THESIS

DIVERSITY OF PSELAPHINE BEETLES (COLEOPTERA: STAPHYLINIDAE: PSELAPHINAE) IN EASTERN FOREST COMPLEX OF THAILAND

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GRADUATE SCHOOL, KASETSART UNIVERSITY
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THESIS

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LIST OF ABBREVIATIONS

ACE	=	Abundance-based coverage estimator
asl	=	above sea level
ANOVA	=	analysis of variance
CBD	=	Convention on Biological Diversity
CCA	=	Caconical Correspondence Analysis
cm	=	centimeter
d	=	day
DCA	=	Detrended Correspondence Analysis
df	=	degree of freedom
DNP	=	National Parks, Wildlife and Plant Conservation Department
GPS	=	global positioning system machine
GOF	=	Goodness of fit
F	=	F-statistic
FIM	=	Forest Insect Museum
HEF	=	hill evergreen forest
hr	=	hour
hrs	=	hours
H	=	Kruskal-Wallis non parametric test
H’	=	Shannon-Wiener’s diversity index
IBOY	=	International Biodiversity Observation Year
IC	=	inter-set correlation
InVal	=	indicator value
ISA	=	indicator species analysis
J’	=	Pielou’s evenness index
KARN	=	Khao Ang Rue Nai Wildlife Sanctuary
kg	=	kilogram
KKK	=	Khao Kitchakut National Park
Km^2	=	square kilometer

LIST OF ABBREVIATIONS (Continued)

KSD	=	Khao Soi Dao Wildlife Sanctuary
KU	=	Kasetsart University
m	=	meter
m^2	=	square meter
MEF	=	moist evergreen forest
MNST	=	Museum of Nature and Science, Tokyo
N	=	number of replicate
NPSAP	=	National Policy, Strategies and Action Plan on the conservation and sustainable use of biodiversity
NP	=	National Park
ns	=	non significant
ONEP	=	Office of the Environmental Policy and Planning
p	=	probability
PC-ORD	=	PC-ORD, program for multivariate analysis of ecological data
PMDF	=	primary mixed deciduous forest
QS	=	Sørensen' s index of similarity
r	=	Pearson's or Spearman's correlation coefficient index
RFD	=	Royal Forest Department
SD	=	standard deviation
SE	=	standard error
SMDF	=	secondary mixed deciduous forest
TMD	=	Thailand Meteorological Department
TNSM	=	Thailand National Science Museum
TP	=	teak plantation (*Tectona grandis* L.)
U	=	Mann-Whitney *U* test
X^2	=	Chi-square test
WS	=	Wildlife Sanctuary

DIVERSITY OF PSELAPHINE BEETLES (COLEOPTERA: STAPHYLINIDAE: PSELAPHINAE) IN EASTERN FOREST COMPLEX OF THAILAND

INTRODUCTION

Tropical rain forests which are the richest ecosystems of the world has occupied 5.6 million square kilometers or 7 % of the earth's land surface, however they contain more than half of the species on earth (Wilson, 1988). The great number of species interacted with complexity of these ecosystem makes tropical rain forest the most important habitats for all organisms. Although, tropical forests are extraordinary richness, they are among the most fragile of all habitats (Wilson, 1988). In recent years, tropical forests have been converted especially in the developing countries. Increasing rates of forest exploitation over tropical forests have caused the loss of whole global diversity.

Thailand is one of the richest biodiversity countries in Southeast Asia. The country lies within two major biogeographical regions, the Indochinese region in the North and the Sundiac region in the South. These have resulted in six distinct biogeographical regions. The biodiversity of these regions accounts for 8-10% of plant and animal varieties in the world. Between 20,000 and 25,000 species of plant are found in Thailand. It is estimated that 87,500 fauna species exist in Thailand, but only 18,073 species have been described. Vertebrate species in Thailand consist of 302 mammals, 982 birds, 350 reptiles, 137 amphibians, 720 freshwater fish, and 2,100 marine fish (CBD, 2008). The majority of invertebrates are insect species, in which only 14,000 have been described which account for few insect species in Thailand (Hutacharern *et al*., 2007).

The knowledge on insect diversity in Thailand is rather inadequate except for few taxa (*i.e.* butterfly). Forest litter-inhabiting arthropods are the most poorly understood fauna because of their small sizes and cryptic habitats. However, they play an essential role in nutrient cycling and contribute valuable data to studies of comparative biodiversity and conservation (Coddington *et al*., 1997; Stork, 1988).

Pselaphine beetles (Coleoptera: Staphylinidae: Pselaphinae) are among the most species rich forest litter-inhabiting group (Carlton, 1999). They are also commonly known as ant-like litter beetles or short-winged mold beetles (Newton and Chandler, 1989; Triplehorn and Johnson, 2005). Although, they are not economically important as pests, they play an important role as components of the soil ecosystem as predators of small invertebrates (Newton and Chandler, 1989). This subfamily is species-rich and cosmopolitan; pselaphine beetles might be used as one of potential indicator species for identification of habitat differences (Carlton, 1999). Newton and Chandler (1989) stated that pselaphine beetles might be useful for indicating of undisturbed old-growth forests (Carlton, 1999).

Although these beetles are diverse in tropic, more than 8,000 described species where most known from the temperate (Newton and Chandler, 1989). However, their ecology has rarely been studied. Few studies reported that pselaphine beetles were among the most diverse group of beetles in their samples (*i.e.* Carlton and Robinson 1998; Carlton *et al*., 2004; Chung *et al*., 2000). The knowledge of pselaphine beetles, particularly the patterns of species distribution and community dynamics, has not been studied. Pselaphine beetles are simply collected with effective extraction methods such as Winkler bags, Berlese or Tullgren funnels and they are readily identified to the generic level with an identification guide (S. Nomura, unpubl. identification guide to genera of pselaphine beetles, 2006; Chandler, 2001).

The general objectives of this study were to examine the ecology, diversity and community of pselaphine beetles in different primary forest habitats as moist evergreen forest, hill evergreen forest, mixed deciduous forest. The study was also conducted in the disturbance selective habitats as the secondary mixed deciduous forest and plantation forest. Data on the diversity, distribution, and relative abundance was expected to provide insights into potential indicator species of habitats. The database and reference specimens were deposited at Insect Museum of Department of Entomology, Kasetsart University and Forest Insect Museum, National Park Wildlife and Plant Conservation Department, Thailand.

The study areas were in eastern forest complex which consist of Khao Ang Rue Nai Wildlife Sanctuary located in Chachoengsao province, Khao Soi Dao Wildlife Sanctuary and Khao Kitchakut National Park located in Chanthaburi. These three areas are connected together forming the last and largest protected area remains in eastern Thailand which support the remnants of several wildlife species in this region.

Several projects dealing with fauna and flora biodiversity in these protected areas have been conducted in Khao Ang Rue Nai Wildlife Sanctuaries by Wanghongsa and Boonkird (2005). However, the knowledge of insect diversity in theses protected areas is rare. Thus, this pioneer researched on pselaphine beetle ecology was conducted in eastern Thailand in order to gain more information on insect diversity.

OBJECTIVES

1. To provide baseline data of pselaphine beetles for effective sampling from various habitats.

2. To document the ecological characteristics of pselaphine beetles communities.

3. To investigate the diversity pattern of pselaphine beetles in relation to other soil insects

4. To establish the taxonomic information and reference collection of pselaphine beetles in Thailand.

LITERATURE REVIEW

1. Biodiversity status in Thailand

Thailand, covering a total land area of 513,115 km^2 located in the hot and humid climate zone and hence supports a variety of tropical ecosystems. A wide diversity of ecosystems is represented in this hotspot, including mixed wet evergreen, dry evergreen, deciduous, and montane forests. There are also patches of shrublands and woodlands on karst limestone outcrops and, in some coastal areas, scattered heath forests. In addition, a wide variety of distinctive localized vegetation formations occur in Indo-Burma, including lowland floodplain swamps, mangroves, and seasonally inundated grasslands. Forests ranging in type from rain forest, evergreen forest, deciduous forest, and mangrove forest harbor the country's large portion of biodiversity. Other ecosystems such as fresh water ecosystems which the most endemic species of Thailand are found and also a variety of agriculture ecosystems, which cover about one fifth of the country, carry certain components agricultural products, all diverse ecosystems in Thailand have made Thailand as one of the biodiversity hotspot country's in Indo-Burma region (Convention International Webpage, 2008).

During the past century, the unsustainable development and the lack of awareness on the importance and value of biodiversity have caused of the reduction and loss of biodiversity in Thailand, and the most serious threat to the biodiversity is deal with human activities such as forest land reform, poverty, and conversion of forest lands to agricultural fields.

To implement the convention and biological diversity, in 2004 Thailand has ratified as the 188th member of the Convention on Biological Diversity on January 29th, 2004 and established the national policy, strategies and action plan on the conservation and sustainable use of biodiversity (NPSAP) since 1998 with the guideline of the National Environmental Board to endorse the formulation for the conservation and use of Thailand's biodiversity.

2. Thailand forest conservation

In the part, Thailand was covered with dense forests distributed all over the country, except in some areas of the great central plain where the land has been using for agriculture. The first forest resources assessment in Thailand was conducted by the Ordance Survey Department in 1961 reported that the existing forest of Thailand in 1961 amounted to 273,680.50 km^2 or 53% of the total area of the country (513,115 km^2; Ongsomwang, 2002; RFD, 2005). The forest areas have been reduced substantially by a combination of legal and illegal logging, encroachment by lowland setters and shifting cultivation and through infrastructural projects. It was reported the existing forest area of Thailand has continuously reduced every year. The deforestation rate was about 92,003 between 1973 to 1998 with the annual deforestation rate of 3,680 km^2 and the deforestation peak was found in the mid-1970s with the annual loss was about 11,596.50 km^2 (Ongsomwang, 2002) . Until 2004, the forest covered area was about 170,110.78 km^2 or 33.09% (RFD, 2005). Since the forest areas have been demolished for long time, forest fragments have been found around Thailand.

The strategy of using the protected area seems to be a fundamental device for conservation in all countries (Jeffries, 2006). Thailand has manipulated the areas to several types of protected areas as follows: 409 protected areas (National Parks, Wildlife Sanctuaries, Non Hunting areas, etc), 27 marine national parks, 10 Ramsar sites, 2 World Heritage sites and 4 biosphere reserves (CBD, 2008b) which the purposes for sustainable conserving genetic, species diversity and ecosystem diversity. The percentage of protected areas accounts for 20% of the total Thailand's area. Most protected areas in mainland located in the northern, western and southern Thailand. While few forest protected areas in central and eastern had been established.

The protected areas in this study are connected to form a largest forest area in eastern Thailand (Figure 3). These areas consist of two wildlife sanctuaries and one national park namely; Khao Ang Rue Nai Wildlife Sanctuary (KARN) with total area of 1,030 km^2, Khao Soi Dao Wildlife Sanctuary (KSD) with total area of 744.58 km^2 and Khao Kitchakut National Park (KKK) with total area of 58.31 km^2. All these protected areas are originally rich in biodiversity, for example KARN is the largest and the last lowland forest remains in Thailand, It is a largest home of elephant in Thailand with 136 elephants recorded in 2002 and the population has annually increased 9.83%. There are recorded about 64 mammal species, 246 species of bird, 53 species of reptile and 18 species of amphibian in KARN (DNP, 2008a)

KSD is closed to Cambodia and its fauna and flora have similar to Indochina region. It is home to 122 mammal species, 276 species of bird, 88 species of reptile, 29 species of amphibian and 3 endemic species of bird (DNP, 2008b).

3. Forest biodiversity and ecological services

Forest biodiversity is broad term referring to all the life forms found within forested areas and the ecological roles they perform. As such, forest biological diversity encompasses not just trees but the multitude of plants, animals and micro-organisms that inhabit forest areas and their associated genetic diversity.

Forest biological diversity can be considered at different levels, including the ecosystem, landscapes, species, populations and genetics. Complex interactions can occur within and amongst these levels. In biologically diverse forests, this complexity allows organisms to adapt to continually changing environmental conditions and to maintain ecosystem functions. In the annex to decision II/9 of CBD meeting (CBD, 2008c) recognized the meaning of forest biodiversity that:

"Forest biological diversity results from evolutionary processes over thousands and even millions of years which, in themselves, are driven by ecological forces such as climate, fire, competition and disturbance. Furthermore, the diversity of forest ecosystems (in both physical and biological features) results in high levels of

adaptation, a feature of forest ecosystems which is an integral component of their biological diversity. Within specific forest ecosystems, the maintenance of ecological processes is dependent upon the maintenance of their biological diversity.”

The mechanisms that cause deforestation, fragmentation and degradation are varied and can be direct or indirect. However, the most important factors associated with the decline of forest biological diversity are of human origin. The conversion of forests to agricultural land, overgrazing, unmitigated shifting cultivation, unsustainable forest management, introduction of invasive alien plant and animal species, infrastructure development (*i.e.* road building, hydro-electrical development, urban sprawl), mining and oil exploitation, anthropogenic forest fires, pollution, and climate change are all having negative impacts on forest biological diversity. This degradation lowers the resilience of forest ecosystems and makes it more difficult for them to cope with changing environmental conditions.

Forests are one of the most biologically rich terrestrial systems. Together, tropical, temperate and boreal forests offer diverse sets of habitats for plants, animals and micro-organisms, and harbour the vast majority of the world’s terrestrial species. Furthermore, forest biodiversity is interlinked to a web of other socio-economic factors, providing an array of goods and services that range from timber and non-timber forest resources to mitigating climate change and genetic resources. At the same time, forests provide livelihoods for people worldwide and play important economic, social, and cultural roles in the lives of many indigenous communities. Therefore, forests and forest biological diversity are innately linked to ecosystem and human well-being**.**

Enrlich and Enrlish (1992) defined the meaning of ecological services as life-support services which this word is derived from many functions that biodiversity performs in providing services that are vital for the well being of humans such as atmospheric regulation, climate regulation, hydrological regulation, nutrient cycling, pest control, photosynthesis, pollination, maintenance of soil fertility and soil formation. Several of these have consequences for critical functions such as water supply and storage, flood control, climate and carbon sequestration. Moreover, all these ecological services are natural systems provide for free.

4. Soil biodiversity

The complexity of the web of soil life can also be appreciated by the diversity of natural enemies of pests that live in the soil and their importance as biological control agents – such is the case for invertebrate predators, parasitic nematodes (which feed and develop in invertebrate pests, often killing them in the process), micro-organisms as control agents of invertebrate pests, weedy plants and other micro-organisms. This extremely rich biodiversity present in soils is threatened by a number of factors including the use of pesticides, particularly insecticides, which leads to the resurgence of insect pests through the selective reduction of their untargeted natural enemy communities. There is a substantial proportion of protoctista, fungi, nematodes, insects and chelicerate (a type of Arthropod) species that are natural enemies of pests. Many soil fauna species need to be described; one of the current limitations to enhance soil fauna research is a lack of information on the biology and ecology of its fauna.

4.1 Structure of soil communities

At an international workshop chaired by Patrick Lavelle (France) and Carlos Fragoso (Mexico) or IBOY (2000) (International Biodiversity Observation Year 2000) reported a study on 200 soil samples, mainly collected from tropical sites. As such, it represents one of the largest and most important datasets on soil macrofauna collected using a standardized method. The results for the percentage biomass and density of soil macrofauna were as follows, ranked in order of decreasing percentage biomass (IBOY, 2000). This dataset showed some important and far-reaching results. First, 95% of both macrofauna biomass and density are made up by just five groups. Earthworms represent almost three quarters of the macrofauna biomass, whilst termites and ants together represent almost 80% of macrofauna density. These results indicated that in terms of the soil macrofauna, these five groups deserve the focus of research effort. The implication can be made that organisms that make up 95% of biomass and abundance are a major influence over soil processes (Table 1). Soil organisms have received a great deal of study over recent decades (*i.e.* termites, ants, beetles or mycorrhiza) and number of described species for all groups of soil organisms has been increasing recorded all over the world (Brown *et al.*, 2007; Table 2).

Table 1 Percent biomass and density of tropical soil macroorganisms (IBOY, 2000).

Taxon	% Biomass	% Density
Oligochaeta	74.4	9.9
Coleoptera	6.9	3.3
Isoptera	6.3	49.2
Myriapoda (Diplopoda + Chilopoda)	5.2	3.3
Formicidae	2.7	29.3
Subtotal	95.5%	95.0%
Gastropoda	1.3	0.5
Aranaea	1.0	1.2
Blattoidea	0.6	0.2
Orthoptera	0.4	0.1
Dermaptera	0.3	0.5
Isopoda	0.3	1.0
Hemiptera	0.2	0.1
Lepidoptera (larvae)	0.2	0.2
Diptera (larvae + adults)	0.2	0.4
Remaining macrofauna	1.3	1.0

Table 2 Total number of described species of major groups of soil organisms (Brown *et al*., 2007 from several sources).

Soil organism	Number of species described
Microorganisms (bacteria and Fungi)	
Bacteria and archaea	3,200
Fungi	60,000
Microfauna	
Protozoa (Protista)	36,000
Nematodes	15,000
Rotifers	2,000
Tardigrads	750
Mesofauna	
Mites (Acari)	ca. 45,000
Springtails (Collembola)	7,500
Pseudo-scorpions	3,235
Diplura	659
Symphyla	200
Pauropoda	700
Enchytraeids	800
Macrofauna	
Root herbivorous insects	> 40,000
Beetles (Coleoptera)	350,000
Millipedes (Diplopoda)	10,000
Centipedes (Chilopoda)	2,500
Scorpions	1,259
Spiders	38,884

Table 2. (Continued).

Soil organism	Number of species described
Harvestmen (Opiliones)	30,000
Snails (Gastropoda)	4,250
Woodlice (Isopoda)	2,800
Termites (Isoptera)	11,826
Ants (Formicidae)	5,500
Earthworms (Oligochaeta)	3,800
Velvet worms (Onchophora)	90

Sources: Harwksworth and Mound (1991); Brussaard *et al*. (1997); Wall and Moore (1999); Moreira *et al*. (2006); Lewinsohn and Prado (2005, 2006).

4.2 The functional role of soil organisms

The ecological functions of soil depend on a healthy and dynamic community of soil biota. Ants, beetles, earthworms, termites, nematodes, enchytraeids, mites, springtails, protozoa, bacteria and fungi are some of the main groups in the diversely rich soil food web (Lavelle *et al*., 1994). Soil organisms can also be classified according to functional groups, for example, nitrifying bacteria, bacterivorous nematodes, litter feeders, ecosystem engineers and others. However, soil biology and function are little recognised, understood or considered in most efforts to reverse land degradation and enhance land productivity and sustainability. Due to its three-dimensional below ground structure, soil cannot be characterized by easily observable organisms; even the larger groups are included in the category of cryptobiota (small and thus "hidden" organisms), not to mention micro-organisms which are invisible to the human eye. Efforts to characterise soils, instead of assessing species richness and abundance as with domesticated plants and livestock, are resorting to assessing functional groups using microbial techniques. In some cases, indicator species are identified to reflect the maintenance of specific soil functions for example, earthworms in regard to soil bio-tillage (mixing) and aeration and rhizobium nodules in regard to soil nitrogen fixation.

The soil fauna is critical to the functioning of ecosystem processes (Giller, 1996; Lavelle *et al*., 1994; Lavelle *et al*., 1997). The activities of soil organisms contribute to the maintenance and productivity of terrestrial ecosystems through their influence on soil quality and soil fertility. This influence is mediated through four major categories of activities (Swift and Bignell, 2001).

Decomposition of organic matter

Decomposition is largely carried out by bacteria and fungi. However, the process is greatly facilitated by animals in the soil and litter such as termites, earthworms, millipedes, woodlice and mites. These detritivorous animals shred dead plant material and spread microbial propagules. Together, these microorganisms and animals are called decomposers, and as a result of their feeding activities, organic carbon is released as CO_2 or CH_4. The residues are incorporated into the soil as soil organic matter where they are subject to further attack by decomposers.

Nutrient cycling

The process of nutrient cycling is closely associated with organic decomposition. As with decomposition, the microorganisms are the most important mediators of the process but the rate at which the transformations occur is determined by grazing micro and mesofauna, such as protozoa, nematodes and Collembola. Larger soil animals may enhance some processes by providing niches for microbial growth, either within their guts or their faecal material. Specific soil microorganisms can also enhance the amount and efficiency of nutrient acquisition by higher plants through the formation of symbiotic associations such as mycorrhiza and N_2-fixing root nodules. The role of soil organisms in nutrient cycling is essential for most forms of plant productivity and all forms of agriculture and silviculture.

Bioturbation

Termites, earthworms, ants, some other groups of macrofauna, and plant roots are all physically active in the soil. They translocate huge quantities of soil by building mounds and nest, constructing tunnels, galleries and pores, forming soil aggregates, and by moving organic matter down the soil profile and moving mineral particles up the soil profile. A major mechanism in many of these processes is ingestion and defecation, particularly by groups such as termites, earthworms and millipedes. This bioturbation affects and determines the physical structure of the soil and the distribution of organic matter. In turn, these activities create modified microhabitats for smaller organisms that can not usually penetrate deeper parts of the soil profile, and thereby offer retreats to protect against predation and unfavourable conditions such as desiccation. In addition, bioturbation aslers soil properties such as aeration, drainage, aggregate stability, bulk density and water holding capacity.

Due to the significant impact on the soil of termites, earthworms and ants, these three groups have been defined as soil ecosystem engineers (Brussaard *et al*., 1997; Lawton 1996; Lavelle *et al*., 1997). Faecal pellets from the soil-feeding members of these groups are often organo-mineral complexes which can be stable in the soil for months or more (Lavelle *et al*., 1997).

Suppression of soil-borne pests and diseases

In natural ecosystems, outbreaks of soil-borne pests and diseases are relatively rare. However, in agricultural and silvicultural systems they are common: it is widely assumed that low plant species diversity renders agroecosystems vulnerable to harmful soil organisms by reducing overall antagonisms (Aslieri and Nicholls, 1999; Swift and Bignell, 2001). Many soil animals are predators which feed on other animals in the soil, or are grazing on fungi. At the same time, many protozoans, nematodes and some mites are micropredators that ingest individual microorganisms or microbial motabolites. All these feeding activities have a regulatory effect on population stability. The effectiveness of such natural controls can be greatly reduced when the original habitat is converted to an agroecosystem.

5. Standard tools for extracting of soil-litter macroarthropods

Soil arthropods are among the most species rich guilds in terrestrial ecosystems (Giller, 1996), but are poorly understood (Hall, 1996). Soil fauna is important to the functioning of the ecosystem processes of decomposition, nutrient cycling and maintenance of soil fertility (Lavelle *et al*., 1997). Most soil and litter animals are tiny, numerous, and can not be seen easily with the naked eye. To study soil animals, special techniques are needed to extract the animals from soil and litter. Many specialized extractors have been developed to assess animal diversity in soil and litter including Tullgren (Berlese) funnels, high-gradient funnels, and Winkler bags (André *et al*., 2002; Chung and Jones, 2003).

One of the best known devices for extracting arthropods is the Tullgen funnel. The apparatus was first invented by Italian Entomologist (A. Berlese) and later modified by Swedish Entomologist (A. Tullgren). Thus, the apparatus is also called Berlese funnel or Berlese-Tullgren funnel (Southwood, 1978). The principle mechanism of the extraction is that the funnel creates warm and dry condition at the upper part by a lighting source equipped on the top, which leads the litter and soil dwelling invertebrates to move down the funnel away from the light source and finally fall out to collecting bottle (André *et al*., 2002; Barnard, 1995; Sutherland, 1996; Vargo, 2000) (Figure 1).

