	001756	*Hemiplecta distincta*	GRID 22	Ground	30/7/2004	C. Tumpeesuwan	-	1D
PPM 2004-157	001757	*Quantula weinkauffiana*	GRID 22	Ground	30/7/2004	C. Tumpeesuwan	-	2D
PPM 2004-158	001758	*Quantula weinkauffiana*	GRID 21	Ground	30/7/2004	C. Tumpeesuwan	-	2D
PPM 2004-159	001759	*Pseudobuliminus (Giardia) siamensis*	GRID 21	Ground	30/7/2004	C. Tumpeesuwan	-	3S
PPM 2004-160	001760	*Phuphania globosa*	GRID 17	Ground	31/7/2004	C. Tumpeesuwan	-	7D
PPM 2004-161	001761	*Phuphania globosa*	GRID 13	Ground	30/7/2004	C. Tumpeesuwan	-	3D
PPM 2004-162	001762	*Hemiplecta distincta*	GRID 13	Ground	30/7/2004	C. Tumpeesuwan	-	1D
PPM 2004-163	001763	*Cyclophorus consociatus*	GRID 12	Ground	13/5/2004	C. Tumpeesuwan	-	3D
PPM 2004-164	001764	*Megaustenia siamensis*	GRID 22	Ground	17/5/2004	C. Tumpeesuwan	-	2D
PPM 2004-165	001765	*Quantula weinkauffiana*	GRID 22	Ground	17/5/2004	C. Tumpeesuwan	-	6D
PPM 2004-166	001766	*Sarika resplendens*	GRID 22	Ground	17/5/2004	C. Tumpeesuwan	-	3D
PPM 2004-167	001767	*Cyclophorus consociatus*	GRID 00	Ground	27/5/2004	C. Tumpeesuwan	-	2D
PPM 2004-168	001768	*Pseudobuliminus (Giardia) siamensis*	GRID 00	Ground	27/8/2004	C. Tumpeesuwan	-	9S
PPM 2004-169	001769	*Sarika resplendens*	GRID 13	Ground	30/7/2004	C. Tumpeesuwan	-	27D
PPM 2004-170	001770	*Quantula weinkauffiana*	GRID 13	Ground	30/7/2004	C. Tumpeesuwan	-	1D
PPM 2004-171	001771	*Phuphania globosa*	GRID 13	Ground	30/7/2004	C. Tumpeesuwan	-	1D
PPM 2004-172	001772	*Phuphania globosa*	GRID 32	Ground	7/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-173	001773	*Amphidromus (Syndromus) zebrinus*	GRID 41	Ground	5/10/2004	C. Tumpeesuwan	39S	-
PPM 2004-174	001774	*Amphidromus (Syndromus) zebrinus*	GRID 34	Ground	7/10/2004	C. Tumpeesuwan	25S	-
PPM 2004-175	001775	*Amphidromus (Amphidromus) givenchyi*	GRID 34	under Bamboo	4/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-176	001776	*Cyclophorus consociatus*	GRID 41	Ground	5/10/2004	C. Tumpeesuwan	117D	-
PPM 2004-177	001777	*Cyclophorus consociatus*	GRID 37	Ground	5/10/2004	C. Tumpeesuwan	41D	-
PPM 2004-178	001778	*Cyclophorus consociatus*	GRID 33	Ground	7/10/2004	C. Tumpeesuwan	21D	-
PPM 2004-179	001779	*Cyclophorus consociatus*	GRID 30	Ground	4/10/2004	C. Tumpeesuwan	38D	-
PPM 2004-180	001780	*Cyclophorus consociatus*	GRID 39	Ground	5/10/2004	C. Tumpeesuwan	5D	-
PPM 2004-181	001781	*Cyclophorus consociatus*	GRID 35	Ground	4/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-182	001782	*Cyclophorus consociatus*	GRID 22	Ground	30/7/2004	C. Tumpeesuwan	13D	1D
PPM 2004-183	001783	*Cyclophorus consociatus*	GRID 32	Ground	4/10/2004	C. Tumpeesuwan	-	6D
PPM 2004-184	001784	*Cyclophorus consociatus*	GRID 21	Ground	16/6/2004	C. Tumpeesuwan	10D	3D
PPM 2004-185	001785	*Cyclophorus consociatus*	GRID 34	Ground	7/10/2004	C. Tumpeesuwan	6D	-