Winkler extraction is also frequently used in ecological surveys and functional studies of soil and litter micro and macroarthropod communities (Chung *et al*., 2000; Hammond, 1990). This is a portable device using the similar principle of extraction as Tullgren extractor but depends on the natural drying by hanging it in the field. The apparatus is sometimes called as Winker/Moczarski or Moczarski/Tullgren extractor (Besuchet *et al*., 1987; Wheeler and McHugh, 1987) (Figure 1). However, these two devices have advantages and disadvantages in their application and extraction efficiency. Different authors have argued about the efficiency of these two extraction devices, *i.e.* Fisher (1999); Kalif and Moutinho (2000); Longino *et al*., (2002).

Figure 1 Winkler (white cloth bags) and Tullgren (metal funnels) extractors.

6. Pselaphine beetles

The most distinctive features of the Coleoptera is the structure of the wings. Most beetles have four wings, with the front paired thickened, leathery, or hard and brittle which called *elytra* (singular, *elytron*). These front wings usually line straight down the middle of the back and cover the hind wings. The hind wings are membranous, are usually longer than the front wings and usually fold under the front wings. The beetle use the hind wings for flying or movement, and use front wings for protect the hind wings and body as hardest object of beetle structure. The front or hind wings may reduce in some beetles depend upon their evolution (Triplehorn and

Johnson, 2005). Beetles are vary in length from less than a millimeter up to about 75 mm. Beetles undergo complete metamorphosis. They are vary in shape of adult and larvae in different families but most beetle larvae are campodeiform or scarabaeiform, some are elateriform and a few are vermiform. Beetles live in vary habitats that is inhabited by insects such as terrestrial, subterranean, aquatic or semi-aquatic. They can feed on all sorts of plants and animals materials. Their feeding gilds can be categories as phytophagous, predaceous, fungivorous, scavengers and parasitic, etc.

Beetles are known than of any other insect order as their extremely diverse which can be found everywhere and they have been interested to study by scientists over the world. Beetles are the largest order of insects, with about 40% of the known species in the Hexapoda which more than 300,000 species of beetle have been described worldwide (Brown *et al*., 2007; Triplehorn and Johnson, 2005).

Soil beetles are among the most biomass and density group of soil macro organisms (IBOY, 2000). Among soil-litter beetles, pselaphine beetles (Coleoptera: Staphylinidae: Pselaphinae) are one of the most species-rich forest soil-litter-inhabiting group (Carlton 1999). Pselaphine beetles are small yellowish or brownish beetles, sizes are varying from 0.5-5.5 mm in length (Triplehorn and Johnson, 2005). Although these beetles are diverse in the tropic and temperate zones but most of the 8,400 described species are known from the temperate zones (Carlton 1999; Newton and Chandler 1989). Although pselaphine beetles are diversify but their ecology has not been studied.

6.1 General appearances

Pselaphine beetles are also known as ant-like litter beetles or short-winged mold beetles (Chandler, 2001; Triplehorn and Johnson, 2005). Pselaphine beetles are classified in subfamily Pselaphinae of family Staphylinidae (Order Coleoptera). The subfamily Pselaphinae is belonging to the family Staphylinidae which it used to classified as family Pselaphidae by Latreille (1802). Latreille (1802) was the first whom placed the family Pselaphidae separated from Staphylinidae because of the different number of tarsal segments of each group. But Latreille also recognized that pselaphine beetles were closely related to certain staphylinids and they should be associated with Staphylinidae. Kirby and Spence (1817) and Leach (1817) concluded that Pselaphidae was closely related with Sydmaenidae and Staphylinidae.

The first authors whom consider the more precise relationships of Pselaphidae was Raffray (1890; 1908), Raffray considered the pselaphid tribe Faronini was an intermediate between pselaphid and staphylinid genus *Solierius*. Casey (1894) and Lameere (1900) also had similar considered with Raffray that pselaphid attached probably to the most primitive forms of Oxytelinae and Omaliini group in Staphylinidae. In recent years, Lawrance and Newton (1982), Thayer (1987), Newton and Thayer (1988) and Nomura (1991) gained much more knowledge of association between pselaphids and Omaliini group in Staphylinidae. Therefore in 1995, Newton and Thayer (1995) rearranged the family Pselaphidae into subfamily Pselaphinae under Omaliinae group in the family Staphylinidae, which based on the strongly supported subordinate position of taxon with the Omaliine group of staphylinids subfamily as well as good evidence for the former tribe Faronini as a sister group to all remaining pselaphines.

The beetles in family Staphylinidae are one of the largest families of beetle (Triplehorn and Johnson, 2005). The former family Pselaphidae (subfamily Pselaphinae) was among the ten largest beetle family (Newton and Chandler, 1989) as worldwide described approximately 10,000-12000 species (Carlton, 1999; Chandler, 2001).

Pselaphine beetles are readily recognized due to their distinctive appearance. Pselaphine beetles resemble staphylinids in having short, truncate elytra exposing most of abdomen, but differ from staphylinids in having shorter, broader, and non-flexible abdomen, Four palpal segments and a small setiform or cone-like apical pseudosegment are dominance characteristics of pselaphine beetles (appearing to be a fifth segment in many physical large genera (Chandler, 2001). Pselaphine beetles have setose foveae on head, prothorax, and other parts of body, Tarsal formula of pselaphine beetles are different from other staphylinids as pselaphine's tarsi formula is 3-3-3 (but seemingly 2-2-2 in Bythinoplectini) with symmetrical tarsal claw or asymmetrical tarsal claws (1 claw) but staphylinids' tarsi formula is 4 to 5). Average body length of pselaphine is about 1.5 mm, with extremes ranging from 0.4 to 7.1 mm (Chandler, 2001). The antennae are apically clubbed except the Faronitae and a few mymecophilous groups. The antennae inserted under shelf-like frontal projections usually 11 antennomeres but some few genera have 10, 9, 6, 5, or 3 antennomeres and 4-8 antennomeres in a few genera (Chandler, 2001). Abdomen and paratergites are associated with the first three or four visible tergites and paratergites are sometimes mostly or entirely fused to their associated tergite and or sternite (Clavigeritae with visible tergites of first three visible segments fused to each other). Ratio of body length to greatest body width is among 1.5–10. The colors of pselaphine beetles are usually redish, yellowish and brownish.

6.2 Taxonomy

Pselaphines are taxonomically placed by Newton and Thayer (1995) as following: Class: Hexapoda

Order: Coleoptera

Suborder: Polyphaga

Series: Staphyliniformia

Superfamily: Staphylinoidae

Family: Staphylinidae

Subfamily: Pselaphinae

At present subfamily Pselaphinae has been classified to seven supertribes as following: Faronitae, Euplectitae, Batrisitae, Goniaceritae, Bythinoplectitae, Pselaphitae, Clavigeritae (Newton and Thayer, 1995).

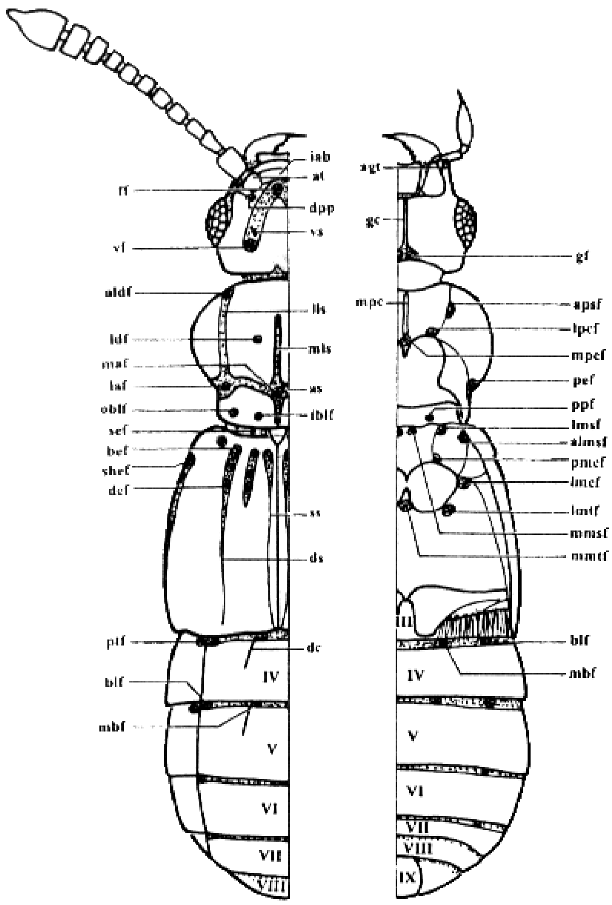


Figure 2 Dorsal and ventral views of pselaphine beetle. (Source: Chandler, 2001).

Abbreviation: Dorsal features (left side). Head: **ff**, frontal fovea; **vf**, vertexal fovea; **iab**, interantennal bridge; **at**, antennal tubercle; **dpp**, dorsal postantennal pit; **vs**, vertexal sulcus. Prothorax: **aldf**, anterolateral discal fovea; **ldf**, lateral discal fovea; **maf**, median antebasal fovea; **laf**, lateral antebasal fovea; **oblf**, **iblf**, outer and inner basolateral fovea; **lls**, lateral longitudinal sulcus; **mls**, median longitudinal sulcus; **as**, antebasal sulcus. Elytra: **sef**, subbasal elytral fovea; **bef**, basal elytral fovea; **shef**, subhumeral elytral fovea; **def**, discal elytral fovea; **ds**, discal stria; **ss**, sutural stria. Abdomen: **ptf**, paratergal fovea; **blf**, basolateral fovea; **mbf**, mediobasal fovea; **dc**, discal carina. Ventral features (right side). Head: **gf**, gular fovea; **gc**, gular carina; **agt**, apicolateral gular tubercles. Prothorax: **apsf**, anteroprosternal fovea; **lpcf**, lateral procoxal fovea; **mpcf**, median procoxal fovea; **pef**, proepimeral fovea; **mpc**, median prosternal carina. Meso and Metathorax: **ppf**, prepectal fovea; **lmsf**, lateral mesosternal fovea; **almsf**, anterolateral mesosternal fovea; **mmsf**, median mesosternal fovea; **mmtf**, medain metasternal fovea. Abdomen: **blf**, basolateral fovea; **mbf**, mediobasal fovea.

6.2.1 Faronitae

Faronitae are the sister group of all other Pselaphinae. There are 20 genera and their members are primarily distributed in temperate (Chandler, 2001). The few species have found in tropical areas which usually from high elevations in the mountains. The greatest number of genera and species are in the southern temperate areas of South America, South Africa, Madagascar, Australia and New Zealand (Chandler, 2001). Faronitae have not occurred in oriental region (Nomura, 2005 personal communication). These groups are litter inhabitants and presumed to be carnivores but not well studied. Larvae are characteristic, without stemmata and without the eversible frontal organs or specialized tibiae of other known pselaphine larvae (Newton 1991).

6.2.2 Euplectitae

A large worldwide group of mainly litter inhabiting species found in tropical and temperate areas. There are currently contain 419 genera (Chandler, 2001) Larvae of this supertribe are less known, four genera larvae of Euplectitae were described by Besuchet (1956) and De Marzo (1987).

6.2.3 Bythinoplectitae

This supertribe is equivalent to the former subfamily Faroninae minus Faronini, hence the required change in group name as well as rank. This group and the included tribes Dimerini, Mayetiini and Bythinoplectini were redefined in a detailed study. Bythinoplectitae were consistently linked to Pselaphitae and Clavigeritae in analysis on the basis of shared absence of eighth sternal glands, but in all other respects they are most similar to Euplectitae and are readily derivable from that group (Newton and Thayer, 1995).

6.2.4 Goniaceritae

These are largest supertribe, with over a fourth of pselaphine species and nearly a fourth of the genera, worldwide with mainly litter-inhabiting species. There are not a demonstrably momophyletic group, probably paraphyletic with respect to Batrisitae and possibly Pselaphitae and Clavigeritae. Larvae of four genera were described by Besuchet (1956) and De Marzo (1987).

6.2.5 Batrisitae

The Batrisitae are primarily found in tropical regions, only a few genera are found in northern or southern temperate areas. There are seven genera described in Australia but all over the world holds 215 genera (Chandler, 2001). Batrisitae are primarily litter inhabitants. Batrisitae are not well separated from Goniaceritae or Euplectitae and may be derived from within one of those groups; at least some of the synapomorphies used to separate Batrisitae (*i.e.*, basal bulb of aedeagus without window) that also occur in some Goniaceritae. The eastern Asian fauna was intensively studied by Nomura (1991; 2005), but the internal classification, monophyletic and origin of the group as a whole need to study (Newton and Thayer, 1995).

6.2.6 Pselaphitae

This is another large worldwide group, mainly litter inhabitants but with many small specialized tribes of myrmecophiles or termitophiles. Although Newton and Thayer (1995) have found some support for monophyly of pselaphites plus clavigerites together (*i.e.* the old informal group Macroscelia), and found none for Pselaphitae itself, which is very likely to be paraphyletic with respect to Clavigeritae.

6.2.7 Clavigeritae

This is a large group of nearly 100 genera and over 300 species, probably all obligate myrmecophiles, found in all areas except New Zealand and southern South America and especially diverse in Madagascar. Because of their morphological specializations for life with ants, clavigerites sometimes have been placed in a family separate from Pselaphidae, or placed as a basal division within the family (Raffray 1890, 1908). Jeannel (1950) placed them with his Faronitae at the base of the family because of their seemingly primitive tarsal structure with two small basal segments, but later (Jeannel, 1955) placed them with Pselaphitae in Macroscelia and considered the internal classification and relationships of Clavigeritae in detail, synonymizing with 13 tribes of earlier authors into one and leaving three distinctive tribes. Jeannel demonstrated that his new tribe Colilodionini in many ways formed a "missing link" between clavigerites and pselaphites, with the implication that the former were derived from the latter. Newton and Thayer (1995) results are consistent with Besuchet's interpretation; many derived conditions in clavigerites such as reduced mouthparts and foveae are anticipated or paralleled in certain pselaphite tribes such as Pselaphini and Arhytodini.

The highly reduced mouthparts capable only of liquid feeding, elaborate trichomes and associated glands, and other specializations common to all clavigerites suggest that all are as highly integrated with their hosts as the few well studied species by Akre and Hill (1973), Cammaerts (1974), Hill *et al*., (1976) Kistner, (1982) and Krüger (1910). Larvae of supertribe Clavigeritae have not been definitely identified or adequately described.

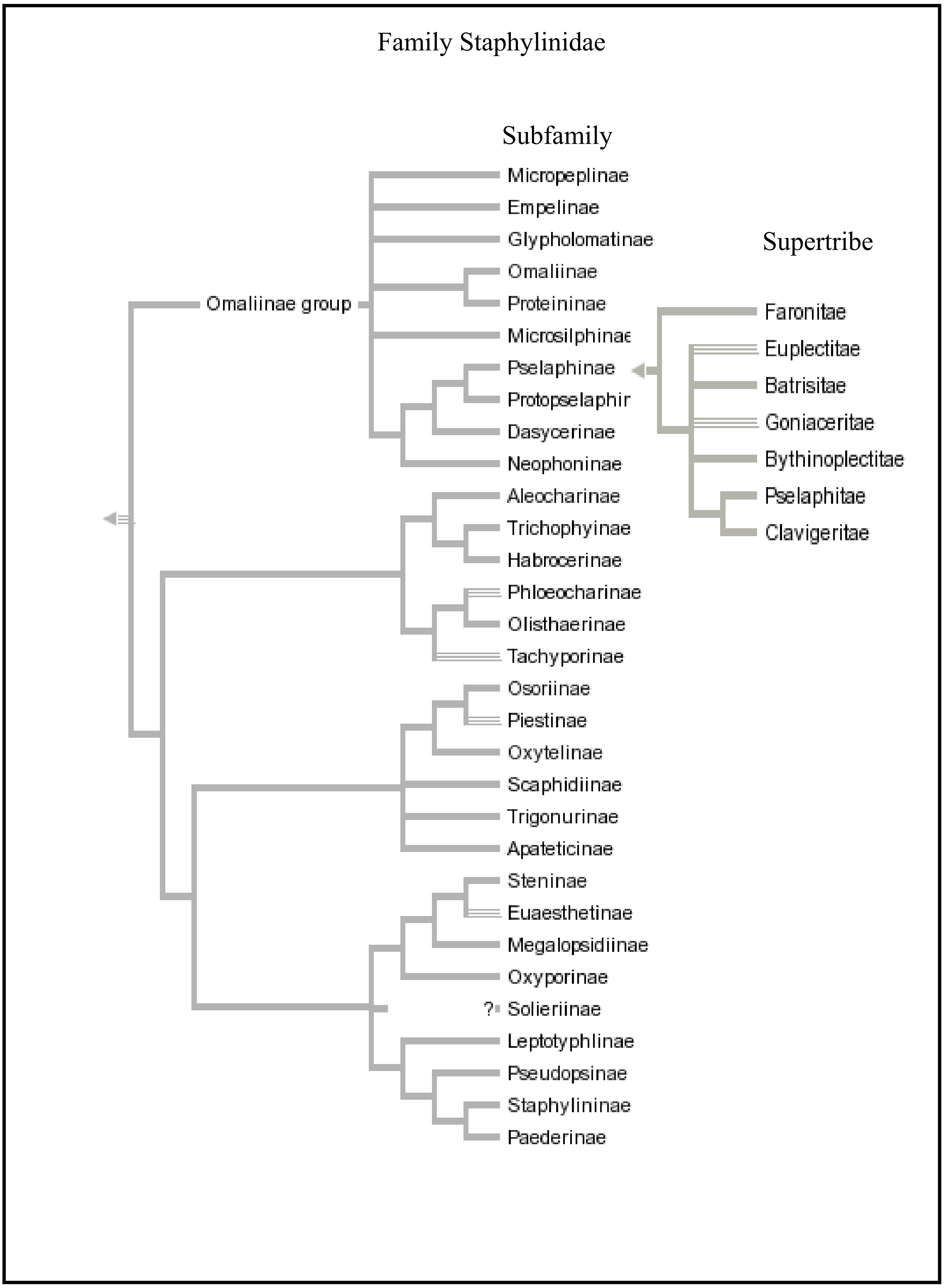


Figure 3 Taxonomic placement of subfamily Pselaphinae (Newton and Thayer, 1995)

6.3. Distribution

Pselaphines are diverse and widely distributed, with species occurring in all parts of the world (Lawrence *et al.,* 2002). Their biogeography regions were recorded in Nearctic; Palearctic; Neotropical; Afrotropical; Oriental and Australian (Lawrence *et. al*., 2002). Taxonomy of pselaphines have been well studied in Europe, Australia and America regions, Although there are about 10,000 described species worldwide but a great number of additional species are undescribed, especially in the tropical regions (Carlton, 1999).

In Asia, Japan is a greater inventory country of its faunas, as reported by Nomura (1991) that pselaphines contained about 170 species in which data are so far recorded, and the number could be estimated over 1,000 species (Nomura, 1991). In Thailand, pselaphine had been recorded 40 species since last centuary (Hlavac, 2002; Motschulsky, 1851; Raffray, 1891, 1896, 1904; Reitter, 1883 and Schaufuss, 1877; Table 3).

Table 3 List of recorded pselaphine species of Thailand.

Supertribe	Tribe	Subtribe	Genus	Species	Author	Year	Distribution
Bythinoplectitae	Bythinoplectini	Bythinoplectina	*Zethopsus*	*opacus*	Schaufuss	1877	Thailand
	Dimerini		*Octomicrus*	*longulus*	Schaufuss	1877	Bangkok
Euplectitae	Euplectini	Bibloplectina	*Euplectodina*	*hipposideros*	Schaufuss	1877	Thailand
			Bibloplectinus	*solskyi*	Schaufuss	1877	Thailand
Batrisitae	Batrisini	Batrisina	*Mina*	*franzi*	Lobl	1973	Tap tie kien bei
			Batriscenodes	*siamensis*	Raffray	1904	Thailand.
			Batriscenodes	*excisus*	Schaufuss	1877	Bangkok
			Physomerinus	*septemfoveolatus*	Schaufuss	1877	Bangkok
Goniaceritae	Brachyglutini	Brachyglutina	*Reichenbachella*	*rufa*	Schmidt-Goebel	1838	Thailand
			Reichenbachella	*bucha*	Raffray	1891	Thailand
			Reichenbachia	*baumeisteri*	Schaufuss	1877	Bangkok
			Reichenbachia	*cordata*	Schaufuss	1877	Bangkok
			Reichenbachia	*casternaui*	Raffray	1891	Thailand
			Reichenbachia	*loti*	Raffray	1891	Thailand
			Trissemus	*mamilla*	Schaufuss	1877	Bangkok

Table 3 (Continued)

Supertribe	Tribe	Subtribe	Genus	Species	Author	Year	Distribution
Goniaceritae	Brachyglutini	Brachyglutina	*Eupines*	*sphaerica*	Motschulsky	1851	Thailand
			Bryaxis	*siamensis*	Schaufuss	1877	Bangkok
			Bryaxis	*nigrocephala*	Schaufuss	1877	Bangkok
Pselaphitae	Pselaphini		*Tyraphus*	*testaceus*	Schaufuss	1877	Bangkok
			Tyraphus	*semiopacus*	Schaufuss	1877	Bangkok
			Pselaphaulax	*bivofeolatus*	Schaufuss	1877	Bangkok
			Pselaphaulax	*articularis*	Schaufuss	1877	Bangkok
			Pselaphidius	*multangulus*	Schaufuss	1877	Bangkok
			Pselaphidius	*parvipalvis*	Reitter	1883	Thailand
			Pselaphus	*canaliculatus*	Schaufuss	1877	Bangkok
	Ctenistini		*Poroderus*	*siamensis*	Schaufuss	1879	Thailand
			Ctenisophus	*bowring*	Raffray	1904	Thailand

Table 3 (Continued)

Supertribe	Tribe	Subtribe	Genus	Species	Author	Year	Distribution
Pselaphitae	Hypocephalini		*Stipesa*	*canriniventris*	Schaufuss	1877	Bangkok
			Stipesa	*ampliventris*	Schaufuss	1877	Bangkok
			Apharina	*conicicollis*	Schaufuss	1877	Bangkok
			Mestogaster	*bruchiformis*	Schaufuss	1877	Bangkok
	Tyrini	Tyrina	*Subulipalpis*	*spinicoxis*	Schaufuss	1877	Bangkok
			Linan	*cardialis*	Hlavac	2002	North-western
		Centrophthalmina	*Enantius*	*punctipennis*	Schaufuss	1877	Bangkok
			Centrophthalmus	*clementis*	Schaufuss	1877	Bangkok
			Centrophthalmus	*forticornis*	Schaufuss	1877	Bangkok
			Centrophthalmus	*pnctipennis*	Schaufuss	1877	Bangkok
			Centrophthalmus	*sernalis*	Raffray	1896	Thailand
Indet	Indet	Indet	*Tetratarsus*	*plicatulus*	Schaufuss	1877	Thailand

6.4 Biology and ecology

The life cycle of pselaphine beetles are poorly known as they are very small and particularly cryptic insects living in litter which many people do not often encounter them. For the various species known in the world, only a few larvae have been described. Pselaphine beetles are predatory, feeding on various small invertebrates, especially mites and springtails (Collembola) (Nomura, personal communication). The males and females of pselaphine adults exhibit sexual dimorphism (Darby, 1991).

Some ecological data have been known are that they typically associated with leaf litter and woody debris of forests, and while their greatest species richness is reached in forest habitats, they can be found in all types of moist habitat as wetland, grassland, beach, cave and arboreal habitats (Chandler, 2001; Newton and Chandler, 1989 and Park, 1964). As long as organic debris, moss, root mats, or seepage through rocks maintain a zone of high humidity where preys exist, pselaphine beetles can be found (Carlton, 1999). Larvae of pselaphines are predators on minute organisms but the knowledge of larvae stages are poorly understood (Newton and Chandler, 1989).

However, the important data on ecology of pselaphine beetles are rarely been studied. The knowledge of pselaphine beetles particularly the patterns of species distribution, diversity, environmental factors, and community dynamics have not been studied. Although, few studies reported that pselaphine beetles were among the most diverse group of beetles in their samples (*i.e.* Carlton and Robinson, 1998; Carlton *et al*., 2004 and Chung *et al*., 2000).