COLL. NO.	CUMZ	SCIENTIFIC NAME	LOCALITY	HABITAT	DATE	COLLECTOR	SPECIMENS	
							SHELL	WET
PPM 2004-186	001786	*Cyclophorus consociatus*	GRID 38	Ground	7/10/2004	C. Tumpeesuwan	31D	-
PPM 2004-187	001787	*Cyclophorus consociatus*	GRID 40	Ground	5/10/2004	C. Tumpeesuwan	31D	-
PPM 2004-188	001788	*Cyclophorus consociatus*	GRID 31	Ground	4/10/2004	C. Tumpeesuwan	10D	-
PPM 2004-189	001789	*Cyclophorus consociatus*	GRID 29	Ground	4/10/2004	C. Tumpeesuwan	3D	-
PPM 2004-190	001790	*Cyclophorus consociatus*	GRID 21	Ground	30/7/2004	C. Tumpeesuwan	3D	-
PPM 2004-191	001791	*Hemiplecta distincta*	GRID 38	Ground	7/10/2004	C. Tumpeesuwan	10D	-
PPM 2004-192	001792	*Hemiplecta distincta*	GRID 41	Ground	5/10/2004	C. Tumpeesuwan	6D	-
PPM 2004-193	001793	*Hemiplecta distincta*	GRID 21	Ground	16/6/2004	C. Tumpeesuwan	5D	-
PPM 2004-194	001794	*Hemiplecta distincta*	GRID 22	Ground	19/6/2004	C. Tumpeesuwan	10D	-
PPM 2004-195	001795	*Hemiplecta distincta*	GRID 21	Ground	29/7/2004	C. Tumpeesuwan	2D	-
PPM 2004-196	001796	*Hemiplecta distincta*	GRID 31	Ground	4/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-197	001797	*Hemiplecta distincta*	GRID 35	Ground	4/10/2004	C. Tumpeesuwan	3D	-
PPM 2004-198	001798	*Hemiplecta distincta*	GRID 40	Ground	5/10/2004	C. Tumpeesuwan	4D	-
PPM 2004-199	001799	*Hemiplecta distincta*	GRID 34	Ground	7/10/2004	C. Tumpeesuwan	7D	-
PPM 2004-200	001800	*Hemiplecta distincta*	GRID 8	Ground	30/7/2004	C. Tumpeesuwan	1D	-
PPM 2004-201	001801	*Hemiplecta distincta*	GRID 30	Ground	4/10/2004	C. Tumpeesuwan	1D	1D
PPM 2004-202	001802	*Hemiplecta distincta*	GRID 37	Ground	5/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-203	001803	*Hemiplecta distincta*	GRID 29	Ground	4/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-204	001804	*Hemiplecta distincta*	GRID 32	Ground	4/10/2004	C. Tumpeesuwan	3D	1D
PPM 2004-205	001805	*Amphidromus (Amphidromus) givenchyi*	GRID 33	Ground	7/7/2004	C. Tumpeesuwan	14D	-
PPM 2004-206	001806	*Quantula weinkauffiana*	GRID 22	Ground	19/6/2004	C. Tumpeesuwan	7D	2D
PPM 2004-207	001807	*Quantula weinkauffiana*	GRID 40	Ground	5/10/2004	C. Tumpeesuwan	3D	-
PPM 2004-208	001808	*Amphidromus (Amphidromus) givenchyi*	GRID 40	Ground	5/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-209	001809	*Pseudobuliminus (Giardia) siamensis*	GRID 40	Ground	5/10/2004	C. Tumpeesuwan	1S	-
PPM 2004-210	001810	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 33	Ground	7/7/2004	C. Tumpeesuwan	4D	-
PPM 2004-211	001811	*Pseudobuliminus (Giardia) siamensis*	GRID 33	Ground	7/7/2004	C. Tumpeesuwan	7S	-
PPM 2004-212	001812	*Amphidromus (Amphidromus) givenchyi*	GRID 36	Ground	4/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-213	001813	*Quantula weinkauffiana*	GRID 36	Ground	4/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-214	001814	*Megaustenia siamensis*	GRID 33	Ground	7/7/2004	C. Tumpeesuwan	2D	-
PPM 2004-215	001815	*Phuphania globosa*	GRID 13	Ground	30/7/2004	C. Tumpeesuwan	2D	-
PPM 2004-216	001816	*Quantula weinkauffiana*	GRID 29	Ground	4/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-217	001817	*Amphidromus (Amphidromus) givenchyi*	GRID 29	Ground	4/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-218	001818	*Hemiplecta danae*	GRID 35	Ground	4/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-219	001819	*Pseudobuliminus (Giardia) siamensis*	GRID 30	Ground	4/10/2004	C. Tumpeesuwan	3S	-
PPM 2004-220	001820	*Phuphania globosa*	GRID 34	Ground	7/10/2004	C. Tumpeesuwan	3D	-
PPM 2004-221	001821	*Quantula weinkauffiana*	GRID 30	Ground	4/10/2004	C. Tumpeesuwan	5D	-
PPM 2004-222	001822	*Megaustenia siamensis*	GRID 31	Ground	4/10/2004	C. Tumpeesuwan	4D	-