6.5 Insect biodiversity monitoring

Arthropods are numerous as individuals and as species. They are the most diverse organisms in ecosystems. Among arthropods, insects are the most successful organisms due to their external skeletal structure, size, physiology and behavior (Samways, 1994). Insects are abundant throughout all habitats such as terrestrial, subterranean, aquatic and semi-aquatic. They apparently consumed about 20% of the foliage annually worldwide. Insects are in association with many other detritivore invertebrates, fungi and bacteria in releasing and recycling the nutrients that are fixed in decaying vegetation (Abbott *et al*., 2002; Samways, 1994). Whilst their huge abundance, many insects can cause outbreak to exceed population.

Soil remains the most inhabited part of ecosystems with dwellings dominated by Collembola and mites (Stork, 1988). There is enormous variation in biomass from one taxon to another, and between areas. In the tropical forests, ants are particularly numerous and huge biomass (Wilson, 1991). Ants scavenge 90% of the dead remains of all insects and are a major element in the turnover of soil. Also beetles represent 40% of the canopy arthropod and represented in forests accounting for about 20% of the total arthropod diversity (Stork, 1988, 1994).

Pselaphine beetles are the enormous group of small dwelling beetles habiting in forest litter (Park, 1964). Pselaphines are found in moist habitat under leaf and wood litter of forest floor where pray exist. Species richness in habitat is very high and often turning up in litter samples from small plots of warm temperate and tropical forests (Newton and Chandler, 1987). This subfamily is not known commercial importance, however they are widely distribute all over the world and high species richness and abundance in certain microhabitats this suggests that pselaphine beetles could be ecological important indicators and highly potential for use in various evolutionary studies such as local and large-scale biogeography and integration of guests into social insect systems. (Chandler, 2001; Newton and Chandler, 1987; Nomura, 1991). Pselaphine beetles are easily the least well known due to their very small to minute size and their reclusive habits (Newton and Chandler, 1987).

Various studies of pselaphine beetles were most concern with the taxonomic study but there were few studies of litter inhabiting beetles diversity including pselaphine beetles as reported by Carlton (1999), Carlton *et al*. (2004), Carlton and Robinson, (1998), Chandler and Recher (2004) and Chung *et al*. (2000).

MATERIALS AND METHODS

Materials

1. Materials

1.1 Field equipment needs for pselaphine adult beetle samplings

- 20 Tullgren extractors with 60 Watt incandescent light
- 10 Winkler extractors with accessories (mesh bags)
- Collecting equipment (debris bags, hand gloves, 1 x 1 m quadrat)
- A variety of bottles, plastic bottles and 80% alcohol
- Forceps, 2B pencils, clipper, notebooks, data sheets, label sheets
- Global Positioning System machine (GPS)
- Spherical densitometer (canopy measurement)
- pH-meter
- Camera and 105 mm macro lens
- Tape meter

1.2 Laboratory equipment needs for pselaphine adult beetle sample processing

- Forceps, Petri-dish, slide, setting pins, insect pins, and insect boxes, vials,
- Stereo microscope with digital camera

2. Study sites

The eastern forest complex of Thailand (Figures 4-5) consists of two wildlife sanctuaries and one national park: Khao Ang Rue Nai Wildlife Sanctuary (KARN) with a total area of 1,030 km^2, Khao Soi Dao Wildlife Sanctuary (KSD) with a total area of 744.58 km^2, and Khao Kitchakut National Park (KKK) with a total area of 58.31 km^2. Precipitation in KARN is blocked by high mountains in KSD, which create a rain shadow, making the KARN climate relatively drier than in KSD and KKK. The annual precipitation in is around 1,600 mm/year in KARN and 3,800 mm/year in KSD. In eastern Thailand, the dry season lasts from November to March and the wet season lasts from May to October (TMD, 2007). Differences in precipitation and altitude, which ranges from 100 to 1,675 m, produce three different forest types (KU, 2007): mixed deciduous forest, moist evergreen forest and hill evergreen forest. To investigate the impact of human disturbance on the local diversity of pselaphine beetles, two anthropogenically modified forest types were chosed: secondary mixed deciduous forest and teak plantation (*Tectona grandis* L.) for sampling. Detail descriptions of forest types as following.

Primary mixed deciduous forest (PMDF)

A primary mixed deciduous forest was dominated by *Lagerstroemia calyculata*, *L. cuspidata* Wall., *Pterocarpus macrocarpus* Kurz, *Suregada multiflorum* (A. Juss.), *Xerospermum noronhianum, Diospros transitoria* and *Syzygium pergamentaceum* (King) P. Chantar. & J. Parn (Appendix Table C1). A mixed deciduous forest site was established in the Lum Jang Wat sub-district in KARN at N 13° 16' 25”, E 101° 44' 44", 155 m asl.

Moist evergreen forest (MEF)

A moist evergreen forest (MEF) site was established in the Ban Thung Krang sub-district at N 13° 01' 08", E 102° 12' 46", 329 m asl. The dominant tree species are *Dipterocarpus alatus* Roxb., *Mallotus peltatus* Muell. Arg., *Shorea guiso* Blume, *Strombosia javanica* Blume, *Diospyros rubra, Scaphium scaphigerum* and *Diospyros transitoria* Bakh (Appendix Table C2).

Hill evergreen forest (HEF)

A hill evergreen forest (HEF) site was established at Khao Prabad at N 12° 50' 14", E 102° 10' 20", 1069 m asl. The most abundant tree species in HEF were *Scaphium scaphigerum* (G. Don) Guib & Planch, *Castanopsis piriformis* Hickel & A. Camus, *Archidendron quocense* (Pierre) I. Nielsen, *Gonocaryum lobbianum* and *Horsfieldia glabra* (Blume) Warb (Appendix Table C3).

Secondary mixed deciduous forest (SMDF)

Human settlements and agriculture disturbed 30% of the land area in the northern part of KARN in 1992. The Royal Forest Department had since relocated the villages and restored the forest in these areas, which has been recovering for approximately 15 years. At the time of sampling, most of the areas once opened by agriculture and villages were covered with vegetation, and some of these areas were approaching an advanced stage of secondary forest; trees were approximately 10-12 m apart with diameters of 8-15 cm. We sampled an SMDF site in the Phuthai sub-district at N 13° 24' 56", E 101° 52' 53", 101 m asl. The most abundant tree species were *Suregada multiflorum* Baill., *Lagerstroemia venusta*, *Pterospermum litorale, Syzygium pergamentaceum* and *Pterocarpus macrocarpus* (Appendix Table C4).

E. Teak plantation (*Tectona grandis* L.) (TP)

Teak plantations (*Tectona grandis* L.) were established along the western boundary of KSD from 1969 to 1992 by the Soi Dao Seed Orchard Station under a Royal Forest Department project (Soi Dao Forest Seed Orchard Station, 1992). The plantations cover 376 ha and have been designated for research and economic use. All teak plantations connect to form one large monocultural habitat in the KSD region. The teak plantation site (N 12° 58' 48", E 102° 17' 49", 202 m asl) chosen for this study was located within a 20 ha area planted in 1976, with trees spaced 6 m apart. The average diameter (DBH) of teak trees was 30 cm and the average height was 25 m. Other dominant tree species in study site were *Parkia sumatrana* Miq., *Pterocarpus macrocarpus*, *Lepisanthes rubiginosa* (Roxb.) Leenh, *Streblus asper* and *Dalbergia nigrescens* Kurz (Appendix Table C5).

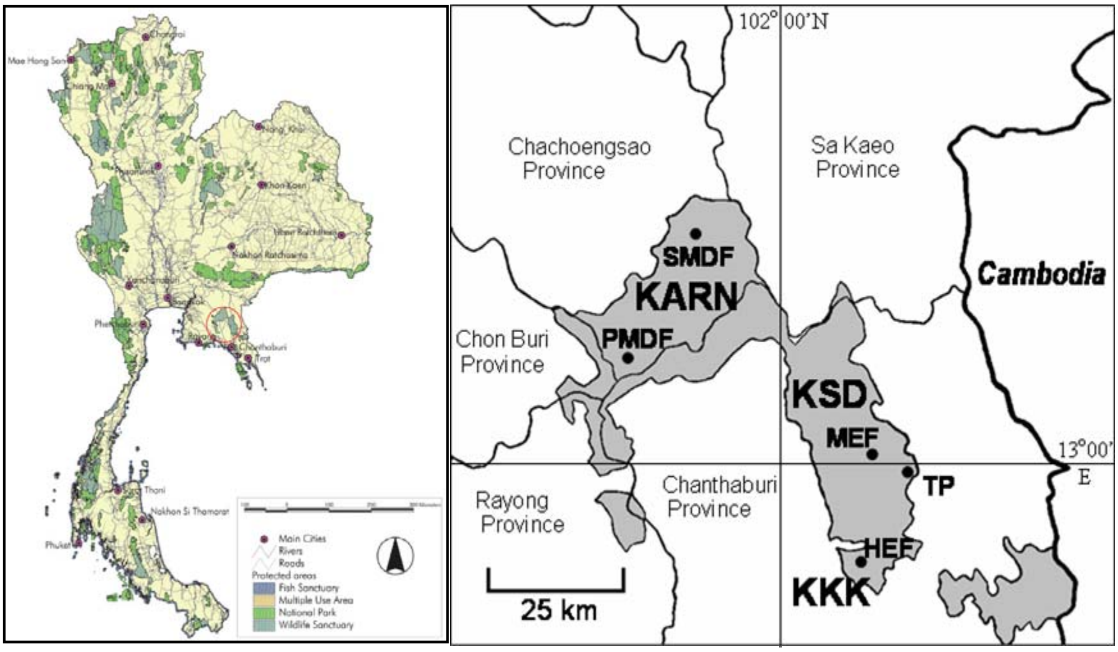


Figure 4 Map showing the study sites in eastern forest complex of Thailand, Khao Ang Rue Nai Wildlife sanctuary (KARN), habitats are primary mixed deciduous forest (PMDF) and secondary mixed deciduous forest (SMDF); Khao Sao Dao Wildlife sanctuary (KSD), habitats are moist evergreen forest (MEF) and teak plantation (TP); Khao Kitchakut National Park (KKK) where the habitat is hill evergreen forest (HEF).

Figure 5 Collecting sites in eastern forest complex of Thailand. A, moist evergreen forest (MEF); B, hill evergreen forest (HEF); C, mixed deciduous forest (PMDF); D, secondary mixed deciduous forest (SMDF); E, teak plantation forest (TP) and F, litter collecting**.**

Methods

1. Study on the extraction efficiency between Winkler and Tullgren in extracting macroarthropods and pselaphine beetles

1.1 Sampling site

Samples were collected in moist evergreen forest at the Khao Soi Dao Wildlife Sanctuary (KSD), Chanthaburi province, (N 13° 01' 08" and E 102° 12' 46", 329 m elevation).

1.2 Model of Winkler extractor

The Winkler extractors (Figure 1) have an internal frame consisting of two wire rectangles (30 x 25 cm) set 50 cm apart between upper and lower wire frames. Below the lower wire frame, the Winkler gab is funnel-shaped and empties into a collecting bottle. The soil sample was placed in a mesh bag (38 x 25 cm, 2 mm^2 mesh size) suspended inside the Winkler bag from the upper wire frame. A maximum of four mesh bags could be suspended in one Winkler bag. For more details of Winkler bag construction, see Chung and Jones (2003).

1.3 Model of Tullgren extractor

The model of Tullgren extractors (Figure 1) used in this study was designed by the second author for extracting soil beetles. It was made of tinplate steel and consisted of three removable parts: funnel-shaped cover, main canister and funnel-shaped bottom. The dimensions of each part were (diameter x height), 38 x 17 cm, 38 x 26 cm and 38 x 17 cm respectively. Inside the main canister was a 34 x 17 cm (diameter x height) internal stainless steel basket (with cover of 1 x 1 cm wire mesh net) placed in its main part. All removable parts were well tight-fitting.

1.4 Samples and extraction procedures

Ten paires of 1 m^2 sample of leaf litter and soil (10 replicates for each extraction) were randomly taken at moist evergreen forest in Khao Soi Dao Wildlife Sanctuary. The litter and surface soil were scraped up to 2cm depth (by hand). Each sample (weighting approximately 1.5-2 kg) was sifted through a wire sieve of 1 m mesh size to exclude the larger elements such as leaves, twigs and stones. After sifting, each sample was stored in ventilated cloth bag and transferred to a field station where ten Tullgren extractors and ten Winkler extractors were set up.

Ten samples were loaded into a single mesh net basket and placed into a Tullgren extractor. Each Tullgren extractor had a 60W incandescent light positioned above the soil sample. The 60 W incandescent lights were turned on throughout the extraction period. A collecting bottle containing 80% ethanol was placed under each Tullgren extractor to collect the falling arthropods. The second sample from each pair was loaded into three mesh bags and was suspended in a Winkler extractor. A collecting bottle containing 80% ethanol was attached to the Winkler cloth bag to collect the falling soil arthropods during extraction.

The extractions were conducted at room temperature over 7 days. The collecting bottles under Tullgren and Winkler extractors were replaced with new 80% ethanol bottles after 3 hr, 6hr, 12hr, 1 d, 2d, 3d, 4d, 5d 6d and 7d. During the extraction periods, temperature and moisture of soil samples inside Tullgren extractors were measured at 0 h (the start time after loading the sample), 1d, 2d, 3 d, 4d, 5d, 6d, and 7d. Temperature and moisture of soil samples in Winkler extractors were only measured twice: at the start time (0 h) and 7d due to the difficulty of accessing the soil samples in Winkler bags.

1. 5 Target Groups

All insects extracted with Winkler and Tullgren extractors were counted and identified. Macroarthropods in the class Arachnida, Chilopoda, Malacostraca

(Isopoda) and Diplopoda were also separated. These groups are among the most abundant in litter samples (IBOY, 2000). Acari (mites and ticks) and Collembola were excluded from this study because they were extremely abundant and would require sub-sampling of litter quadrats to limit the number of samples. Comparisons of extraction efficiency were done for all soil and litter arthropods: (1) major arthropod class, (2) beetle families (3) beetle species using pselaphine beetles (Staphylinidae: Pselaphinae) as a reference taxon.

For identification of arthropods was used the keys to the Terrestrial Invertebrates (Mohamed, 1999), beetle identification using keys to beetle family of Chung (2003) and for pselaphine beetle was used the keys of S. Nomura (S. Nomura, unpublished identification guide on subfamilies Protopselaphinae and Pselaphinae of Asia [Staphylinidae: Protopselaphinae; Pselaphinae] 2006) and specimens were then identified to morphospecies based on the external appearance of specimens–a technique commonly used as a surrogate for species level identification in biodiversity studies (Abbott *et al*. 2002).

2. Study on survival time of macroarthropods and pselaphine beetles in the ventilation cloth bags before extraction

2.1 Field sampling

Twenty of 1 m^2 quadrat samples of leaf litter and soil were collected in KSD. The litter and surface soil was scraped up to 2 cm depth (with hand groves). Each sample (weighting between 1-2 kg) was sifted through a wire sieve bag to exclude the larger elements such as leaves, twigs and stones. After sifting each sample was stored in ventilate cloth bag and transferred to the laboratory.

2.2 Storage samples at different times

Twenty samples were then randomly assigned to four storage periods resulting in five replicates of each: 3 (3 hrs before extraction), 6, 12, and 24 hrs. Upon arrival to the laboratory, one set (3 hrs before extraction, N = 5) was set up for extraction using the modified Tullgren extraction. This method relies in a constant tight source (60 W incandescent light) fitted inside Tullgren funnel which are placed above soil sample. The extraction was conducted at the room temperature (27° C) for 72 hrs (3 days) period. The three remaining sets were stored in a ventilate cloth bag with room temperature of 27 °C for 6, 12, and 24 hrs, respectively before extraction. The collections of macroarthropods were stored in 80% alcohol. Sorting and counting the targeted arthropods were conducted in laboratory. Identification was conducted to pselaphine genera and morphospecies.

During storage times, each soil sample set was measured temperature and moisture before extraction. Data on number of species and individuals of pselaphine beetles and only number of individuals of selected soil arthropods were contrasted the statistical differences with Kruskal-Wallis test (H) nonparametric test.

3. Pselaphine beetle diversity in eastern forest complex of Thailand

3.1 Spatial and seasonal diversity pattern

3.1.1 Sampling method

Ten 1 m^2 quadrats were randomly sampled in each plot. The litter and surface soil to a depth of 3 cm was scraped from the ground and sifted through a 1 cm wire mesh sieve to exclude larger debris. After sifting, each sample was transferred to a debris bag for transportation to the field station where Tullgren funnels were set up. After arriving at the field station, the contents of each in debris bags were weighed and divided into ten samples, then put in Tullgren funnels for extraction. Soil and litter dwelling organisms were extracted over 48 hrs using 60 Watt incandescent lights. Specimens were preserved in 80% alcohol prior to processing. Collections were conducted in all sites at bimonthly intervals during the months of January, March, May, July, September and November 2006 (Table 4).

3.1.2 Sorting and Identification

The samples were taken to the laboratory and pselaphine beetles were separated and stored in 80% alcohol. Specimens were identified to genus using the keys of S. Nomura (S. Nomura, unpublished identification guide on subfamilies Protopselaphinae and Pselaphinae of Asia [Staphylinidae: Protopselaphinae; Pselaphinae] 2006), which adopts the taxonomic conventions of Newton and Thayer (1995) and Chandler (2001). After generic identification, specimens were then identified to morphospecies based on the external appearance of specimens–a technique commonly used as a surrogate for species level identification in biodiversity studies (Abbott *et al*. 2002). Specimens were mounted, labeled, and deposited in the Museum of Nature and Science Tokyo (MNST), Japan; the Insect Museum of Department of Entomology, Kasetsart University, Bangkok and the Forest

Insect Museum (FIM), Department of National Parks, Wildlife and Plant Conservation (DNP), Bangkok, Thailand.

3.1.3 Data analysis

Data on the number of species, individuals of beetles from ten quadrates in each sampling time were pooled. The Shannon-Wiener-Wiener's diversity index (*H'*) was calculated to measure diversity of habitats (Magurran 1988), the formula as

$$H' = -\Sigma p_i \ln p_i$$

where p_i is the proportion abundance of the *i*th species = (n_i / N).

The Pielou's evenness index (*J*') was used to quantify the component of diversity (Ludwig & Reynolds 1988). The formula as

$$J' = H'/\ln (S)$$

where *H*' is the proportion abundance of the *i*th species, S is the number of species

The Kruskal-Wallis nonparametric test was conducted to test differences in beetle species, individuals, Shannon-Wiener's diversity index (*H*') and Pielou's evenness index (*J*') among habitats and Mann-Whitney's *U*- test was conducted to test the differences in beetle species richness, individuals, Shannon-Wiener diversity index (*H*') and Pielou's evenness index (*J*') between season.

Table 4 Details of collecting sites and periods of pselaphine inventory. Locality abbreviations: KARN, Khao Ang Rue Nai Wildlife Sanctuary; KSD, Khao Sao Dao Wildlife Sanctuary and KKK, Khao Kitchakut National Park; forest types abbreviations: PMDF, Primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; TP, teak plantation (*Tectona grandis* L.) and HEF, hill evergreen forest

Periods	Locality	Forest types	Altitude	Date
January	KARN	PMDF	155	17.I.2006
2006	KARN	SMDF	100	17.I.2006
	KSD	MEF	329	21.I.2006
	KSD	TP	215	15.I.2006
	KKK	HEF	1069	19.I.2006
March	KARN	PMDF	155	17.III.2006
2006	KARN	SMDF	100	17.III.2006
	KSD	MEF	329	16.III.2006
	KSD	TP	215	15.III.2006
	KKK	HEF	1069	15.III.2006
May	KARN	PMDF	155	3.V.2006
2006	KARN	SMDF	100	3.V.2006
	KSD	MEF	329	6.V.2006
	KSD	TP	215	7.V.2006
	KKK	HEF	1069	5.V.2006
July	KARN	PMDF	155	12.VII.2006
2006	KARN	SMDF	100	12.VII.2006
	KSD	MEF	329	15.VII.2006
	KSD	TP	215	16.VII.2006
	KKK	HEF	1069	9.VIII.2006
September	KARN	PMDF	155	28.IX.2006
2006	KARN	SMDF	100	28.IX.2006
	KSD	MEF	329	30.IX.2006

Table 4 (Continued)

Periods	Locality	Forest types	Altitude	Date
	KSD	TP	215	26.IX.2006
	KKK	HEF	1069	26.IX.2006
November	KARN	PMDF	155	28.XI.2006
2006	KARN	SMDF	100	28.XI.2006
	KSD	MEF	329	30.XI.2006
	KSD	TP	215	26.XI.2006
	KKK	HEF	1069	26.XI.2006

3.2 Community and indicator species of habitats

3.2.1 Data analysis

Data on species and individuals from six sampling in the experiment three was used to study the species similarity in each forest habitat types, similarity of beetle (using binary data of species) in samples were calculated data by Sørensen similarity index (*QS*) (Wolda, 1981), the formula as

$$QS = 2c/(a+b),$$

where a = the number of species in sample a; b = the number of species in sample b; c = the number of species in common between a and b.

The detrended correspondence analysis (DCA) (Hill and Gauch, 1980) was used to determine the beetle similarity based on pselaphine assemblages. DCA was performed using species and abundance data. Data on individual species that were occurred less than 3 times of the total catch (6 samplings) was excluded as species caught in low occurrence can usually be seen as accidental that do not supported the real composition. Axes were rescaled with a threshold of zero, and the number of segments was set to 26 (default).

The canonical correspondence analysis (CCA) was also used to determine beetle similarity based on pselaphine assemblages. CCA was performed by using species and abundance data, species that occurred less than 3 times of the total catch (6 samplings) were excluded. CCA axis scores was centered and standardized to unit variance. Axes scaled to optimize representation of row (plot) or scores for plots were weighted mean scores for species. Scores for graphing plot were derived from species and the program was set up to 99 randomization.

Indicator species analysis (ISA) was performed using the technique of Dufrene and Legendre (1997) by the significant level on $p \leq 0.01$, as proposed by Dufrene and Legendre (1997).

The DCA, CCA and indicator species analysis were performed by PC-ORD 4.27 (McCune and Milford, 1999).

3.3 Micronvironmental variables related to pselaphine assemblages

3.3.1 Weather and microenvironment data

Monthly rainfall, relative humidity, and temperature data were obtained from the Thailand Department of Meteorology (TMD; Table 10), all data were collected by the provincial meteorological stations located in Chachoengsao (KARN) and Chanthaburi (KSD, KKK; TMD, 2007). Microenvironmental variables were measured at each site to investigate their relationship with species presence and abundance, and percent canopy cover was measured with a spherical densitometer at each site. Percent soil moisture was calculated by comparing wet and dry weights of soil samples collected with a core sampler 5 cm long and 5 cm in diameter. Ten samples were taken from each site by driving the core sampler into the ground in the middle of a 1 m^2 sampling area. The samples were weighed then dried in an oven until the weight remained constant. After sifting, leaf litter mass was measured in the field. Each of these environmental variables was measured when a sample was collected (Table 11). Tree species and individuals in the SMDF and TP (100 x 100 m) were counted and number of tree species and individuals in primary forests were received from permanent study plots in each site (S. Boonyawetchewin, personal communication).

3.3.2 Data analysis

Data on species and individuals from six sampling in the experiment three was used to study. Regression, Stepwise multiple regression and Pearson's correlation analysis were used to determine which environmental variables related to species richness and abundance. Regression and Pearson's correlation analysis was performed with Systat version 8 (Systat software, 1998).

The canonical correspondence analysis (CCA) was also used to determine environmental variables related to pselaphine assemblages (species and abundance). CCA was performed by using species and abundance; species that occurred less than 3 times of the total catch (6 samplings) were excluded. CCA axis scores was centered and standardized to unit variance. Axes scaled to compromise representation of species and plot. Scores for graphing plot were linear combinations of environmental variables and set up to 99 randomization. The environmental variables using in CCA were soil moisture, soil acidity (pH), weight of litter, canopy cover and rainfall.