COLL. NO.	CUMZ	SCIENTIFIC NAME	LOCALITY	HABITAT	DATE	COLLECTOR	SPECIMENS	
							SHELL	WET
PPM 2004-223	001823	*Pseudobuliminus (Giardia) siamensis*	GRID 41	Ground	5/10/2004	C. Tumpeesuwan	7S	-
PPM 2004-224	001824	*Quantula weinkauffiana*	GRID 33	Ground	7/10/2004	C. Tumpeesuwan	4D	-
PPM 2004-225	001825	*Amphidromus (Amphidromus) givenchyi*	GRID 30	Ground	4/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-226	001826	*Phuphania globosa*	GRID 32	Ground	4/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-227	001827	*Quantula weinkauffiana*	GRID 32	Ground	4/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-228	001828	*Pseudobuliminus (Giardia) siamensis*	GRID 39	Ground	5/10/2004	C. Tumpeesuwan	1S	-
PPM 2004-229	001829	*Quantula weinkauffiana*	GRID 34	Ground	7/10/2004	C. Tumpeesuwan	4D	-
PPM 2004-230	001830	*Quantula weinkauffiana*	GRID 31	Ground	4/10/2004	C. Tumpeesuwan	10D	-
PPM 2004-231	001831	*Pseudobuliminus (Giardia) siamensis*	GRID 34	Ground	7/10/2004	C. Tumpeesuwan	10S	-
PPM 2004-232	001832	*Quantula weinkauffiana*	GRID 41	Ground	5/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-233	001833	*Sarika resplendens*	GRID 31	Ground	4/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-234	001834	*Pseudobuliminus (Giardia) siamensis*	GRID 31	Ground	4/10/2004	C. Tumpeesuwan	2S	-
PPM 2004-235	001835	*Cyclophorus consociatus*	GRID 8	Ground	30/7/2004	C. Tumpeesuwan	1D	-
PPM 2004-236	001836	*Amphidromus (Amphidromus) givenchyi*	GRID 32	Ground	4/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-237	001837	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 31	Ground	4/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-238	001838	*Amphidromus (Amphidromus) givenchyi*	GRID 31	Ground	4/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-239	001839	*Quantula weinkauffiana*	GRID 22	Ground	30/7/2004	C. Tumpeesuwan	5D	-
PPM 2004-240	001840	*Pseudobuliminus (Giardia) siamensis*	GRID 21	Ground	30/7/2004	C. Tumpeesuwan	1D	-
PPM 2004-241	001841	*Pseudobuliminus (Giardia) siamensis*	GRID 21	Ground	16/6/2004	C. Tumpeesuwan	6S	-
PPM 2004-242	001842	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 22	Ground	30/7/2004	C. Tumpeesuwan	1D	-
PPM 2004-243	001843	*Sarika resplendens*	GRID 17	Ground	31/7/2004	C. Tumpeesuwan	2D	-
PPM 2004-244	001844	*Quantula weinkauffiana*	GRID 21	Ground	20/6/2004	C. Tumpeesuwan	11D	-
PPM 2004-245	001845	*Amphidromus (Amphidromus) givenchyi*	GRID 21	Ground	16/6/2004	C. Tumpeesuwan	14D	-
PPM 2004-246	001846	*Amphidromus (Amphidromus) givenchyi*	GRID 22	bamboo trunk	30/7/2004	C. Tumpeesuwan	2D	7D
PPM 2004-247	001847	*Pseudobuliminus (Giardia) siamensis*	GRID 21	Ground	29/7/2004	C. Tumpeesuwan	6S	-
PPM 2004-248	001848	*Amphidromus (Amphidromus) givenchyi*	GRID 38	Ground	7/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-249	001849	*Hemiplecta danae*	GRID 37	Ground	5/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-250	001850	*Quantula weinkauffiana*	GRID 21	Ground	29/7/2004	C. Tumpeesuwan	6D	-
PPM 2004-251	001851	*Megaustenia siamensis*	GRID 22	Ground	19/6/2004	C. Tumpeesuwan	5D	-
PPM 2004-252	001852	*Amphidromus (Amphidromus) givenchyi*	GRID 21	Ground	30/7/2004	C. Tumpeesuwan	8D	-
PPM 2004-253	001853	*Megaustenia siamensis*	GRID 8	Ground	13/6/2004	C. Tumpeesuwan	2D	-
PPM 2004-254	001854	*Pseudobuliminus (Giardia) siamensis*	GRID 22	Ground	30/7/2004	C. Tumpeesuwan	1S	-
PPM 2004-255	001855	*Pseudobuliminus (Giardia) siamensis*	GRID 22	Ground	19/6/2004	C. Tumpeesuwan	11S	-
PPM 2004-256	001856	*Quantula weinkauffiana*	GRID 35	Ground	4/10/2004	C. Tumpeesuwan	2D	-
PPM 2004-257	001857	*Quantula weinkauffiana*	GRID 39	Ground	5/10/2004	C. Tumpeesuwan	13D	-
PPM 2004-258	001858	*Amphidromus (Amphidromus) givenchyi*	GRID 21	Ground	16/6/2004	C. Tumpeesuwan	55D	-
PPM 2004-259	001859	*Pseudobuliminus (Giardia) siamensis*	GRID 38	Ground	7/7/2004	C. Tumpeesuwan	16S	-