3.4 Estimating pselaphine species richness

3.4.1 Data analysis

Data on species and individuals from six sampling in the experiment three were plotted the species-abundance distribution for each habitat and fitted the pooled data to the lognormal model (Magurran (1988) as the null hypothesis that relative abundances are log normally distributed are normally found in specious group. Lognormal model was calculated with the program Ecological Methodology (Kenney and Krebs, 1998).

Species accumulation curves and richness estimates were generated using EstimateS version 7.5 (Colwell, 2005). EstimateS generated estimates of species richness based on empirical data using formulae that have been adapted from several estimate theories (Colwell and Coddinton, 1994). Eight non-parametric algorithms richness estimators were performed with our data sets: ACE, first-order jackknife, second order jackknife, bootstrap mean and Michaelis-Menten means.

The EstimateS program generates richness estimators computes the estimates using data from a species-by-sample abundance matrix, the program selects a sample and calculates the richness estimates base on that sample, selects a second sample, recomputed and so on until all samples are included (100 randomizations). ACE (abundance-based coverage estimator) is found to be consistently over estimate richness, especially with small samples (Colwell and Coddington, 1994). ACE is abundance-based estimators, which use abundance to quantify rarity. Both jackknife estimators and the bootstrap estimators are incidence-based, that rely on incidence (presence/absence) data to quantify rarity. For quadrat sampling, both jackknife estimators and bootstrap richness estimators are good for estimating the number of species (Smith and van Belle, 1984). The data from six samplings during 2006 were pooled (60 samples) and one hundred randomizations were generated in this study.

3.5 Determination on diversity pattern between ants and pselaphine beetles

3.5.1 Ant sampling and identification

All ant species and individuals from six samplings in the experiment three were collected and were identified to genera using key of Bolton (1994) and Hashimoto and Rahman (2003), and later to species and morphospecies level, using the reference collection of Thailand National Science Museum (TNSM). Voucher specimens were deposited in the Thailand National Science Museum (TNSM) and Forest Insect Museum (FIM) of National Park, Wildlife and Plant Conservation Department, Thailand.

3.5.2 Data analysis

Parameters on ant species and individuals, Shannon-Wiener's diversity index and Pielou's evenness index from six sampling were analyzed and contrasted with pselaphine beetles. Variation in the number of individuals of ant was large compared to pselaphine individuals. However, all the samples were produced using the same sample collections, effort, and method. Ant species, individuals, and Shannon-Wiener's diversity index (*H'*) was calculated to measure diversity of habitats (Magurran 1988), The Pielou's evenness index (*J*') was used to quantify the component of diversity (Ludwig & Reynolds 1988). The Kruskal-Wallis nonparametric test was conducted to test differences in beetle species, individuals, Shannon-Wiener's diversity index (*H*') and Pielou's evenness index (*J*') among habitats and Mann-Whitney's *U*- test was conducted to test the differences in beetle species richness, individuals, Shannon-Wiener diversity index (*H*') and Pielou's evenness index (*J*') between season.

Relationship between the parameters on number of species, individuals Shannon-Wiener's diversity index and Pielou's evenness index of ants and pselaphine beetles were tested using Spearman's correlation coefficient and regression.

Spearman's correlation and regression analysis was used Systat Version 8 program (Systat Software, 1998).

Duration of research

Pselaphine beetles were sampled every binary month in 2006 and additional samples were also carried out in June – July 2007. Specimen identification and data analysis was conducted throughout 2006-2007.

RESULTS AND DISCUSSION

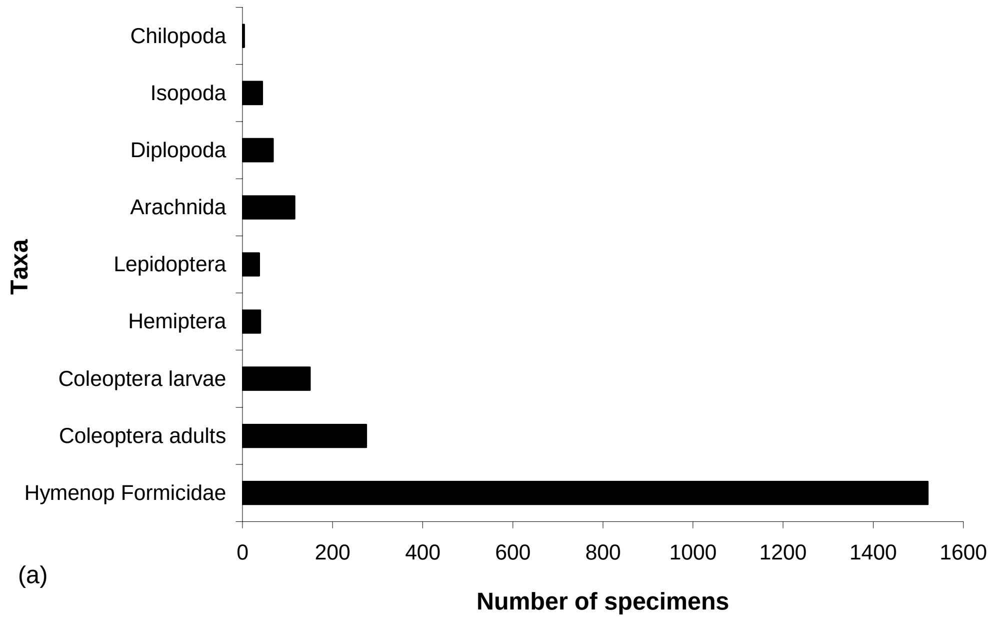
Results

1. Extraction efficiency between Winkler and Tullgren in extracting macroarthropods and pselaphine beetles

1.1 Extraction efficiency between Tullgren and Winkler extractors

After seven days, the number of specimens in each class extracted with Tullgren funnels was higher than the numbers extracted by Winkler bags **(**Figure 6). Both methods extracted arthropods in the similar proportions (Figure 7). Ants were the most abundant arthropod group extracted by both Winkler and Tullgren methods in the class Insecta followed by Coleoptera, Hemiptera, and Lepidoptera, respectively. Among the non-insects, Arachnida was the most abundant group extracted by both methods followed by Diplopoda, Isopoda, and Chilopoda (Figure 6).

The number of specimens extracted by Tullgren and Winkler extractors were very different, 5,904 ants specimens were extracted by Tullgren funnels, while 1,521 specimens (25.76%) were extracted by Winkler bags, adult beetles were extracted 1,820 (Tullgren) and 275 (15.11% Winkler), Arachnida was extracted 481 (Tullgren) and 116 (24.12%, Winkler), Diplopoda 205 (Tullgren) and 68 (33.17%,Winkler) and all other groups of arthropods in this study had shown similar extraction trends. Winkler had shown low efficient for extracting Chilopoda, our data showed that only 4 centipedes were extracted by Winkler extractors, and 88 were extracted by Tullgren extractors.



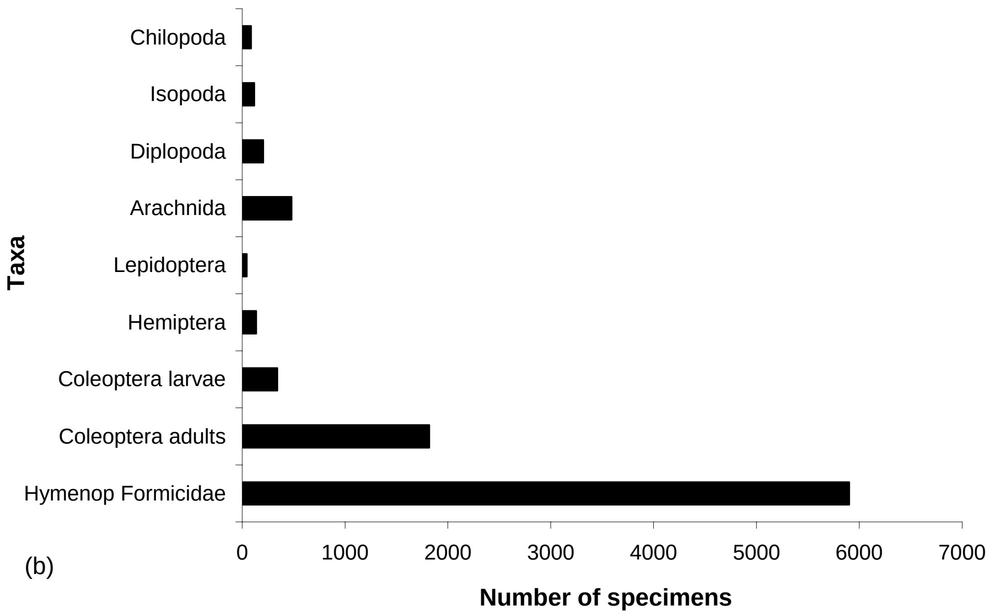
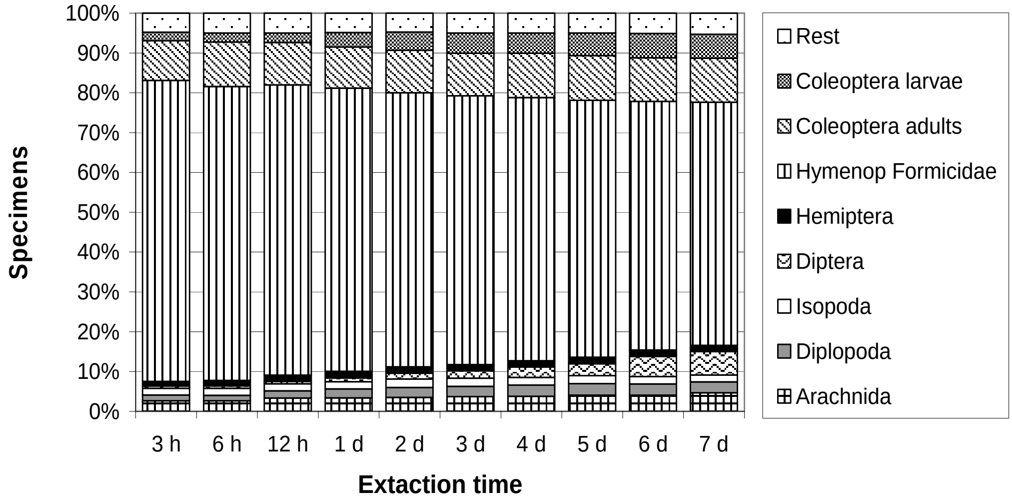


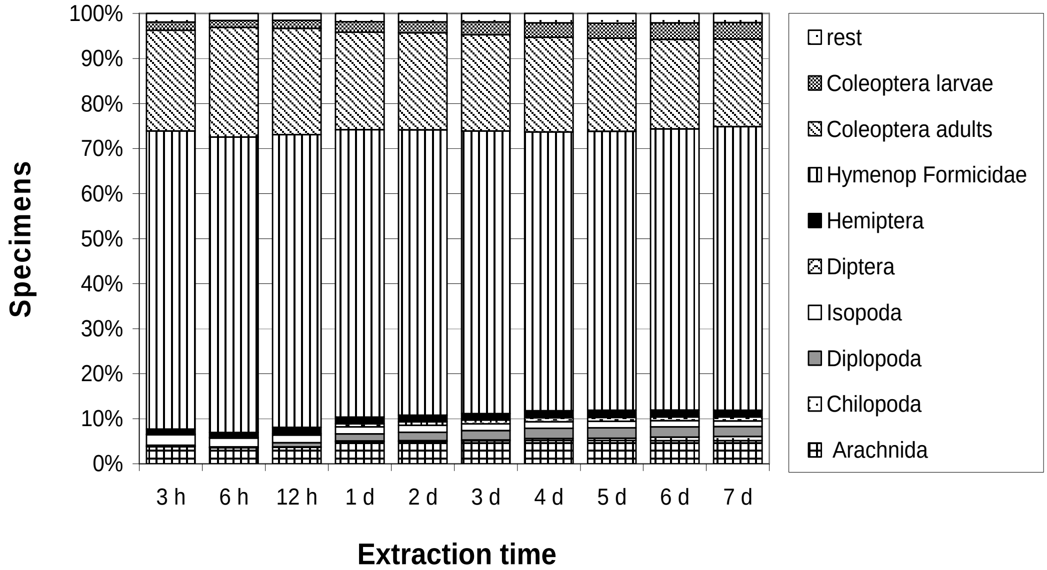
Figure 6 Number of specimens of soil and litter macroarthropod groups extracted after 7 days with Winkler extractors (a); Tullgren extractors (b).

1.1Composition of higher taxonomic level

The composition of specimens changed as extraction time increased (Figure 6). Ants and adult beetles always high proportion of extracted specimens regardless of extraction time and the proportion of these groups gradually decreased with increasing extraction time but were still higher than other groups. Diptera, Hemiptera, and Coleoptera larvae increased in proportion as extraction time increased in both Winkler and Tullgren extractions. Chilopoda, Diplopoda, and Arachnida comprised a small proportion of the sample immediately after extraction began, but increased in proportion as extraction progressed (Figure 6). The proportion of macro-arthropods extracted with these two methods was quite similar throughout the time course of extraction.



(a)

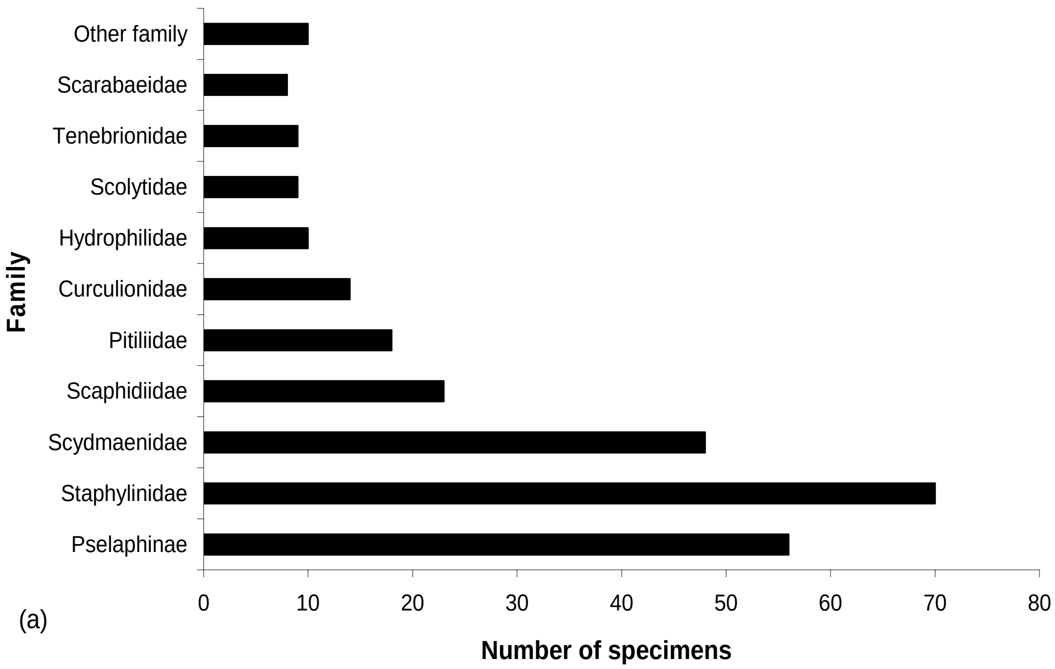


(b)

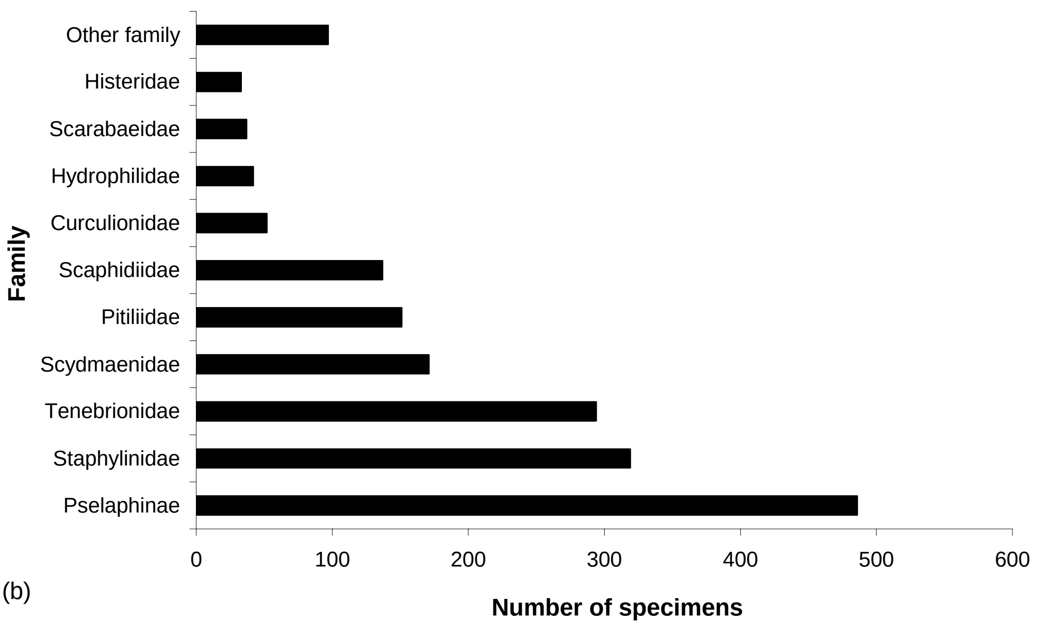
Figure 7 Proportion of soil and litter macroarthropod groups among the extracted specimens from samples after varying periods of time (accumulated) by Winkler extractors (a); Tullgren extractors (b).

1.2 Extraction and composition at beetle families

Twenty-two families were collected in this study (Table 5). Beetles in subfamily Pselaphinae were separately counted from other Staphylinidae, as this group is abundant in forest litter (Chandler, 2001) and the focus of our taxonomic study. Winkler extractors were inefficient for collecting soil and litter beetles, Only 275 adult and 150 larval of beetles were extracted. Tullgren funnels extracted 1,820 adult and 344 larval Coleoptera (Figure 8). Fifteen beetle families were collected with Winkler extractors, while 22 families were collected with Tullgren extractors. Beetles in families Staphylinidae, Scydmaenidae, Scaphidiidae, Ptiliidae, and in the staphylinid subfamily Pselaphinae were among the top ten most abundant taxa (Figure 8). The proportion of beetle families extracted by Winkler and Tullgren extractors was similar (Figure 9). The families Silvanidae, Throscidae, Salpingidae, Eucnemidae, Discolomidae, Heteroceridae, Hydrophilidae, Leiodidae and Nitidulidae were only extracted by Tullgren extractors. Tenebrionidae was the third most abundant beetle family extracted with Tullgren extraction, but few individuals were extracted with Winkler extractors (Figure 8).

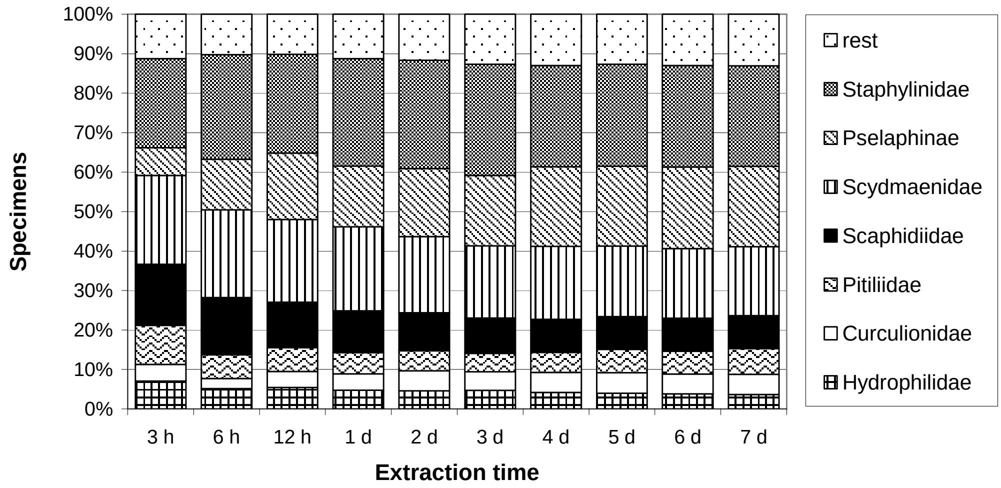


(a)

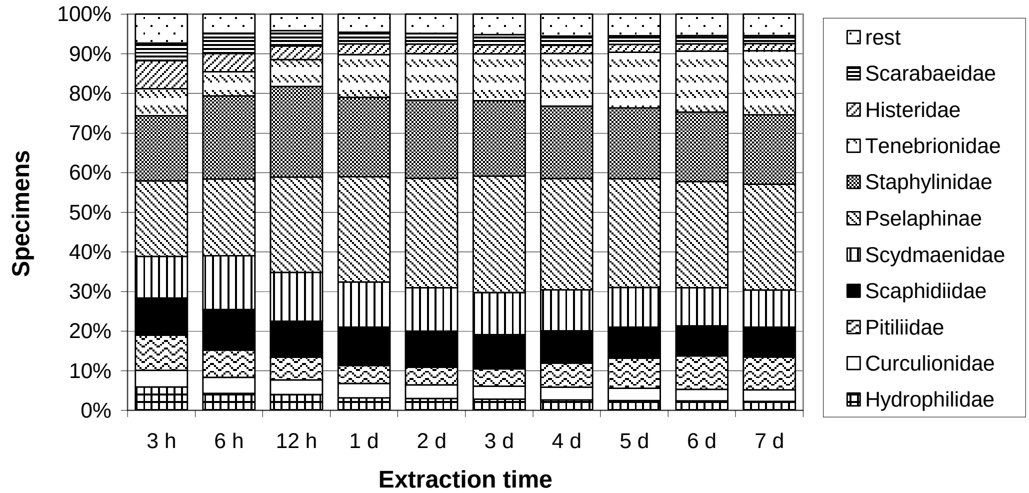


(b)

Figure 8 Number of specimens of beetle families extracted after 7 days with Winkler extractors (a); Tullgren extractors (b).



(a)



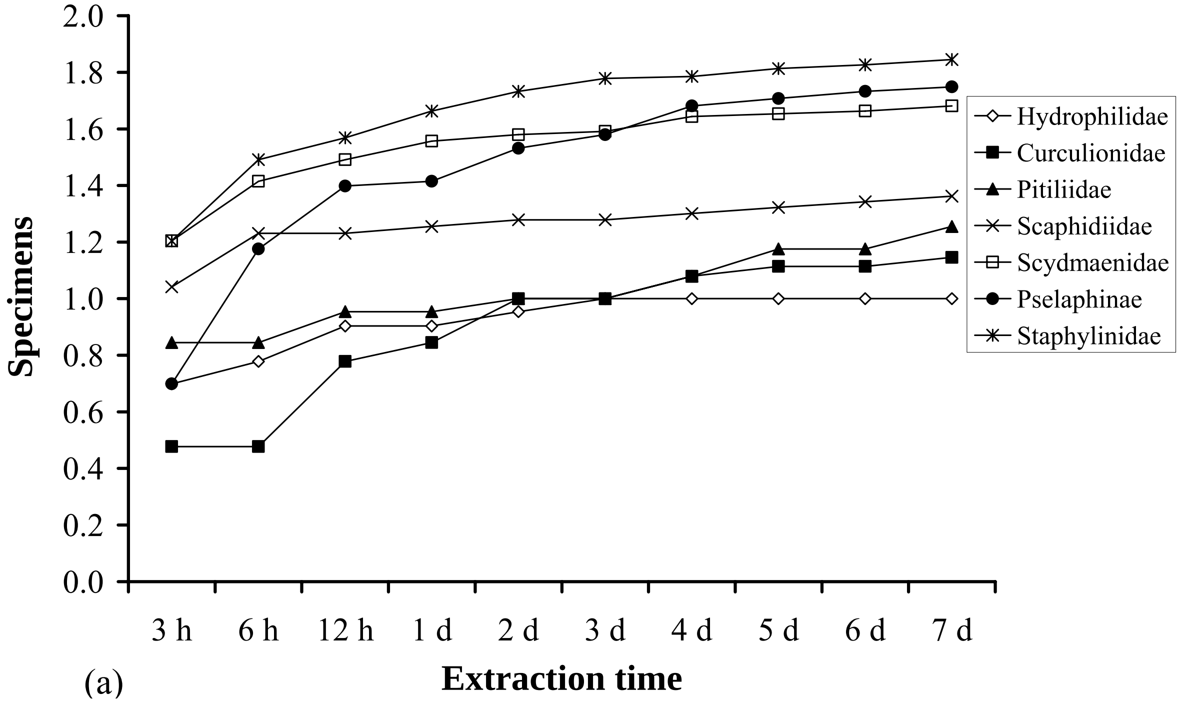
(b)

Figure 9 Proportion of beetle families extracted among the extracted specimens from samples after varying periods of time (accumulated) with Winkler extractors (a); Tullgren extractors (b).