COLL. NO.	CUMZ	SCIENTIFIC NAME	LOCALITY	HABITAT	DATE	COLLECTOR	SPECIMENS	
							SHELL	WET
PPM 2004-260	001850	*Cyclotus (Siphonocyclotus) hinlapensis*	GRID 8	Ground	30/7/2004	C. Tumpeesuwan	2D	-
PPM 2004-261	001861	*Phuphania globosa*	GRID 31	Ground	4/10/2004	C. Tumpeesuwan	15D	-
PPM 2004-262	001862	*Megaustenia siamensis*	GRID 8	Ground	30/7/2004	C. Tumpeesuwan	2D	-
PPM 2004-263	001863	*Thaitropis* sp.	GRID 8	Ground	30/7/2004	C. Tumpeesuwan	2D	-
PPM 2004-264	001864	*Pseudobuliminus (Giardia) siamensis*	GRID 8	Ground	30/7/2004	C. Tumpeesuwan	2S	-
PPM 2004-265	001865	*Amphidromus (Amphidromus) givenchyi*	GRID 21	Ground	16/6/2004	C. Tumpeesuwan	66D	-
PPM 2004-266	001866	*Amphidromus (Amphidromus) givenchyi*	GRID 22	Ground	19/6/2004	C. Tumpeesuwan	25D	-
PPM 2004-267	001867	*Quantula weinkauffiana*	GRID 38	Ground	7/7/2004	C. Tumpeesuwan	13D	-
PPM 2004-268	001868	*Cryptozona siamensis*	GRID 13	Ground	30/7/2004	C. Tumpeesuwan	1D	-
PPM 2004-269	001869	*Megaustenia siamensis*	GRID 22	Ground	30/7/2004	C. Tumpeesuwan	5D	-
PPM 2004-270	001870	*Quantula weinkauffiana*	GRID 21	Ground	30/7/2004	C. Tumpeesuwan	2D	-
PPM 2004-271	001871	*Quantula weinkauffiana*	GRID 21	Ground, shrub	16/6/2004	C. Tumpeesuwan	7D	8D
PPM 2004-272	001872	*Megaustenia siamensis*	GRID 21	Ground	20/6/2004	C. Tumpeesuwan	5D	-
PPM 2004-273	001873	*Amphidromus (Amphidromus) givenchyi*	GRID 22	Ground	16/6/2004	C. Tumpeesuwan	15D	-
PPM 2004-274	001874	*Phuphania globosa*	GRID 36	Ground	4/10/2004	C. Tumpeesuwan	12D	-
PPM 2004-275	001875	*A. (A.) schomburgki dextrochlorus*	GRID 8	bamboo trunk	30/7/2004	C. Tumpeesuwan	2D	10D
PPM 2004-276	001876	*Amphidromus (Amphidromus) givenchyi*	GRID 21	Ground	16/6/2004	C. Tumpeesuwan	15D	-
PPM 2004-277	001877	*Sarika resplendens*	GRID 8	Ground	30/7/2004	C. Tumpeesuwan	1D	-
PPM 2004-278	001878	*Pseudobuliminus (Giardia) siamensis*	GRID 37	Ground	5/10/2004	C. Tumpeesuwan	7S	-
PPM 2004-279	001879	*Pseudobuliminus (Giardia) siamensis*	GRID 8	Ground	30/7/2004	C. Tumpeesuwan	2S	-
PPM 2004-280	001880	*Sarika resplendens*	GRID 21	Ground	19/7/2004	C. Tumpeesuwan	2D	-
PPM 2004-281	001881	*Megaustenia siamensis*	GRID 30	Ground	4/10/2004	C. Tumpeesuwan	1D	-
PPM 2004-282	001882	*Sarika resplendens*	GRID 21	Ground	30/7/2004	C. Tumpeesuwan	1D	-
PPM 2004-283	001883	*A. (A.) schomburgki dextrochlorus*	GRID 8	Ground	13/6/2004	C. Tumpeesuwan	5D	-
PPM 2004-284	001884	*Chloritis (Trichochoritis) tenella*	GRID 17	Ground	31/7/2004	C. Tumpeesuwan	5D	-
PPM 2004-285	001885	*Trochomorpha* sp.	GRID 17	Ground	31/7/2004	C. Tumpeesuwan	1D	-
PPM 2004-286	001886	*Cyclophorus consociatus*	GRID 12	Ground	4/7/2005	C. Tumpeesuwan	33D	-
PPM 2004-287	001887	*Cyclophorus consociatus*	GRID 12	Ground	4/7/2005	C. Tumpeesuwan	33D	-
PPM 2004-288	001888	*Cyclophorus consociatus*	GRID 1	Ground	1/7/2005	C. Tumpeesuwan	41D	-
PPM 2004-289	001889	*Cyclophorus consociatus*	GRID 33	Ground	2/7/2005	C. Tumpeesuwan	8D	-
PPM 2004-290	001890	*Cyclophorus consociatus*	GRID 31	Ground	3/7/2005	C. Tumpeesuwan	6D	-
PPM 2004-291	001891	*Phuphania globosa*	GRID 30	Ground	4/7/2005	C. Tumpeesuwan	7D	-
PPM 2004-292	001892	*Hemiplecta distincta*	GRID 1	Ground	1/7/2005	C. Tumpeesuwan	2D	-
PPM 2004-293	001893	*Hemiplecta distincta*	GRID 31	Ground	3/7/2005	C. Tumpeesuwan	10D	-
PPM 2004-294	001894	*Quantula weinkauffiana*	GRID 30	Ground	4/7/2005	C. Tumpeesuwan	2D	-
PPM 2004-295	001895	*A. (A.) schomburgki dextrochlorus*	GRID 6	Ground	1/7/2005	C. Tumpeesuwan	4D	-
PPM 2004-296	001896	*A. (A.) schomburgki dextrochlorus*	GRID 6	Ground	3/7/2005	C. Tumpeesuwan	2D	-

COLL. NO.	CUMZ	SCIENTIFIC NAME	LOCALITY	HABITAT	DATE	COLLECTOR	SPECIMENS	
							SHELL	WET
PPM 2004-297	001897	*Phuphania globosa*	GRID 31	Ground	3/7/2005	C. Tumpeesuwan	4D	-
PPM 2004-298	001898	*Quantula weinkauffiana*	GRID 31	Ground	3/7/2005	C. Tumpeesuwan	3D	-
PPM 2004-299	001899	*Amphidromus (Amphidromus) givenchyi*	GRID 34	Ground	4/7/2005	C. Tumpeesuwan	5D	-
PPM 2004-300	001900	*Megaustenia siamensis*	GRID 34	Ground	4/7/2005	C. Tumpeesuwan	1D	-

Abbreviation:

COLL. NO. refers Collection number

D. refers dextral shell

S. refers sinistral shell

PPM refers Phu Phan mountain range

APPENDIX II

LAND SNAILS IN 45 GRIDS

Grid 1 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	32
2. *Megaustenia siamensis*	15
3. *Pseudobuliminus (Giardia) siamensis*	8
4. *Hemiplecta distincta*	12
5. *Ganesella (Ganesella) capitium*	6
6. *Semperula* sp.	4
7. *Achatina (Lissachatina) fulica*	4
8. *Thaitropis* sp.	13
9. *Trochomorpha* sp.	3
10. *Cyclotus (Siphonocyclotus) hinlapensis*	9
11. *Sarika resplendens*	8
total	114

Grid 2 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	23
2. *Cyclotus (Siphonocyclotus) hinlapensis*	4
3. *Hemiplecta distincta*	8
4. *Sarika resplendens*	9
total	44

Grid 3 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	23
2. *Hemiplecta distincta*	16
3. *Megaustenia siamensis*	8
total	47

Grid 4 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	22
2. *Cyclotus (Siphonocyclotus) hinlapensis*	6
3. *Hemiplecta distincta*	13
4. *Sarika resplendens*	9
5. *Phuphania globosa*	6
6. *Chloritis (Trichochloritis) tenella*	12
total	68

Grid 5 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	22
2. *Hemiplecta distincta*	24
3. *Megaustenia siamensis*	9
total	55