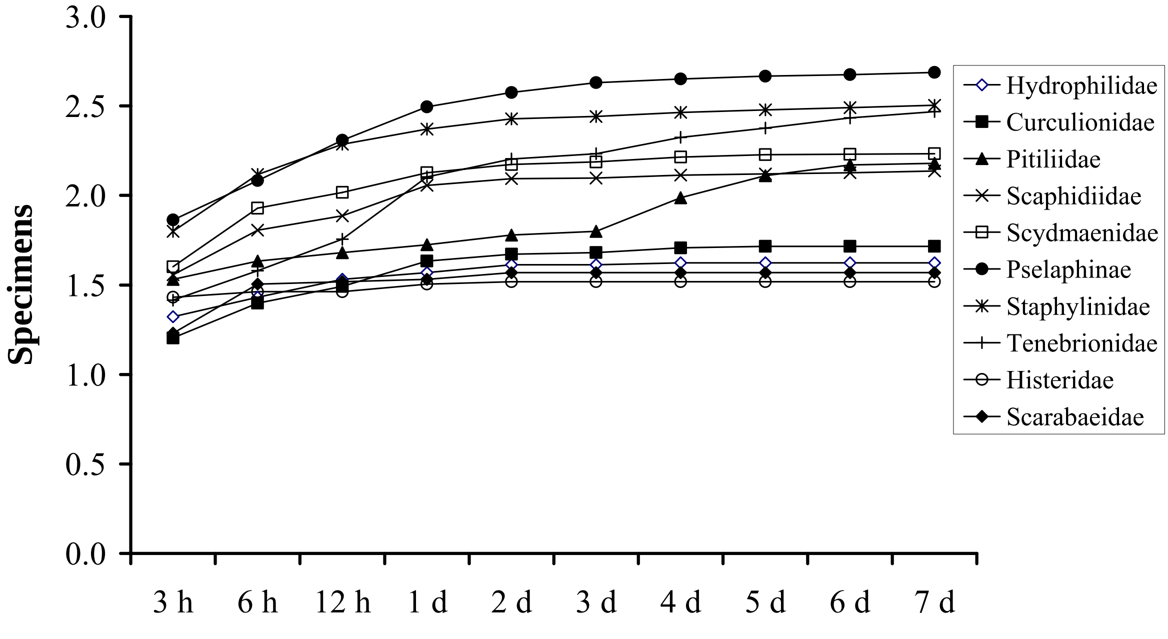
1.3 Taxonomic bias: Species collecting

Specimen accumulation curves for abundant beetle families are given in Figure 10. Hydrophilidae, Scarabaeidae, Curculionidae, Scaphidiidae and Histeridae were completely extracted after three days and Scydmaenidae were completely extracted on the day four with Tullgren funnels (Figure 10b). Only specimens in the family Hydrophilidae showed saturation by Winkler extractors after three days (Figure 10a). Other abundant families were not completely extracted with Winkler bags at the end of the extraction period (Figure 10a).

Pselaphine beetles are the most dominant group of soil and litter beetles. They are abundant (56/275 beetles via Winkler extraction; 486/1,820 via Tullgren extraction) (Table 5). Nine and 19 pselaphines species were extracted with Winkler and Tullgren extractors respectively (Figure 11). In this set of comparisons at the species level, *Plagiophorus* sp. 1, *Pseudophanias* sp. 1 were the dominant species collected by both methods. *Apharina* sp. 1 and *Batraxis doriae* were two additional dominant species extracted with Tullgren extractors. For the other species, Tullgren funnels extracted more pselaphine species as well as other soil and litter beetle families. The species accumulation curve for pselaphine beetles for Winkler and Tullgren samples approached saturation on the first day for Winklers and on the second day for Tullgren samples (88.88% and 94.73%, respectively) and both methods extracted all pselaphines by day four. However, pselaphine species and specimens collected by these two methods were quite different (Figure 11; Table 6).



(a)



(b)

Figure 10 Specimen accumulation curve of dominant beetle families extracted after certain periods of time with Winkler extractors (a); Tullgren extractors (b).

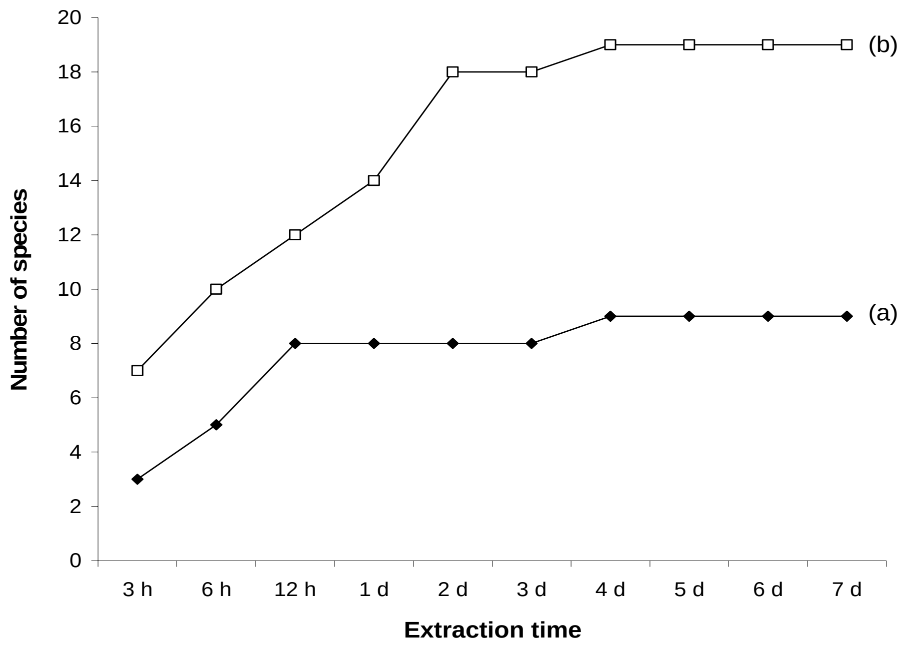


Figure 11 Species accumulation curve of pselaphine beetles (Staphylinidae: Pselaphinae) extracted after varying periods of time with Winkler extractors (a); Tullgren extractors (b).

Table 5 Number of beetle specimens in each family after 7 days extraction by Winkler and Tullgren extractors. Average are mean ± SD (N = 10). Most of tropic guilds of each family are after Hammond (1990). Abbreviation of trophic guilds, Pr, predacious; F, fungivorous; H, herbivorous; Pa, parasitic; S, saprophagous; X, xylophagous.

		Extraction method		
Family	**Trophic guild**	**Winkler**	**Tullgren**	**%**
SF. Pselaphinae	Pr	56	486	25.87
Staphylinidae	Pr, S	70	319	18.57
Tenebrionidae	F, S, H	9	294	14.46
Scydmaenidae	Pr	48	171	10.45
Pitiliidae	S, F	18	151	8.07
Scaphidiidae	F	23	137	7.64
Curculionidae	X, H	14	52	3.15
Hydrophilidae	Pr, S	10	42	2.48
Scarabaeidae	S, X, H	8	37	2.15
Histeridae	Pr	2	33	1.67
Scolytidae	X, F	9	26	1.67
Discolomidae	F		16	0.76
Salpingidae	?F		12	0.57
Crytophagidae	?F	2	10	0.57
Leiodidae	F, S		9	0.43
Carabidae	Pr	4	7	0.53
Coccinellidae	Pr, H	1	5	0.29
Silvanidae	F, S		4	0.19
Acanthoceridae	F		4	0.19
Nitidulidae	F, S		2	0.10

Table 5 (Continued).

		Extraction method		
Family	**Trophic guild**	**Winkler**	**Tullgren**	**%**
Chrysomelidae	H	1	1	0.10
Eucnemidae	F, X		1	0.05
Throseidae	?F, ?X		1	0.05
Coleoptera larvae		150	344	
Coleoptera adults		275	1820	
Average specimens in 1 m^2		42.5 ± 15.6	216.4 ± 61.2	

Table 6 Number of pselaphine beetle specimens after 7 days extraction by Winkler and Tullgren extractors. Number showed in the last row is mean ± SD (N = 10).

Family Staphylinidae	**Extraction method**	
Subfamily Pselaphinae	**Winkler**	**Tullgren**
Plagiophorus sp. 1	36	399
Pseudophanias sp. 1	11	18
Batraxis doriae	3	15
Apharina sp. 1	1	12
Pseudoplectus sp. 1	1	7
Euplectus sp. 1	1	5
Parapyxidicerus sp. 1		5
Articerodes sp. 1	1	4
Leptoplectus sp. 1		4
Euplectodina sp. 1		3
Pseudophanias sp. 2*		3
Leptoplectus sp. 2		2
Philiopsis sp. 1		2
Plagiophorus sp. 2	1	2
Atenisodus sp. 1		1
Parapyxidicerus sp. 3		1
Tribasodites sp. 1		1
Hypochareus sp. 1	1	
Undetmined genus allied to *Hypochareus*		1
Hamophorus sp. 1		1
Total specimens	56	486
Average specimens in 1 m^2 (quadrat)	5.6 ± 7.1	48.6 ± 14.2

Figures of * *Pseudophanias* sp. 2 was available in page 115.

2. Survival time of macroarthropods and pselaphine beetles in the ventilation cloth bags before extraction

The temperature and moisture of soil samples in the ventilation cloth bags (N = 5) had gradually increased after 3 hrs to 6 hrs and decreased with longer storage times at 12 and 24 hrs. But only temperature had found statistically significant (ANOVA, $F_{3,16}$ = 16.066, P < 0.001) while, there was not significantly different in soil moisture (ANOVA, $F_{3,16}$ = 0.493, P = 0.692; Figure 12).

Soil arthropods were most still alive after three hrs collected in the field, and resulted on the extraction efficiency that showed more efficient in extracting soil-litter arthropods in the first set of storage samples (N = 5). A total of 622 individuals and 46 species of pselaphine beetles from 20 Tullgren extractors were collected. Pselaphines showed decline in species and individuals with longer time. At 3 hrs, a total of 277 individuals were extracted from the first set (N = 5), and after 24 hrs, 77 individuals were extracted (Table 7). An average of 55 pselaphine individuals per sample extracted after 3 hrs was linearly dropped to 15.4 per sample after 24 hrs (Figure 14). The total number of species (from 5 replicates) was 28 species at 3 hours storage time and total number of species (from 5 replicates) was decline to 20 species after 24 hrs (Table. 7). Mean number of species was 9 ± 1.08 at 3 hrs had linearly dropped to 6 ± 0.83 after 24 hrs (R^2 = 0.94, Figure 13). Although there was marginally significant on number of specimens (Krusal-Wallis test, H = 7.5, P = 0.057, df = 3) but not significant on species number of pselaphine beetles (H = 3.9, P > 0.05, df = 3).

The other terrestrial arthropods collected had shown the similar results, ants were the most extraction arthropods with total of 9,183 (individuals); 68.48; (%) from 20 Tullgrens, beetles including pselaphines was the second extraction (3,255 individuals; 24.27%), Hemiptera (123 individuals; 0.92%) and spiders (226 individuals; 1.68%). In ant extraction, the mean of 552.2 ± 104.32 individuals were extracted from the 3 hrs and the number of ants decreased to 347 ± 24.92 individuals after 24 hrs of storage time (Figure 15). For beetles, the mean number of individuals was 172 ± 22.55 per Tullgren at 3 hrs (Figure 16), the average number of individuals had declined to 111-121 individuals per Tullgren after six up to 24 hrs of storage time (Figure 16). Both ants and beetle specimens were not significantly different among the storage sets (3 hrs to 24 hrs) (ants, $H = 3.9$, $P > 0.05$; beetles, $H = 5.6$ $P > 0.05$) Only the low abundant groups (Hemiptera and Araneae) were significant (Hemiptera, $H = 8.2$, $P = 0.04$; Araneae, $H = 14.5$, $P = < 0.01$) which extracted in higher number of individuals in the first set of storage sample and number of individuals reduced with longer storage samples as other soil arthropods (Figure 17-18). In this study, three patterns of declining curves of extraction were shown as following; the first pattern was gradual decrease as in ants, the second pattern was rapid decline to 12 hours as in Hemiptera and spiders; and the third pattern was rapid decline to 6 hours as in beetles including pselaphine beetles.

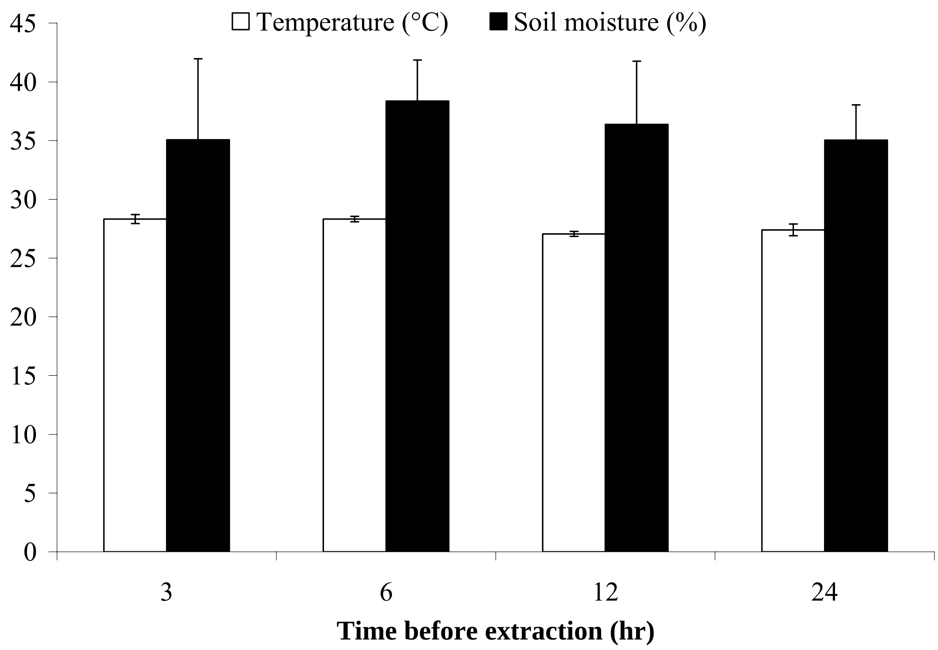


Figure 12 Changes of soil temperature and percentage of moisture in storage samples. Bars shown are mean ± SD ($N = 5$).

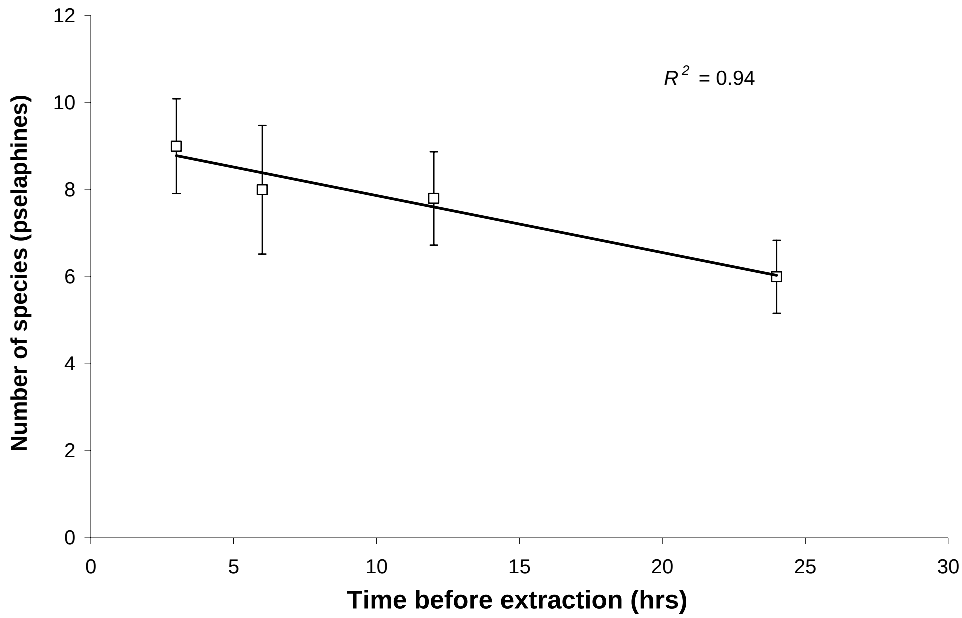


Figure 13 Number of pselaphine species extracted from soil samples among the different storage times. Point showed mean ± SE (N = 5).

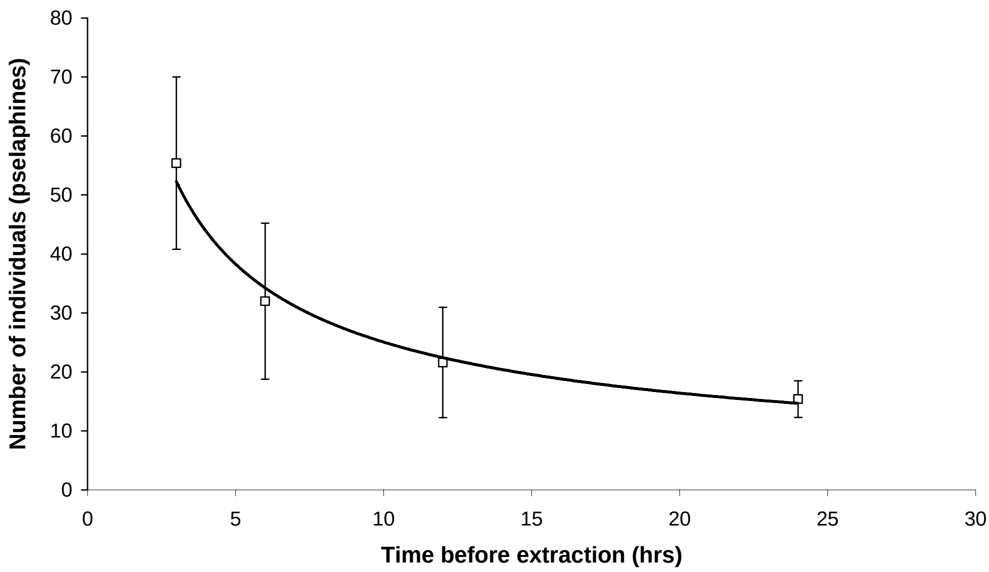


Figure 14 Number of pselaphine specimens extracted from soil samples among the different storage times. Points showed mean ± SE (N = 5).

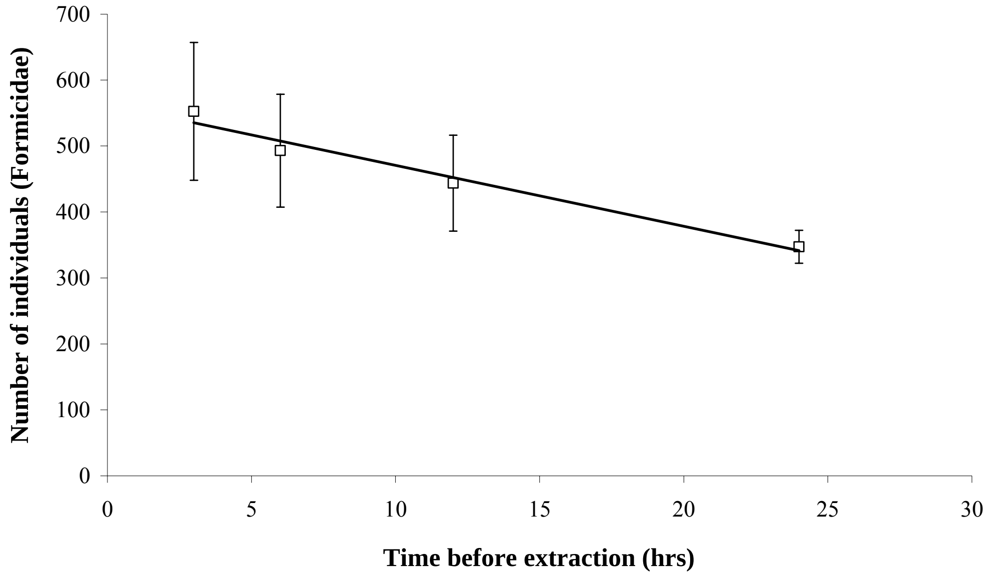


Figure 15 Number of Formicidae (ants) individuals extracted from soil samples among the different storage times. Points showed mean ± SE (N = 5).

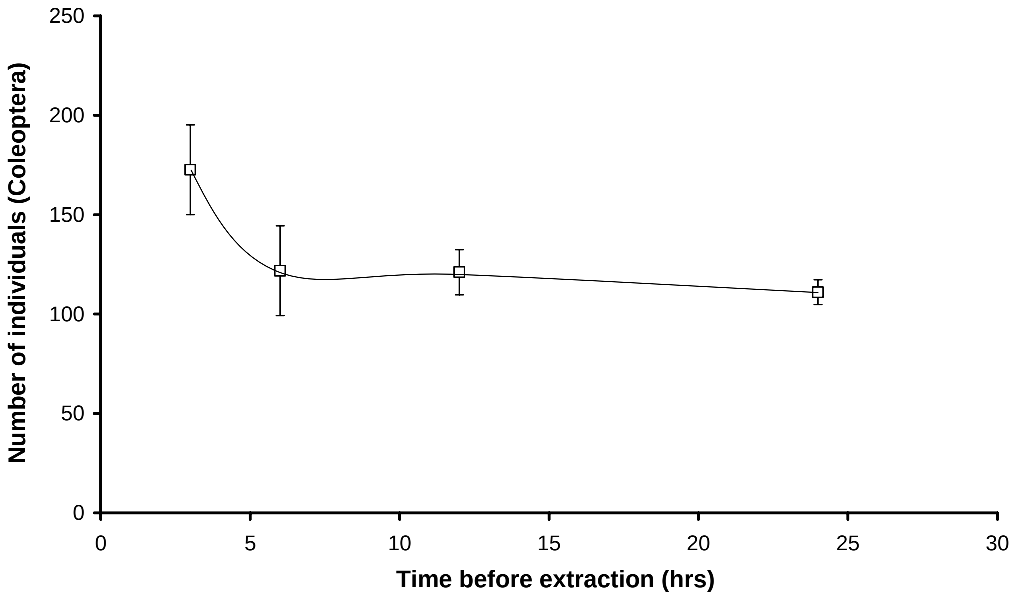


Figure 16 Number of Coleoptera (beetles) individuals extracted from soil samples among the different storage times. Points showed mean ± SE (N = 5).