Grid 6 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	25
2. *Hemiplecta distincta*	16
3. *Quantula weinkauffiana*	9
4. *Thaitropis* sp.	12
total	62

Grid 7 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	24
2. *Cyclotus (Siphonocyclotus) hinlapensis*	6
3. *Pupina* sp.	12
4. *Hemiplecta distincta*	17
5. *Sarika resplendens*	16
6. *Oxychilus* sp.	2
7. *Thaitropis* sp.	14
8. *Quantula weinkauffiana*	9
9. *Megaustenia siamensis*	9
10. *Pseudobuliminus (Giardia) siamensis*	17
11. *Amphidromus (Amphidromus) schomburgki dextrochlorus*	9
total	135

Grid 8 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	19
2. *Hemiplecta distincta*	8
3. *Megaustenia siamensis*	5
4. *Thaitropis* sp.	5
5. *Pseudobuliminus (Giardia) siamensis*	8
6. *Quantula weinkauffiana*	12
total	57

Grid 9 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	20
2. *Hemiplecta distincta*	8
3. *Quantula weinkauffiana*	12
4. *Thaitropis* sp.	5
5. *Pseudobuliminus (Giardia) siamensis*	8
total	53

Grid 10 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	14
2. *Hemiplecta distincta*	9
3. *Sarika resplendens*	3
4. *Thaitropis* sp.	12
5. *Chloritis (Trichochloritis) tenella*	3
total	41

Grid 11 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	23
2. *Hemiplecta distincta*	15
3. *Quantula weinkauffiana*	22
total	60

Grid 12 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	23
2. *Hemiplecta distincta*	8
3. *Quantula weinkauffiana*	12
4. *Sarika resplendens*	8
5. *Amphidromus (Amphidromus) schomburgki dextrochlorus*	3
6. *Pseudobuliminus (Giardia) siamensis*	7
total	61

Grid 13 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	18
2. *Hemiplecta distincta*	9
3. *Quantula weinkauffiana*	12
total	39

Grid 14 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	26
2. *Cyclotus (Siphonocyclotus) hinlapensis*	8
3. *Hemiplecta distincta*	17
4. *Quantula weinkauffiana*	18
5. *Sarika resplendens*	18
6. *Amphidromus (Amphidromus) givenchyi*	16
7. *Durgella* sp.	2
8. *Oxychilus* sp.	2
9. *Megaustenia siamensis*	9
10. *Pseudobuliminus (Giardia) siamensis*	9
total	125

Grid 15 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	32
2. *Hemiplecta distincta*	6
3. *Quantula weinkauffiana*	17
total	55

Grid 16 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	25
2. *Hemiplecta distincta*	12
3. *Quantula weinkauffiana*	19
4. *Megaustenia siamensis*	8
total	64

Grid 17 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	19
2. *Hemiplecta distincta*	9
3. *Quantula weinkauffiana*	16
4. *Phuphania globosa*	11
5. *Amphidromus (Amphidromus) givenchyi*	16
total	71

Grid 18 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	29
2. *Cyclotus (Siphonocyclotus) hinlapensis*	8
3. *Hemiplecta distincta*	15
4. *Quantula weinkauffiana*	21
5. *Amphidromus (Amphidromus) givenchyi*	32
6. *Thaitropis* sp.	31
7. *Pseudobuliminus (Giardia) siamensis*	22
total	158

Grid 19 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	29
2. *Hemiplecta distincta*	17
3. *Quantula weinkauffiana*	23
4. *Megaustenia siamensis*	8
total	77

Grid 20 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	22
2. *Hemiplecta distincta*	9
3. *Quantula weinkauffiana*	12
4. *Phuphania globosa*	4
5. *Megaustenia siamensis*	6
total	53

Grid 21 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	17
2. *Hemiplecta distincta*	14
3. *Quantula weinkauffiana*	22
4. *Phuphania globosa*	3
total	56

Grid 22 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	14
2. *Hemiplecta distincta*	19
3. *Quantula weinkauffiana*	23
4. *Phuphania globosa*	2
total	58

Grid 23 Dry evergreen forest	
species	no. of individual
1. *Cyclophorus consociatus*	19
2. *Hemiplecta distincta*	8
3. *Quantula weinkauffiana*	21
total	48

Grid 24 Dry evergreen forest	
species	no. of individual
1. *Cyclophorus consociatus*	24
2. *Hemiplecta distincta*	16
3. *Quantula weinkauffiana*	23
4. *Phuphania globosa*	16
5. *Cyclophorus* sp.	23
total	102