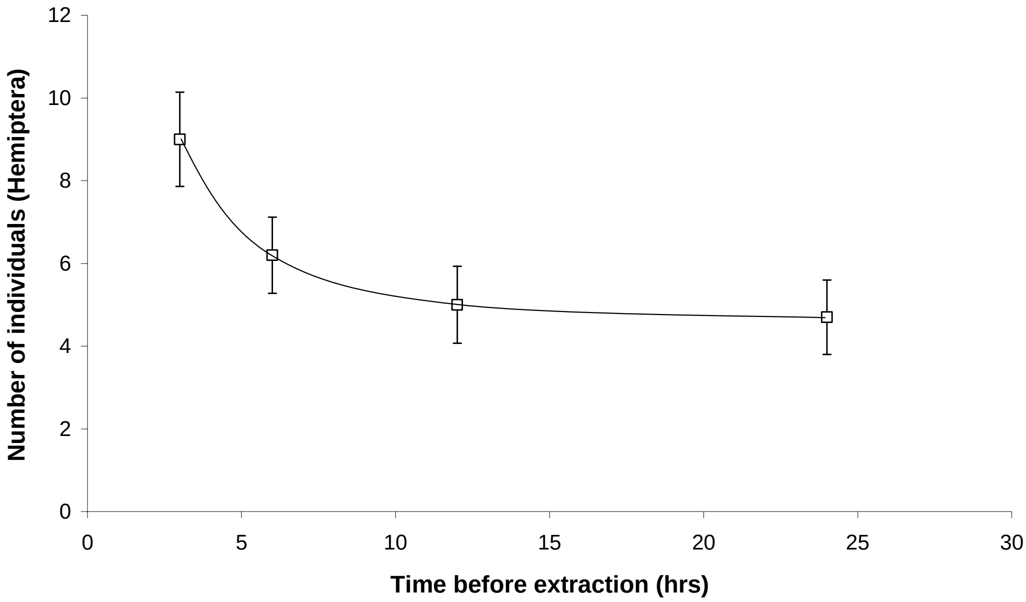


Figure 17 Number of Hemiptera bugs) individuals extracted from soil samples among the different storage time. Points shown are mean ± SE (N = 5).

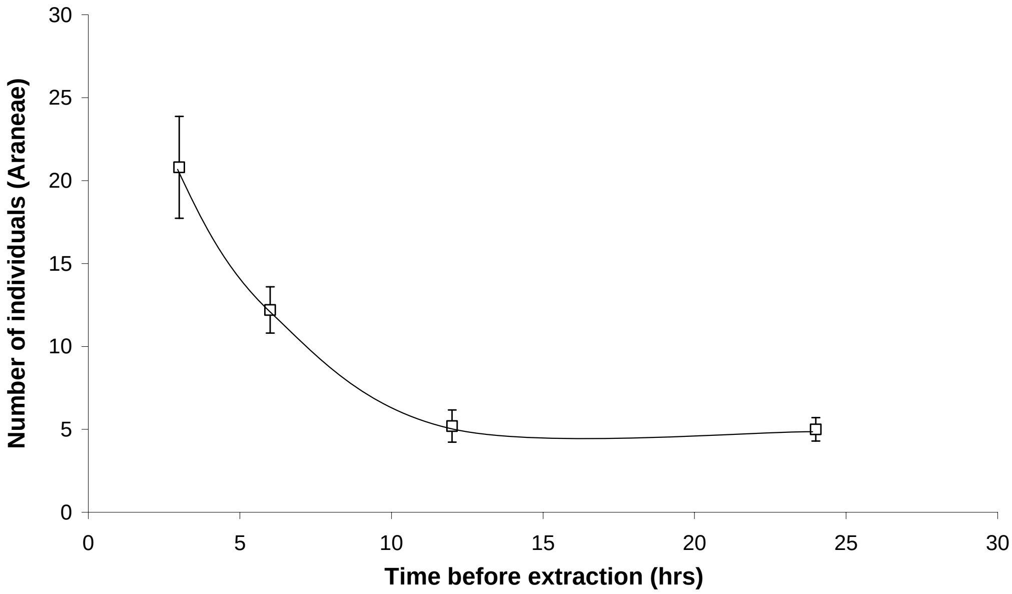


Figure 18 Number of Araneae (spiders) individuals extracted from soil samples among the different storage time. Points shown are mean ± SE (N = 5).

Table 7 Number of pselaphine beetles extracted among the different storage times (*N* = 5).

Supertribe	**Species**	**Time before extraction (hrs)**				**Total**
		3	**6**	**12**	**24**	
Batrisitae	*Aphilia* sp. 1	2	1	10	1	14
Batrisitae	*Batriscenaulax* sp. 1	4			1	5
Batrisitae	*Batrisoplisus* sp. 1	1	1	3	7	12
Batrisitae	*Mnia* sp. 1	3	32	22	9	66
Batrisitae	*Oxyomera* sp. 1		1			1
Batrisitae	*Sathytes* sp. 1			1		1
Batrisitae	*Tribasodites* sp. 1	9	7			16
Bythinoplectitae	Bythinoplectina gen.undet. sp. 1	20				20
Bythinoplectitae	Bythinoplectina gen.undet. sp. 2	3				3
Bythinoplectitae	Parapyxidicerina gen.undet. sp. 1	2			1	3
Bythinoplectitae	Parapyxidicerina gen.undet. sp. 2	5		3		8
Bythinoplectitae	Parapyxidicerina gen.undet. sp. 3	1				1
Bythinoplectitae	Parapyxidicerina gen.undet. sp. 4	1				1
Bythinoplectitae	*Tuberoplectus* sp. 1	1	2			3
Euplectitae	*Bibloplectus* sp. 1			1		1
Euplectitae	*Bibloporus* sp. 1	1	2	7	1	11
Euplectitae	*Euplectodina* sp. 1			2		2
Euplectitae	*Euplectus* sp. 1		2			2
Euplectitae	*Leptoplectus* sp. 1				3	3
Euplectitae	*Philiopsis* sp. 1		2		1	3
Euplectitae	*Prophilus* sp. 1	1	26	1		28
Euplectitae	*Pseudoplectus* sp. 1	3		1		4
Goniaceritae	*Atenisodus* sp. 1	17	13	15	16	61
Goniaceritae	*Atenisodus* sp. 2		5			5
Goniaceritae	*Batraxis doriae*	12	21	11	1	45
Goniaceritae	*Batraxis* sp. 2	2	23	3		28

Table 7 (Continued).

Supertribe	Species	Time before extraction (hrs)				Total
		3	**6**	**12**	**24**	
Goniaceritae	*Batraxis* sp. 3	1	3	3		7
Goniaceritae	*Batraxis* sp. 4		1			1
Goniaceritae	*Hamophorus* sp. 1	3	2	2		7
Goniaceritae	*Hamophorus* sp. 2				3	3
Goniaceritae	*Morana* sp. 1	12	1	2	21	36
Goniaceritae	*Morana* sp. 2				1	1
Goniaceritae	*Natyplerus* sp. 1		3			3
Goniaceritae	*Plagiophorus* sp. 1	60	52	23	31	166
Goniaceritae	*Plagiophorus* sp. 2	1			2	3
Goniaceritae	*Plagiophorus* sp. 3		1		1	2
Goniaceritae	*Plagiophorus* sp. 4			3		3
Pselaphitae	*Ancystrocerus* sp. 1		2			2
Pselaphitae	*Hamotopsis* sp. 1	2		1	1	4
Pselaphitae	*Megatyrus* sp. 1*		2			2
Pselaphitae	*Pseudophanias* sp. 1	7	2	13	2	24
Pselaphitae	*Pseudoplectus* sp. 2	1	1			2
Pselaphitae	*Apharina* sp. 1	1				1
Pselaphitae	*Tmesiphorus* sp. 3?*	1	2		1	4
Pselaphitae	*Pselaphodes* sp. 1			1	1	2
	Protopselaphus sp. 1			2		2
	Total individuals	277	160	108	77	622
	Total species	28	26	22	20	46

Figures of * *Megatyrus* sp. 1 and *Tmesiphorus* sp. 3 were available in page 113.

3. Pselaphine beetle diversity in eastern forest complex of Thailand

3. 1 List of morpho-species and some ecological data of pselaphine beetles collected in 2006 in eastern forest complex of Thailand.

Supertribe Batrisitae

Tribe Batrisini

Subtribe Batrisina

The Genus-Group of *Batrisus*

1. *Batrisodes?* sp. 1 (Figure 19A)

Specimens examined. 1 ex, HEF, Khao Kitchakut national Park,1,069 m asl., Chanthaburi province, 19. I. 2006.

Subtribe Batrisina

The Genus group of *Tribasodes*

2. Batrisina gen. undet. sp. 1 (Figure 19B)

Specimens examined. 2 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006.

Remarks. This species is allied to genus *Hypochareus.*

3. Batrisina gen.undet sp. 2 (Figure 19C)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 15. III. 2006.

Remarks. This species is largest size among subtribe Batrisitae collected in this project.

4. *Tribasodites* sp. 1 (Figure 19D)

Specimens examined. 6 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. I. 2006; 2 exs, same locality as above, 16. III. 2006; 2 exs, same locality as above, 28. IX. 2006; 1 ex, MEF, Khao Sao Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006; 8 exs, same 2nd locality as above, 30. IX. 2006; 5 exs, same 2nd locality as above, 30. XII. 2006.

Remarks. This species is the most abundant of *Tribasodites* species and occurred all year round. This genus is characterized by having a pair of long and acute spines on the basimedian part of pronotum (Nomura, 2002).

5. *T.* sp. 2 (Figure 19E)

Specimens examined. 3 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. III. 2006.

6. *T.* sp. 3 (Figure 19F)

Specimens examined. 1 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006; 2 exs, same locality as above, 12. VII. 2006; 3 exs, same locality as above, 28. IX. 2006; 1 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006.

7. *T.* sp. 4 (Figure 19G)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006.

8. *T.* sp. 5 (Figure 19H)

Specimens examined. 4 exs, PMEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006; 2 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 28. IX. 2006.

9. *Hypochraeus* sp. 1 ((Figure 19I)

Specimens examined. 3 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. I. 2006; 1 ex, same locality as above, 17. III. 2006; 2 exs, same locality as above, 3. V. 2006; 1 ex, same locality as above, 28. XI. 2006; 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 101m asl., Chachoengsao province, 17. I. 2006.; 1 ex, same 2nd locality as above, 17. VII. 2006; 1 ex, same 2nd locality as above, 28. XI. 2006; 1 ex, same 2nd locality as above, 28. XI. 2006; 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 16. VII. 2006.

Remarks. This species is the most abundant species in genus *Hypochraeus*. It has very unique characters, for example, the broadened body, and very large spines on the pronotum and the parallel-sided paratergite on the fourth to fifth abdominal tergites. Additionally, this genus is closely allied to genus *Amana* (Nomura, 2002).

10. *H.* sp. 2 (Figure 20A)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province; 1 ex, same locality as above, 15. III. 2006.

11. *H.* sp. 3 (Figure 20B)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. XI. 2006.

12. *Amana* sp. 1 (Figure 20C)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 19. I. 2006; 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. IX. 2006.

Remarks. This genus is allied to the genus *Hypochraeus***.**

Subtribe Batrisina

The Genus-Group of *Batrisocenus*

13. *Physomerinus* sp. 1 (Figure 20D)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 19. I. 2006.

Remarks. This genus is easily distinguished by the strongly swollen hind femora.

14. *Trisinus* sp. 1 (Figure 20E)

Specimens examine. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006; 2 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 28. IX. 2006.

15. *Batriscenaulax* sp. 1 (Figure 20F)

Specimens examined. 14 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006; 2 exs, same locality as above, 28. IX. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006; 1 ex, same 2nd locality as above, 6. V. 2006; 8 exs, same 2nd locality as above, 15. VII. 2006; 8 exs, same ^{2nd} locality as above, 30. IX. 2006; 3 exs, same 2nd locality as above, 30. XI. 2006.

Remarks. This species is widely distributed in PMDF and MEF and occurred all year. This genus has been known from Japan, Vietnam and Malaysia. It has the sexual patch on the fourth abdominal tergite and the small pencil on the fore tibia in male (Nomura, 2005).

16. *Batrisiella* sp. 1 (Figure 20G)

Specimens examined. 2 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. VI. 2006; 4 exs, same locality as above, 15. VII. 2006; 7 exs, same locality as above, 30. IX. 2006.

Remarks. This species is found in MEF in wet season.

Subtribe Batrisina incertae sedis

17. *Mnia* sp. 1 (Figure 20H)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006; 2 exs, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 19. I. 2006; 11 exs, same 2^{nd} locality above, 15. III. 2006; 2 exs, same 2^{nd} locality above, 5. V. 2006; 4 exs, same 2^{nd} locality above, 9. VII. 2006; 6 exs, same 2^{nd} locality above, 26. XI. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; same 3^{rd} locality as above, 16. III. 2006; 18 exs, same 3^{rd} locality as above, 6. V. 2006; 15 exs, same 3^{rd} locality as above, 15. VII. 2006; 61 exs, same 3^{rd} locality as above, 30. IX. 2006; 112 exs, same 3^{rd} locality as above, 30. XI. 2006.

Remarks. *Mnia* sp.1 was the dominant species in MEF.

18. *Sathytes* sp.1 (Figure 20I)

Specimens examined. 2 males, 1 female, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006; 1 female, same locality above, 15. VII. 2006.

Remarks. This genus is widely distributed in subtropical and tropical areas of Asia. Three species have been known from Penang and Sarawak, Malaysia (Nomura, 2005).

Supertribe Bythinoplctitae

Tribe Bythinoplectini

Subtribe Bythinoplectina

1. Bythinoplectina gen.undet. sp. 1 (Figure 21A)

Specimens examined. 2 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006; 1 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006; 1 exs, same 2nd locality, 30. XI. 2006.

2. Bythinoplectina gen.undet. sp. 2 (Figure 21B)

Specimens examined. 5 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. XI. 2006.

3. Bythinoplectina gen.undet. sp. 3 (Figure 21C)

Specimens examined. 2 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006; 12 exs, same locality as above, 12. VII. 2006; 3 exs, same locality as above, 28. IX. 2006; 1 ex, same locality as above, 28. XI. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 1 ex, same 2nd locality as above, 30. XI. 2006.

4. Bythinoplectina gen.undet. sp. 4 (Figure 21D)

Specimens examined. 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. XI. 2006.

5. *Zethopsus opacus* Schaufuss (Figure 21E)

Specimens examined. 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 7. V. 2006.; 2 exs, same locality above, 16. VII. 2006; 2 exs, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 9. VIII. 2006; 2 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 28. XI. 2006.

Remarks. This genus *Zethopsus* is known from Southeast Asia including Indo-Chinese region, Thailand and Myanma (Nomura, 2000). The type specimen was collected in Thailand and described by Schaufuss (1877).

Tribe Bythinoplectini

Subtribe Pyxidicerina

6. *Parapyxidicerus* sp. 1? (Figure 21F)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 1 ex, same locality as above, 30. XI. 2006; 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 17. I. 2006; 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 15. I. 2006; 1 ex, same 3^{rd} locality as above, 7. V. 2006; 1 ex, same 3^{rd} locality as above, 16. VII. 2006., 3 exs, same 3^{rd} locality as above, 26. IX. 2006, 5 exs, same 3^{rd} locality as above, 26. XI. 2006; 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. XI. 2006.

Remarks. This species is dominated in teak plantation.

7. Pyxidicerina gen.undet. sp. 1 (Figure 21G)

Specimens examined. 2 exs, HEF, Khao Kitchakut National Park, 1,069 m asl., Chanthaburi province, 15. III. 2006; 1 exs, same locality as above, 5. V. 2006; 2 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 3. V. 2006; 2 exs, same 2^{nd} location as above, 12. VII. 2006; 2 exs, same 2^{nd} location as above, 28. IX. 2006; 3 exs, MDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006; 2 exs, same 3^{rd} locality as above, 28 IX. 2006; 3 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 15. VII. 2006; 1 ex, same 4^{th} locality as above, 30. IX. 2006.

8. Pyxidicerina gen.undet. sp. 2 (Figure 21H)

Specimens examined. 5 exs, HEF, Khao Kitchakut National Park, 1,069 m asl., Chanthaburi province, 15. III. 2006; 2 exs, PMDF, Khao Ang Rue Nai Wildlife

Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006; 1 ex, same 2nd locality as above, 28. IX. 2006; 3 exs, TP, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 26. IX. 2006.

9. Pyxidicerina gen.undet. sp. 3 (Figure 21I)

Specimens examined. 2 exs, Khao Soi Dao Wildlife Sanctuary, 329 m asl, Chanthaburi province, 30. IX. 2006; 1 ex, same locality as above, 30. XI. 2006; 2 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 28. IX. 2006; 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 28. IX. 2006; 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 26. IX. 2006.

10. Pyxidicerina gen.undet. sp. 4 (Figure 22A)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 15. III. 2006; 2 exs, same above locality, 5. V. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006.

11. Pyxidicerina gen.undet. sp. 5 (Figure 22B)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 12. VII. 2006.

12. Pyxidicerina gen.undet. sp. 6 (Figure 22C)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006.

13. Pyxidicerina gen.undet. sp. 7 (Figure 22D)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006.

14. Pyxidicerina gen.undet. sp. 8 (Figure 22E)

Specimens examined. 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 12. VII. 2006.

15. Pyxidicerina gen.undet. sp. 9 (Figure 22F)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 15. III. 2006; 1 ex, same location as above, 9. VIII. 2006.

16. Pyxidicerina gen.undet. sp. 10 (Figure 22G)

Specimens examined. 2 exs, HEF, Khao Kitchakut National Park, 1,069 m asl., Chanthaburi province, 15. III. 2006.

Tribe Dimerini

17. *Octomicrus longulus* Schaufuss (Figure 22H)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006.

Remarks. This type species was collected in Thailand and described by Schaufuss (1877)

18. *Tuberoplectus* sp. 1 (Figure 22I)

Specimens examined. 8, exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. XI. 2006.

Supertribe Euplectitae
Tribe Euplectini

1. *Euplectus* sp. 1 (Figure 23A)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3.V. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006; 10 exs, same 2nd locality as above, 30. XI. 2006; 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. XI. 2006.

2. *E.* sp. 2 (Figure 23B)

Specimens examined. 2 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006; 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 28. IX. 2006.

3. *Leptoplectus* sp. 1 (Figure 23C)

Specimens examined. 2, exs, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. XI. 2006; 3 exs, same locality as above, 9. VIII. 2006; 12 exs, same locality as above, 26. XI. 2006; 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. XI. 2006

Remarks. This genus is closely with *Euplectus* but it is distinguished by deep emargination on anterior margin of labrum (Nomura, 2000).

4. *L.* sp. 2 (Figure 23D)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 15. III. 2006; 2 exs, same locality as above, 9. VIII. 2006; 2 exs, same locality as above, 26. XI. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 15. VII. 2006.

5. *L.* sp. 3 (Figure 23E)

Specimens examined. 4 exs, HEF, Khao Kitchakut National Park, 1,069 m asl., Chanthaburi province, 9. VIII. 2006; 1 ex, same location as above, 26. XI. 2006.

6. *L.* sp. 4 (Figure 23F)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park, 1,069 m asl., Chanthaburi province, 26. XI. 2006.

Tribe Trichonychini
Subtribe Bibloporina

7. *Aphilia* sp. 1 (Figure 23G)

Specimens examined. 5 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. I. 2006; 10 exs, same locality as above, 17. III. 2006; 5 exs, same locality as above, 3. V. 2006; 3 exs, same locality as above, 12. VII. 2006; 7 exs, same locality as above, 28. IX. 2006; 5 exs, same locality as above, 28. XI. 2006; 4 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 28. IX. 2006; 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. IX. 2006; 17 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 4 ex, same 3rd location as above, 6. V. 2006; 1 ex, same 3rd location as above, 15. VII. 2006; 1 ex, same 3rd location as above, 30. IX. 2006; 23 exs, same 3rd location as above, 30. XI. 2006; 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. IX. 2006.

Remarks. Aphilia sp. 1 is the most abundant species in supertribe Euplectitae and found all year in all habitat types.

8. *Bibloporus* sp. 1 (Figure 23H)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006; 1 ex, same locality as above, 15. VII. 2006; 1 ex, same locality as above, 30. XI. 2006.

9. *B.* sp. 2 (Figure 23I)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 1 ex, same locality as above, 30. IX. 2006; same locality as above, 30. XI. 2006.

10. *B.* sp. 3 (Figure 24A)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. XI. 2006.

11. *B.* sp. 4 (Figure 24B)

Specimens examined. 2 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 28. XI. 2006.

12. *B.* sp. 5 (Figure 24C)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006.

13. *B.* sp. 6 (Figure 24D)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. XI. 2006.

Tribe Trichonychini

Subtribe Panaphantina

14. *Bibloplectus* sp. 1 (Figure 24E)

Specimens examined. 5 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006; 1 ex, same locality as above, 30. IX. 2006; 2 exs, same locality as above, 30. XI. 2006.

15. Panaphantina gen.undet. sp.1 (Figure 24F)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 5. V. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006.

16. *Euplectodina* sp. 1 (Figure 24G)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 1 ex, same locality as above, 6. V. 2006;3 exs, same locality as above, 15. III. 2006; 14 exs, same locality as above, 30. IX. 2006; 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. IX. 2006; 1 ex, MPDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006; 1 ex, same 3rd locality as above, 28, IX. 2006.

Remarks. This genus is closely allied to genus *Philopsis* (Nomura, personal communication).

17. *Philiopsis* sp. 1 (Figure 24H)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 15. VII. 2006; 1 ex, same locality as above, 30. IX. 2006; 3 exs, same locality as above, 30. XI. 2006; 1 ex, MDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 28. IX. 2006; 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. XI. 2006.

18. *Pseudoplectus* sp. 1 (Figure 24I)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006.

Remarks. Genus *Pseudoplectus* includes highly diversified many species in eastern forest complex of Thailand.

19. *P.* sp. 2 (Figure 25A)

Specimens examined. 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 3. V. 2006.

20. *P.* sp. 3 (Figure 25B)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006.

21. *P.* sp. 4 (Figure 25C)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006; 3 exs, same locality as above, 16. VII. 2006; 9 exs, same locality as above, 30. IX. 2006; 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006.

22. *P.* sp. 5 (Figure 25D)

Specimens examined. 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. IX. 2006.

23. *P.* sp. 6 (Figure 25E)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. XI. 2006; 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 28. XI. 2006.

Tribe Trichonychini

Subtribe Trimiina

24. *Prophilus* sp. 1 (Figure 25F)

Specimens examined. 1ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. III. 2006; 2 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 4 exs, same 2nd locality as above, 15. VII. 2006.; 7 exs, same 2nd locality as above, 30. IX. 2006; 7 exs, same 2nd locality as above, 30. XI. 2006.

Remarks. This genus is distinct in this subtribe in having ten-segmented antennae (Nomura, 2000).

25. *P.* sp. 2 F (Figure 25G)

Specimens examined. 1 ex, 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. XI. 2006.

24. *Saucyella* sp. 1 (Figure 25H)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 19. I. 2006; 1ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 12. VII. 2006; 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 12. VII. 2006.

Remarks. This genus is easily distinct in having the nearly triangular head and large pronotum with a pair of transverse depressions.

26. *S.* sp. 2 (Figure 24I)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. IX. 2006.

27. *S.* sp. 3 (Figure 26A)

Specimens examined. 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 28. IX. 2006; 26 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. XI. 2006.

29. *S.* sp. 4 (Figure 26B)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 19. I. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. XI. 2006.

Supertribe Goniaceritae

Tribe Arnylini

1. *Harmophorus* sp. 1 (Figure 27A)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 28. VII. 2006; 2 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006; 12 exs, same 2nd locality as above, 6. V. 2006; 4 exs, same 2nd locality as above, 15. VII. 2006; 12 exs, same 2nd locality as above, 30. IX. 2006; 1 ex, same 2nd locality as above, 30. XI.

2006; 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 9. VIII. 2006; 3 exs, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. IX. 2006.

Remarks. This genus is easily distinguished by large body, and densely covers by long hairs on antennae, pronotum elytra and abdomen. This genus is widely distributed in subtropical to tropical Asia and includes 11 species known and many undescribed species (Nomura, 2005).