Grid 25 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	18
2. *Hemiplecta distincta*	11
3. *Quantula weinkauffiana*	17
4. *Amphidromus (Amphidromus) schomburgki dextrochlorus*	12
5. *Prosopeas* sp.	3
6. *Megaustenia siamensis*	16
7. *Pseudobuliminus (Giardia) siamensis*	14
total	91

Grid 26 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	34
2. *Cyclotus (Siphonocyclotus) hinlapensis*	9
3. *Hemiplecta distincta*	13
4. *Quantula weinkauffiana*	16
5. *Sarika resplendens*	22
6. *Amphidromus (Amphidromus) schomburgki dextrochlorus*	9
7. *Oxychilus* sp.	3
8. *Megaustenia siamensis*	16
9. *Pseudobuliminus (Giardia) siamensis*	8
10. *Semperula* sp.	8
11. *Parmarion martensi*	4
12. *Cryptozona siamensis*	14
13. *Vitrinopsis* sp.	3
14. *Achatina (Lissachatina) fulica*	2
total	161

Grid 27 Dry evergreen forest	
species	no. of individual
1. *Cyclophorus consociatus*	24
2. *Cyclotus (Siphonocyclotus) hinlapensis*	5
3. *Hemiplecta distincta*	16
4. *Quantula weinkauffiana*	23
5. *Sarika resplendens*	17
6. *Amphidromus (Amphidromus) givenchyi*	42
total	127

Grid 28 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	34
2. *Hemiplecta distincta*	15
3. *Quantula weinkauffiana*	24
4. *Sarika resplendens*	14
5. *Amphidromus (Amphidromus) givenchyi*	58
6. *Oxychilus* sp.	2
7. *Pseudobuliminus (Giardia) siamensis*	19
total	166

Grid 29 Dry evergreen forest	
species	no. of individual
1. *Cyclophorus consociatus*	23
2. *Hemiplecta distincta*	15
3. *Quantula weinkauffiana*	15
4. *Phuphania globosa*	5
5. *Amphidromus (Amphidromus) givenchyi*	5
6. *Pseudobuliminus (Giardia) siamensis*	8
total	71

Grid 30 Dry evergreen forest	
species	no. of individual
1. *Cyclophorus consociatus*	13
2. *Hemiplecta distincta*	9
3. *Quantula weinkauffiana*	22
4. *Phuphania globosa*	2
5. *Amphidromus (Amphidromus) givenchyi*	6
total	52

Grid 31 Dry evergreen forest	
species	no. of individual
1. *Cyclophorus consociatus*	15
2. *Cyclophorus* sp.	12
3. *Hemiplecta distincta*	8
4. *Hemiplecta danae*	3
5. *Sarika resplendens*	12
6. *Phuphania globosa*	13
7. *Prsopeas* sp.	2
8. *Megaustenia siamensis*	15
9. *Pseudobuliminus (Giardia) siamensis*	7
total	87

Grid 32 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	23
2. *Hemiplecta distincta*	15
3. *Sarika resplendens*	11
4. *Pseudobuliminus (Giardia) siamensis*	9
total	58

Grid 33 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	17
2. *Cyclotus (Siphonocyclotus) hinlapensis*	9
3. *Hemiplecta distincta*	11
4. *Quantula weinkauffiana*	18
5. *Sarika resplendens*	9
6. *Amphidromus (Amphidromus) schomburgki dextrochlorus*	14
7. *Oxychilus* sp.	1
8. *Megaustenia siamensis*	6
9. *Pseudobuliminus (Giardia) siamensis*	12
10. *Semperula* sp.	3
11. *Parmarion martensi*	2
12. *Cryptozona siamensis*	8
13. *Vitrinopsis* sp.	1
14. *Achatina (Lissachatina) fulica*	2
total	113

Grid 34 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	16
2. *Hemiplecta distincta*	12
3. *Quantula weinkauffiana*	12
4. *Amphidromus (Amphidromus) givenchyi*	5
5. *Megaustenia siamensis*	8
6. *Pseudobuliminus (Giardia) siamensis*	12
total	65

Grid 35 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	25
2. *Hemiplecta distincta*	20
3. *Quantula weinkauffiana*	22
4. *Phuphania globosa*	13
5. *Amphidromus (Amphidromus) givenchyi*	8
6. *Amphidromus (Syndromus) zebrinus*	8
7. *Durgella* sp.	2
8. *Pseudobuliminus (Giardia) siamensis*	9
9. *Oxychilus* sp.	2
total	109

Grid 36 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	12
2. *Hemiplecta distincta*	4
3. *Quantula weinkauffiana*	23
4. *Hemiplecta danae*	2
5. *Sarika resplendens*	15
total	56