2. *H.* sp. 2 (Figure 27B)

Specimens examined. 2 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. I. 2006; 4 exs, same locality as above, 17. III. 2006; 4 exs, same locality as above, 3. VI. 2006; 3 exs, same locality as above, 12. VII. 2006; 3 exs, same locality as above, 28. IX. 2006.

3. *H.* sp. 3 (Figure 27C)

Specimens examined. 2 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 3. V. 2006; 1 ex, same locality as above, 28. IX. 2006; 1 ex, same locality as above, 28. XI. 2006.

4. *H. gibbioides* Motschulsky? (Figure 27D)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006; 2 exs, same locality as above, 12. VII. 2006; 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 15. III. 2006; 1 ex, same 2nd locality as above, 5. V. 2006; 2 exs, same 2nd locality as above, 26. XI. 2006.

Tribe Brachyglutini

Subtribe Brachyglutina

5. *Atenisodus* sp. 1 (Figure 27E)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006; 2 exs, same locality as above, 28. IX. 2006; 3 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006; 10 exs, same 2nd locality as above, 6. V. 2006; 7 exs, same 2nd locality as above, 15. VII. 2006; 9 exs, same 2nd locality as above, 30. IX. 2006; 3 exs, same 2nd locality as above, 30. XI. 2006; 3 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 3. V. 2006; 2 exs, HEF, Khao Kitchakut National Park, 1,069 m asl., Chanthaburi province, 26. IX. 2006.

Remarks. The genus *Atenisodus* is closely allied to *Comatopselaphus* Schaufuss in having the fourth abdominal segment and long palpal spine. However, it is distinguished by the small head with large eyes, the external expanded fourth segment and the truncate or subconical abdomen (Nomura, personal communication). It is widely distributed in all habitats of eastern forest except in teak plantation.

6. *A.* sp. 2 (Figure 27F)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 15. III. 2006; 3 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006.

7. *A.* sp. 3 (Figure 27G)

Specimens examined. 2 exs (1 male, 1 female), SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 26. IX. 2006.

8. *Comatopselaphus puncticollis* Raffray? (Figure 27H)

Specimens examined. 2 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 1 ex, same locality as above, 6. V. 2006; 8 exs, same locality as above, 30. IX. 2006.

Remarks. This genus is closely allied to *Atenisodus*.

9. *Batraxis doriae* Schaufuss (Figure 27I)

Specimens examined. 51 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 28. IX. 2006; 6 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. V. 2006; 6 ex, same 2nd locality as above, 6. V. 2006; 58 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006; 1 ex, same locality as above, 6. V. 2006; 70 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 1 ex, same locality as above, 30. XI. 2006.

Remarks. This genus is a large Brachyglutine genus consisting of more than 40 species which distributed in the Palearctic, Oriental, and Australian regions (Nomura, 2000). *Batraxis doriae* Schaufuss is the most abundant species among this genus in MEF and PMDF.

10. *Batraxis brevis* Raffray (Figure 28A)

Specimens examined. 3 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006. ; 1 ex, same locality as above, 6. V. 2006, 13 exs, same locality as above, 30. IX. 2006, 10 exs, same locality as above, 30. XI. 2006.

11. *B.* sp. 3 (Figure 28B)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006; 1 ex, same locality as above, 30. XI. 2006.

12. *B.* sp. 4 (Figure 28C)

Specimens examined. 2 exs (1 male, 1 female), PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 28. XI. 2006.

13. *Eupines* sp. 1 (Figure 28D)

Specimens examined. 2 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 3. V. 2006; 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 16. VII. 2006.

14. *E.* sp. 2 (Figure 28E)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 15. VII. 2006.

15. *Rybaxis* sp. 1 (Figure 28F)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. III. 2006.

Remarks. Many species of this genus are known from temperate zone though relatively rare in tropical area (Nomura, 2000).

16. *Trissemus* sp. 1 (Figure 28G)

Specimens examined. 2 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 3. V. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006.

Remarks. This genus is similar to *Rybaxis,* but separable by having the pronotum without sulcus between three basal foveae and the trifoveae elytron (Nomura, 2005).

17. *T.* sp. 2 (Figure 28H)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. XI. 2006.

18. *T.* sp. 3 (Figure 28I)

Specimens examined. 2 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006;1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 26. XI. 2006.

Tribe Cyathigerini

19. *Plagiophorus* sp. 1 (Figure 29A, B)

Specimens examined. (total 431 exs) 8 females, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. I. 2006; 8 males, 36 females, same locality as above, 17. III. 2006; 4 males, 22 females, same locality as above, 3. V. 2006; 28 males, 132 females, same locality as above, 12. VII. 2006; 35 males, 88 females, same locality as above, 28. IX. 2006; 8 females, same locality as above, 28. XI. 2006; 1 male, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 5. V. 2006; 1 male, same 2nd locality as above, 9. VIII. 2006; 13 males, 28 females, same 2nd locality as above, 26. IX. 2006; 2 males, 2 females, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 15. VII. 2006; 1 male, 16 females, same 3rd locality as above, 30. IX. 2006; 5 females, same 3rd locality as above, 30.XI. 2006; 1 male, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 17. I. 2006; 8 males, 36 females, same locality as above, 3. V. 2006.

Remark. Plagiophorus sp.1 is the most abundant species in eastern forest of Thailand. It was an indicator species of MDF.

20. *P.* sp. 2 (Figure 29C, D)

Specimens examine. 2 males, 4 females, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006; 7 males, 9 females, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006; 1 female, same 2nd locality as above, 15. IX. 2006; same 2nd locality as above, 15. IX. 2006; 2 males, 1 female, same 2nd locality as above, 30. XI. 2006; 4 females, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 5.

V. 2006; 1 male, 2 female, same 3rd locality as above, 9. VII. 2006; 1 male, 1 female, same 3rd locality as above, 26. IX. 2006.

21. *P.* sp. 3 (Figure 29E)

Specimens examined. 1 female, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. XI. 2006.

Tribe Iniocyphini

Subtribe Iniocyphina

22. *Sunorfa* sp. 1 (Figure 29F)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006; 1 ex, same locality as above, 12. VII. 2006; 5 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006; 15 exs, same 2nd locality as above, 30. XI. 2006.

Remarks. This genus includes 25 species described from the Oriental and Australian regions (Nomura, 2005).

Tribe Iniocyphini

Subtribe Natypleurina

23. *Natyplerus* sp. 1 (Figure 29G)

Specimens examined. (5 exs) 2 males, 3 females, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006; 3 exs, same 2nd locality as above, 30. XI. 2006.

Remarks. This genus is similar in appearance to the genus *Eupines* of the subtribe Brachyglutina in the rounded, thick and shiny body than the other subtribe Natypleurina (Nomura, personal communication).

24. Natyplerina gen.undet. sp.1 (Figure 29H)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 5. V. 2006; 2 exs, same locality as above, 9. VIII. 2006.

Remarks. This species is closely allied to genus *Morana*.

25. *Morana* sp. 1 (Figure 29I)

Specimens examined. 15 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006; 31 exs, same locality as above, 30. VII. 2006; 6 exs, same locality as above, 30. IX. 2006.

Remarks. This species is found dominated in MEF. This genus has previously been known in Japan, southern China and Indochina (Nomura, 2005).

Tribe Protini

26. *Mechanicus* sp. 1 (Figure 30A)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 9. VIII. 2006.

27. *Pareuplectops* sp. 1 (Figure 30B)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 28. IX. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 15. VII. 2006; 2 exs, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 9. VIII. 2006; 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 12. VII. 2006; 2 exs, same 4th locality as above, 28. IX. 2006; 2 exs, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. IX. 2006.

Remarks. This genus is distinct in having the stout body, the strongly foveate frons, the large eyes and the abdomen with indistinctly demarcated paratergites (Nomura, 2005). It was previously known from Sumatra and Vietnam (Nomura, 2005).

28. *P.* sp. 2 (Figure 30C)

Specimens examined. 2 exs, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. IX. 2006.

Tribe Tychini

29. *Atychodea* sp. 1 (Figure 30D)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 26. IX. 2006.

Supertribe Pselaphitae

Tribe Hypocepharini

1. *Apharina conicicollis* (Schaufuss) c.f.(Figure 31A)

Specimens examined. 8 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. IX. 2006.

2. *A.* sp. 1 (Figure 31B)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. XI. 2006.

3. *Apharinodes* sp. 1 (Figure 31C)

Specimens examined. 1 female, HEF, Khao Kitchakut National Park, 1,069 m asl., Chanthaburi province, 15. III. 2006.; 1 female, same locality as above, 9. VIII. 2006.

Remarks. This genus is very distinct in this tribe by having the conspicuously large eleventh antennal segment which forms the antennal club and has a large excavation on the ventral side in male. It is distributed in east and south-east Asia (Nomura, 2000).

Tribe Pselaphini

4. *Pselaphidius* sp. 1 (Figure 31D)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006.

5. *Tyraphus pilosus* Raffray (Figure 31E)

Specimens examined. 1 ex, MDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 3. V. 2006.

Tribe Tmesiphorini

6. *Ancystrocerus* sp. 1 (Figure 31F, G)

Specimens examined. 1 male, 1 female, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006; 1 male, same locality as above, 6. V. 2006; 1 male, same locality as above, 15, VII. 2006; 1 male, same locality as above, 30. IX. 2006; 1 male, 2 females, same locality as above, 30. XI. 2006.

Remarks. This genus distinguished by maxillary palpus which slender and small.

7. *Pseudophanias* sp. 1 (Figure 31H, I)

Specimens examined. 4 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. III. 2006; 12 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 2 exs, same 2nd locality as above, 16. III. 2006; 2 exs, same 2nd locality as above, 6. V. 2006; 4 exs, same 2nd locality as above, 15. VII. 2006; 1 ex, same 2nd locality as above, 30. IX. 2006; 5 exs, same 2nd locality as above, 30. XI. 2006.

Remarks. This genus is widely distributed in tropical Asia and most species are undescribed (Nomura, 2005).

8. *Tmesiphorus* sp. 1 (Figure 32A)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. I. 2006; 7 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006; 5 exs, same 2 nd locality as above, 30. XI. 2006.

Remarks. Genus *Tmesiphorus* is a common pselaphine genus in habiting decayed wood and under bark (Nomura, 2005).

9. *T.* sp. 2 (Figure 32B)

Specimens examined. 9 exs, HEF, Khao Kitchakut National Park, 1,069 m asl., Chanthaburi province, 19. I. 2006; 3 exs, same locality as above, 5. V. 2006; 3 exs, same locality as above, 9. VIII. 2006.

Tribe Tyrini

Subtribe Centrophthalmina

10. *Centrophthalmus* sp. 1 (Figure 32C)

Specimens examined. 5 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. I. 2006; 6 exs, same locality as above, 17. III. 2006; 12 exs, same locality as above, 3. V. 2006; 27 exs, same locality as above, 12. VII. 2006; 13 exs, same locality as above, 28. IX. 2006; 2 exs, same locality as above, 28. XI. 2006; 3 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 17. III. 2006; 6 exs, same 2 nd locality as above, 3. V. 2006; 7 exs, same 2nd locality as above, 12. VII. 2006; 8 exs, same 2 nd locality as above, 28. IX. 2006.

Remarks. This species is dominant in PMDF and SMDF in eastern Thailand. This genus is common in tropical Asia (Nomura, 2005).

11. *C.* sp. 2 (Figure 32D)

Specimens examined. 1 male, TP, MEF, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 26. XI. 2006.

Tribe Tyrini

Subtribe Tyrina

12. *Hamotopsis* sp. 1 (Figure 32E)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 2 exs, same locality as above, 16. III. 2006; 1 ex, same locality as above, 15. VII. 2006.

Remarks. This genus is distinct in very large and stout body and the maxillary palpi each with very large and ovoid fourth segment. It has been known from Australia, whereas it also occurs in wide areas of east and southeast Asia (Nomura, 2000).

13. *Labomimus* sp. 1 (Figure 32F)

Specimens examined. 2 exs, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 21. I. 2006; 4 exs, same locality as above, 6. V. 2006; 2 exs, same locality as above, 30. XI. 2006; 1 ex, HEF, Khao Kitchakut National Park, 1069 m asl., Chanthaburi province, 5. V. 2006; 2 exs, same 2nd locality as above, 26. IX. 2006.

Remarks. This genus is distinctly by having the large body, the long and slender antennae, and the second to fourth segments of the maxillary palpi each with a short and subcylindrical projection on its external side. It was recorded the distribution in some areas from northern part of India to Japan (Nomura, 2005).

14. *L.* sp. 2 (Figure 32G)

Specimens examined. 1 ex, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 17. I. 2006; 1 ex, MEF, Khao Soi Dao Wildlife

Sanctuary, 329 m asl., Chanthaburi province, 15. VII. 2006; 3 exs, same 2[nd] locality as above, 30. IX. 2006.

15. *L.* sp. 3 (Figure 32H)

Specimens examined. 1 ex, TP, Khao Soi Dao Wildlife Sanctuary, 215 m asl., Chanthaburi province, 15. I. 2006; 3 exs, same locality as above, 26. IX. 2006.

16. *Pselaphodes* sp. 1 (Figure 32I)

Specimens examined. 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 16. III. 2006; 1 ex, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 17. III. 2006.

Remarks. Genus *Pselaphodes* is separated from *Labomimus* by having the maxillary palpi each with the second to fourth segments each roundly expanded on the external side. It distributed in tropical Asia and includes many undescribed species (Nomura, 2000).

Supertribe Clavigeritae

Tribe Clavigerini

1. *Articerodes ohmomoi* Nomura et Sakchoowong (Figure 34A)

Specimens examined. 2 exs, PMDF, Khao Ang Rue Nai Wildlife Sanctuary, 155 m asl., Chachoengsao province, 28. IX. 2006.

Remarks. The supertribe Clavigeritae is easily distinguished genus level by the unique character of its body and appendix (Nomura, personal communication). Three species of *Articerodes* were recently described from the collected samples of this study by Nomura *et al*. (2008).

2. *A. thailandicus* Nomura et Sakchoowong (Figure 34B)

Specimens examined. 5 exs, SMDF, Khao Ang Rue Nai Wildlife Sanctuary, 100 m asl., Chachoengsao province, 2. VII. 2006; 3 exs, same locality as above, 28. IX. 2006.

3. *A. jariyae* Nomura et Sakchoowong (Figure 34C)

Specimens examined. 3 exs, HEF, Khao Kitchakut National Park, 1,069 m asl., Chanthaburi province, 19. I. 2006.

4. *Cerylambus reticulatus* Raffray (Figure 34D)

Specimens examined. 1 ex, HEF, Khao Kitchakut National Park,1,069 m asl., Chanthaburi province, 5. V. 2006; 4 exs, same locality as above, 9. VIII. 2006; 4 exs, same locality as above, 26. IX. 2006; 1 ex, same locality as above, 26. XI. 2006; 1 ex, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 6. V. 2006.

Subfamily Protopselaphinae

1. *Protopselaphus* sp.1 (Figure 35)

Specimens examined. (9 exs) 2 males, 7 females, MEF, Khao Soi Dao Wildlife Sanctuary, 329 m asl., Chanthaburi province, 30. XI. 2006.

Remarks. Subfamily Protopselaphinae is regarded as a sister group of subfamily Pselaphinae (Nomura, 2000).

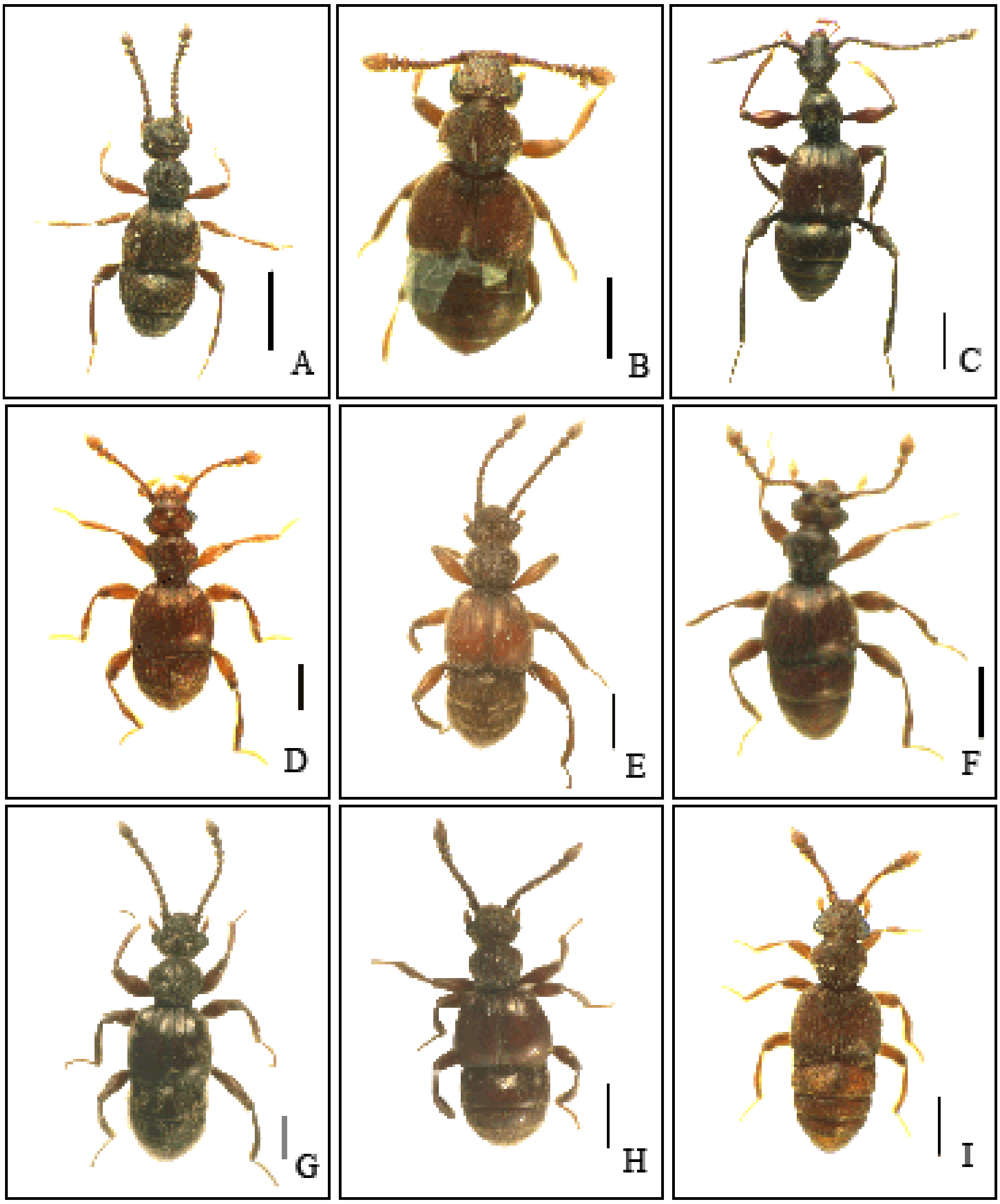


Figure 19 Supertribe Batrisitae; *Batrisodes* sp. 1 (A), Batrisina gen. undet. sp. 1 (B), Batrisina gen. undet. sp. 2 (C), *Tribasodites* sp. 1 ♂ (D), *T.* sp. 2 ♂ (E) and *T.* sp. 3 ♂ (F), *T.* sp. 4 ♂ (G), *T.* sp. 5 (H) and *Hypochraeus* sp. 1 (I). *T.* sp. 4 (G), *T.* sp. 5 (H) and *Hypochraeus* sp. 1 (I). All scales = 0.5 mm.

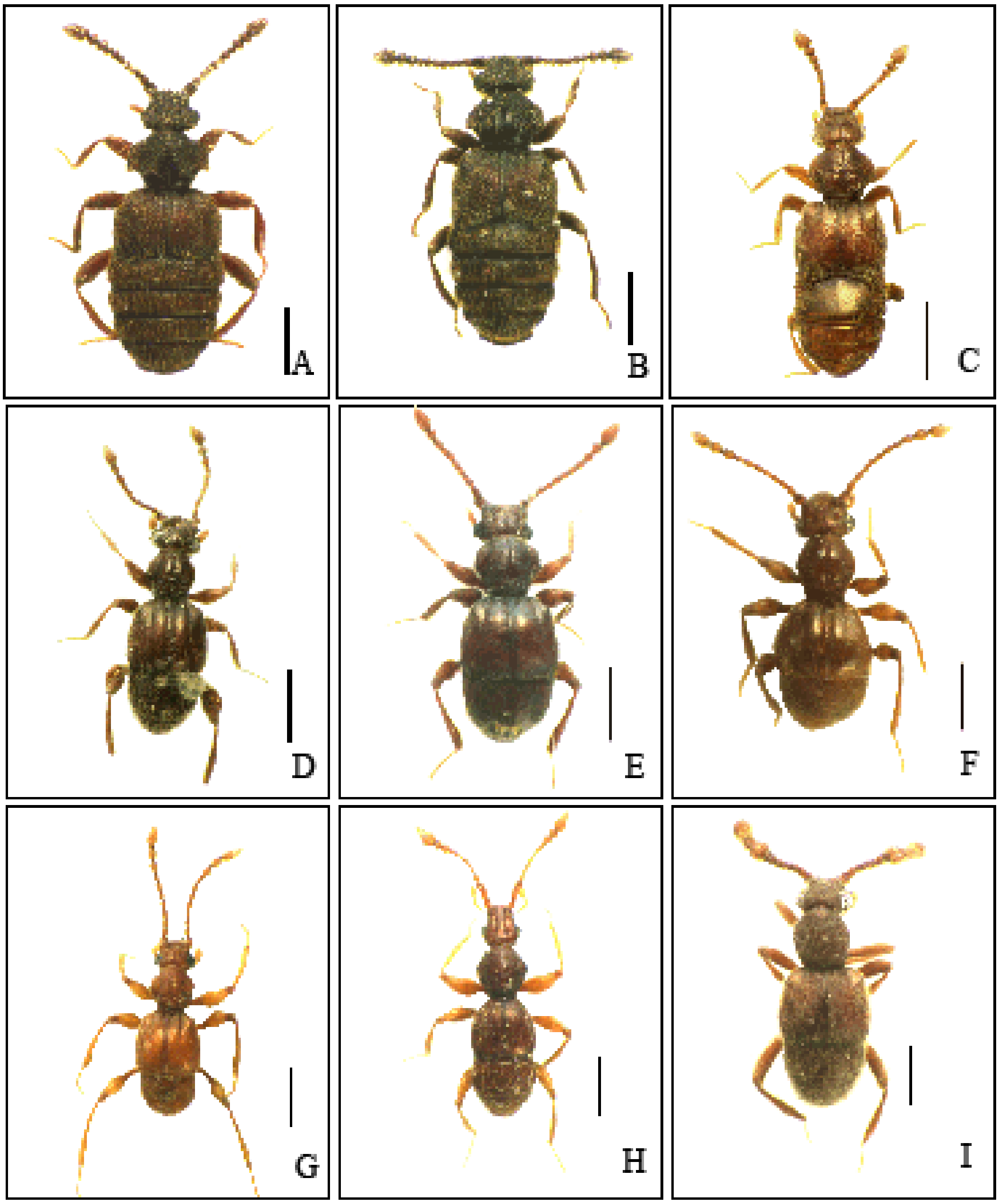


Figure 20 Supertribe Batrisitae; *Hypochraeus* sp. 2 (A), *H*. sp. 3 (B), *Amana* sp. 1 (C), *Physomerinus* sp. 1 (D), *Trisinus* sp. 1 (E), *Batriscenaulax* sp. 1 ♀(F), *Batrisiella* sp. 1 ♂(G), *Mnia* sp. 1 ♂ (H) and *Sathytes* sp. 1 ♂ (I).
All scales = 0.5 mm.