Grid 37 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	25
2. *Cyclotus (Siphonocyclotus) hinlapensis*	3
3. *Hemiplecta distincta*	8
4. *Quantula weinkauffiana*	12
5. *Phuphania globosa*	2
6. *Amphidromus (Amphidromus) givenchyi*	7
total	57

Grid 38 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	22
2. *Cyclophorus* sp.	9
3. *Hemiplecta distincta*	8
4. *Hemiplecta danae*	2
5. *Sarika resplendens*	8
6. *Phuphania globosa*	6
7. *Prsopeas* sp.	2
8. *Megaustenia siamensis*	9
9. *Pseudobuliminus (Giardia) siamensis*	14
total	80

Grid 39 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	6
2. *Hemiplecta distincta*	4
3. *Quantula weinkauffiana*	26
total	36

Grid 40 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	27
2. *Cyclotus (Siphonocyclotus) hinlapensis*	7
3. *Hemiplecta distincta*	12
4. *Quantula weinkauffiana*	15
5. *Hemiplecta danae*	2
6. *Pseudobuliminus (Giardia) siamensis*	17
total	80

Grid 41 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	28
2. *Hemiplecta distincta*	15
3. *Quantula weinkauffiana*	22
4. *Amphidromus (Amphidromus) givenchyi*	3
5. *Pseudobuliminus (Giardia) siamensis*	9
total	77

Grid 42 Mixed deciduous forest	
species	no. of individual
1. *Cyclophorus consociatus*	19
2. *Hemiplecta distincta*	9
3. *Quantula weinkauffiana*	23
4. *Pseudobuliminus (Giardia) siamensis*	12
total	63

Grid 43 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	16
2. *Hemiplecta distincta*	8
3. *Quantula weinkauffiana*	21
4. *Amphidromus (Amphidromus) givenchyi*	3
5. *Pseudobuliminus (Giardia) siamensis*	11
total	59

Grid 44 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	27
2. *Hemiplecta distincta*	9
3. *Quantula weinkauffiana*	12
4. *Amphidromus (Amphidromus) givenchyi*	5
5. *Amphidromus (Syndromus) zebrinus*	29
6. *Pseudobuliminus (Giardia) siamensis*	8
total	90

Grid 45 Dry dipterocarp forest	
species	no. of individual
1. *Cyclophorus consociatus*	9
2. *Hemiplecta distincta*	12
3. *Quantula weinkauffiana*	24
total	45

APPENDIX III

MATERIALS EXAMINED

(Dissected specimens and radula)

Species	Dissected specimens		Radula	
	Collection number	Number	Collection number	Number
Cyclophorus consociatus	CUMZ 001746	5	CUMZ 001746	2
Cyclophorus sp.	CUMZ 001745	3	CUMZ 001745	2
Pupina sp.	CUMZ 001617	1	CUMZ 001617	1
Amphidromus (A.) givenchyi	CUMZ 001946	2	CUMZ 001846	2
Quantula weinkauffiana	CUMZ 001757, CUMZ 001758	1 1	CUMZ 001757, CUMZ 001758	1 1
Phuphania globosa	CUMZ 001760	5	CUMZ 001760	2
Megaustenia siamensis	CUMZ 001764	2	CUMZ 001764	2
Parmarion martensi	CUMZ 001741	2	CUMZ 001741	2
Hemiplecta distincta	CUMZ 001801	1	CUMZ 001801	1
Cryptozona siamensis	CUMZ 001740	5	CUMZ 001740	2
Sarika resplendens	CUMZ 001747	4	CUMZ 001747	2
Oxychilus sp.	CUMZ 001738	1	CUMZ 001738	1
Pseudobuliminus (G.) siamensis	CUMZ 001729	5	CUMZ 001729	2
Thaitropis sp.	CUMZ 001753	1	CUMZ 001753	1
Achatina (L.) fulilca	CUMZ 001749	1	CUMZ 001749	1
Semperula sp.	CUMZ 001742	-	CUMZ 001742	1

BIOGRAPHY

Mrs. Chanidaporn Tumpeesuwan was born on the 24th January 1974 in Waritchaphum District, Sakon Nakhon Province. She obtained her bachelor's degree of science in 1997 from the Department of Biology, Faculty of Science, Mahasarakham University. Later, she has been position lecturer at the Department of Biology, Faculty of Science, Mahasarakham University. She graduated Master degree in Zoology at Chulalongkorn University in 2001. She proposed Ph. D. in Biological Science Program, Department of Biology, Faculty of Science, Chulalongkorn University by grant supports from Mahasarakham University since June 2002, and also received a research grant from BRT Program.