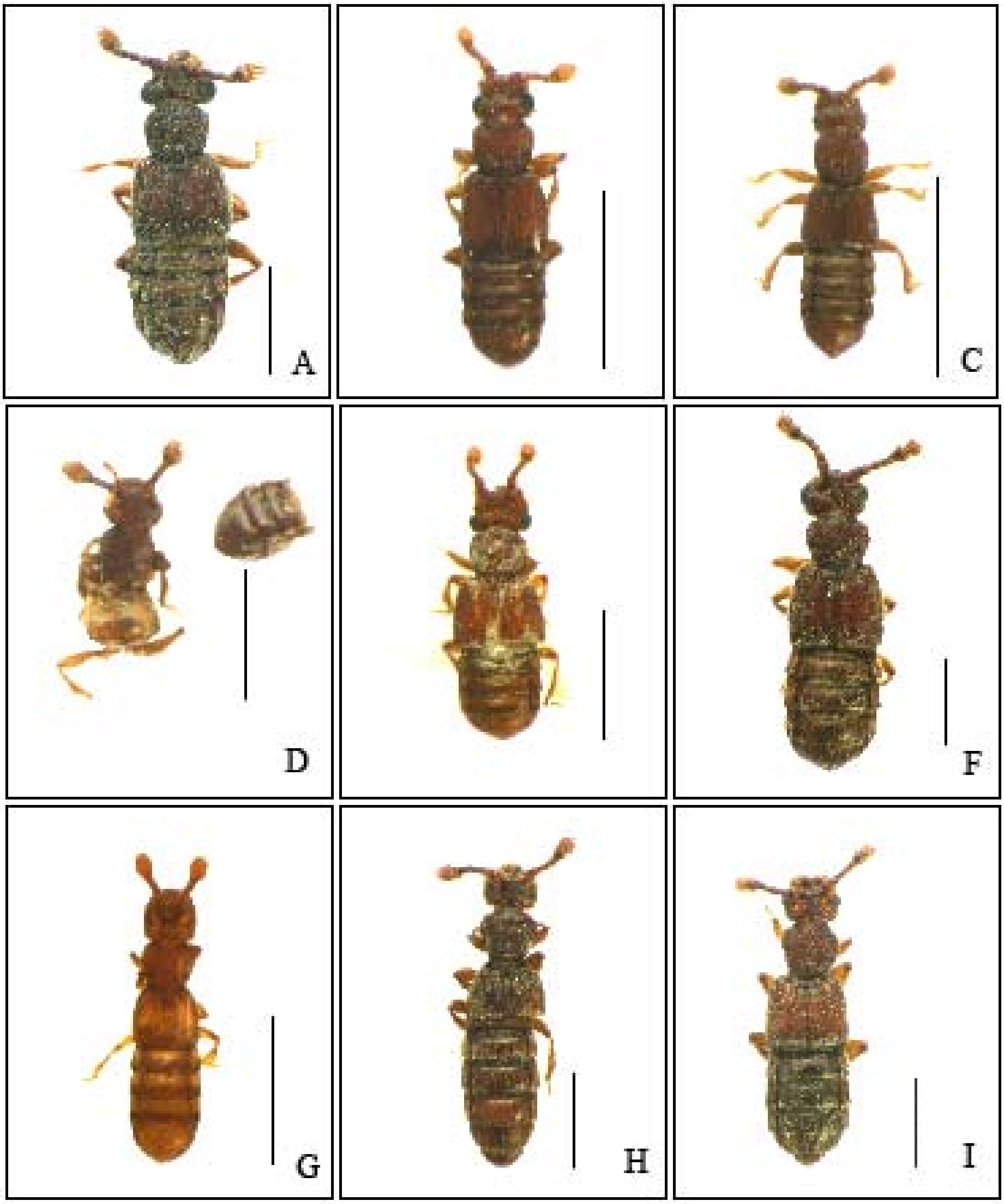


Figure 21 Supertribe Bythinoplectitae; Bythiniplectina gen.undet. sp. 1 ♂(A), Bythiniplectina gen.undet. sp. 2 ♂ (B), Bythiniplectina gen.undet. sp. 3 ♀(C), Bythiniplectina gen.undet. sp. 4 ♀ (D), *Zethopsus opacus* (E),*Parapyxidicerus* sp. 1 ♂(F), Pyxidicerina gen.undet. sp. 1 ♀(G), Pyxidicerina gen.undet. sp. 2 ♀ (H) and Pyxidicerina gen.undet. sp. 3 ♀ (I). All scales = 0.5 mm.

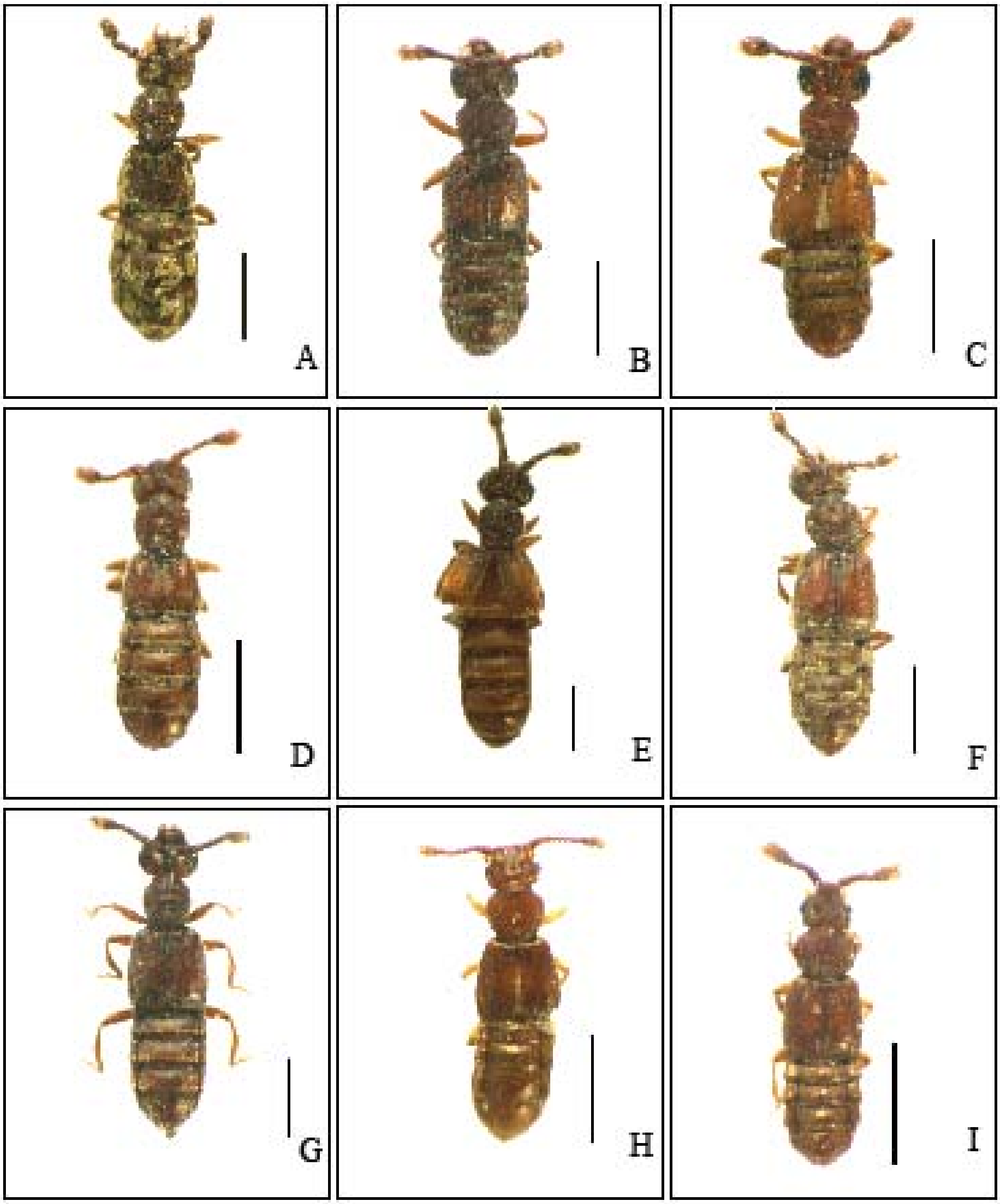


Figure 22 Supertribe Bythinoplectitae; Pyxidicerina gen.undet. sp. 4 ♀(A), Pyxidicerina gen.undet. sp. 5 ♂ (B), Pyxidicerina gen.undet. sp. 6 ♂ (C), Pyxidicerina gen.undet. sp.7 ♀ (D), Pyxidicerina gen.undet. sp. 8 ♂ (E), Pyxidicerina gen.undet. sp. 9 ♂ (F), Pyxidicerina gen.undet. sp. 10 ♂ (G), *Octomicrus longulus* (H) and *Tuberoplectus* sp. 1 (I). All scales = 0.5 mm.

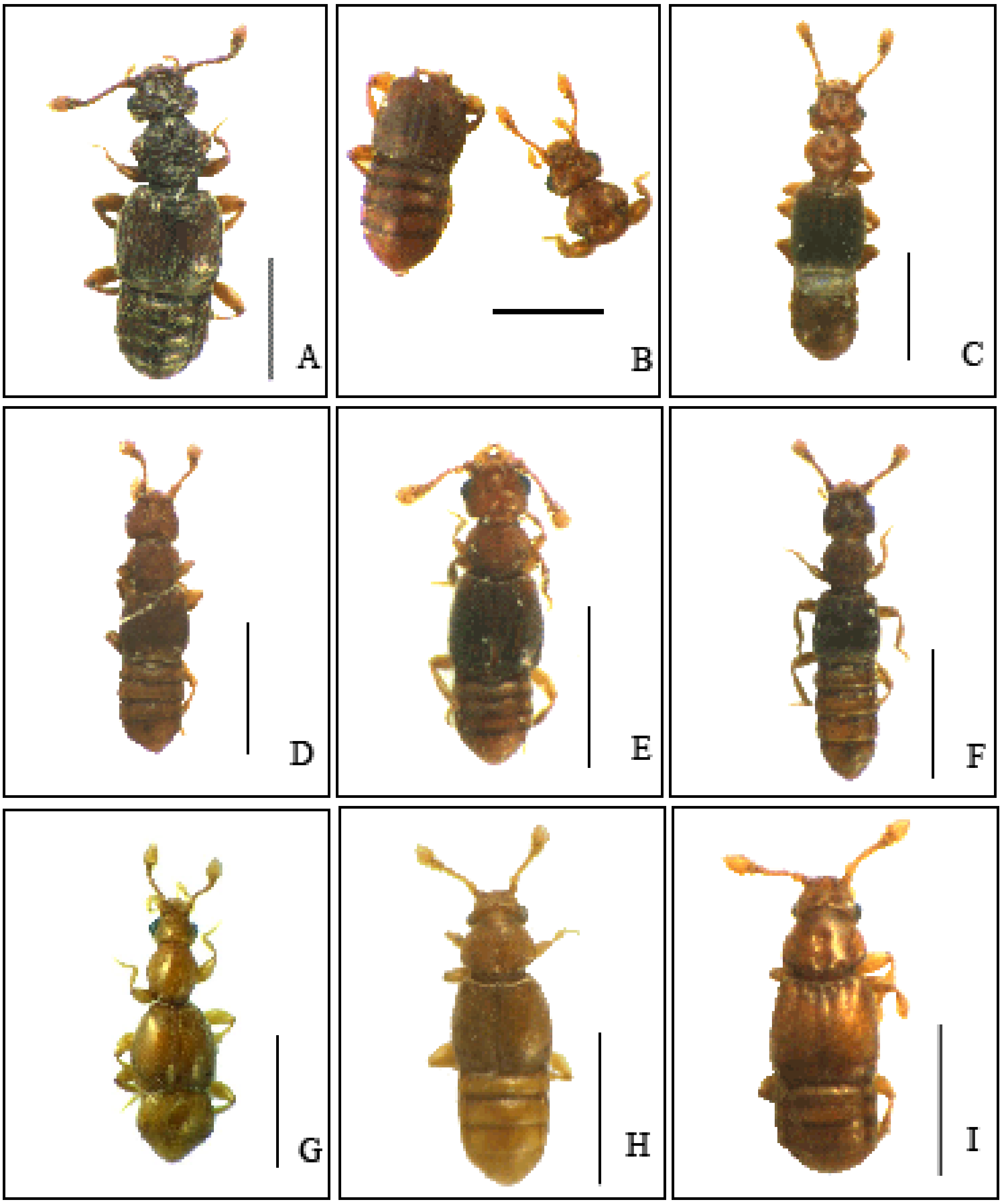


Figure 23 Supertribe Euplectitae; *Euplectus* sp. 1 (A), *E.* sp. 2 (B), *Leptoplectus* sp. 1 (C), *L.* sp. 2 (D), *L.* sp. 3 (E), *L.* sp. 4 (F), *Aphilia* sp. 1 ♂(G), *Bibloporus* sp. 1 (H) and *B.* sp. 2 (I). All scales = 0.5 mm.

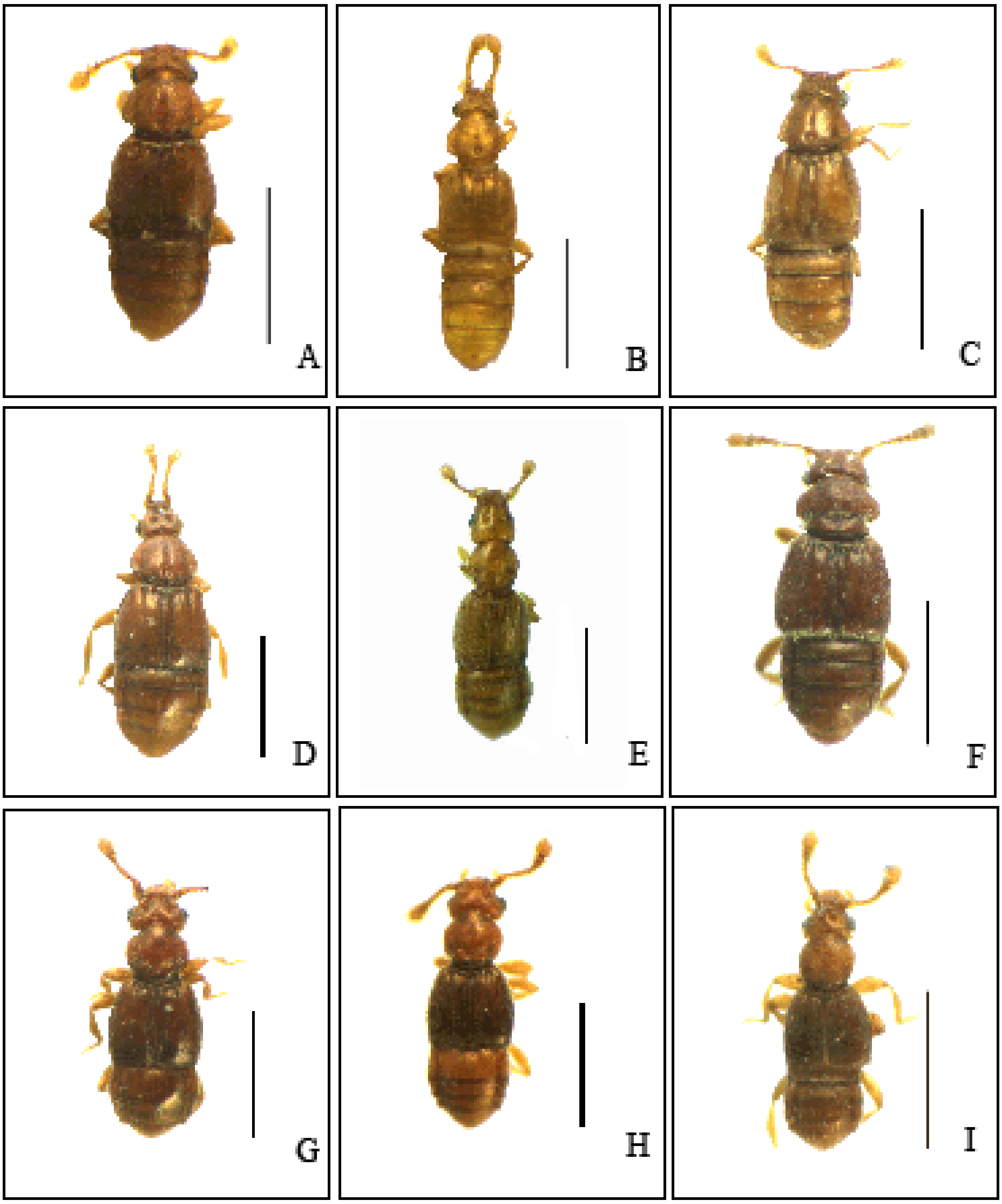


Figure 24 Supertribe Euplectitae; *Bibloporus* sp. 3 (A), *B.* sp. 4 (B), *B.* sp. 5 (C), *B.* sp. 6 (D), *Bibloplectus* sp. 1 ♂ (E), Panaphantina gen.undet. sp. 1 (F), *Euplectodina* sp. 1 (G), *Philiopsis* sp. 1 ♀ (H) and *Pseudoplectus* sp. 1 ♂ (I). All scales = 0.5 mm.

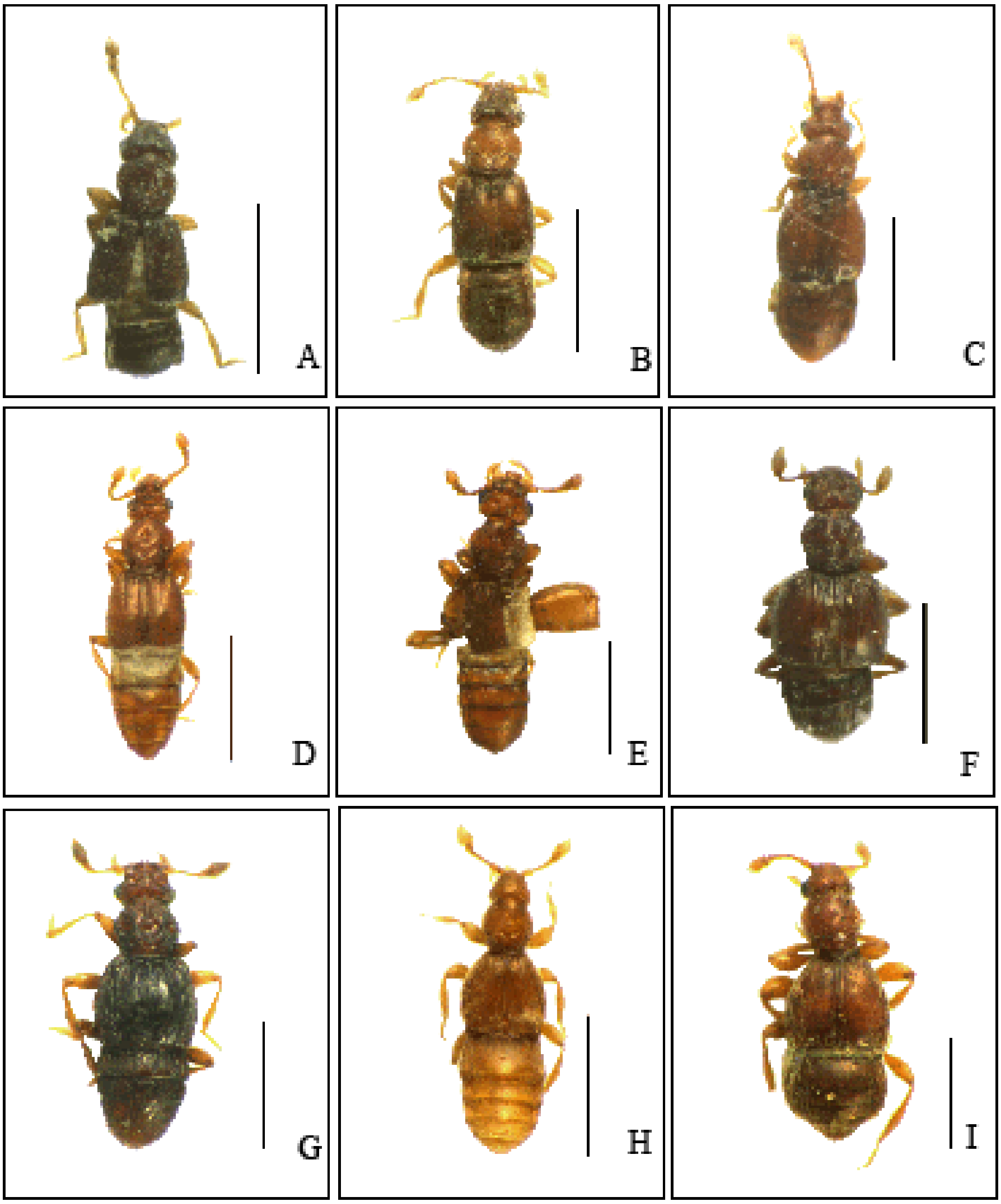


Figure 25 Supertribe Euplectitae; *Pseudoplectus* sp. 2 (A), *P*. sp. 3 (B), *P*. sp. 4 ♀ (C), *P*. sp. 5 (D), *P*. sp. 6 (E), *Prophilus* sp. 1 (F), *P*. sp. 2 (G), *Saucyella* sp. 1(H) and *S*. sp. 2 (I). All scales = 0.5 mm.

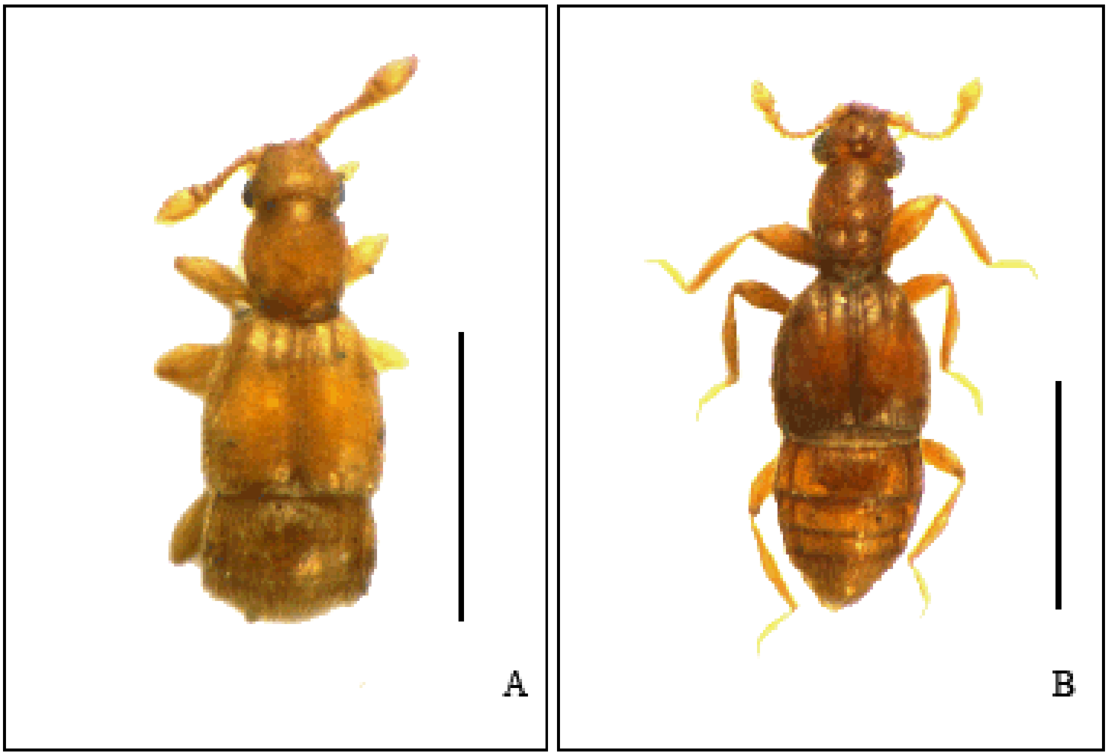


Figure 26 Supertribe Euplectitae; *Saucyella* sp. 3 (A), and *S.* sp. 4 (B).
All scales = 0.5 mm.

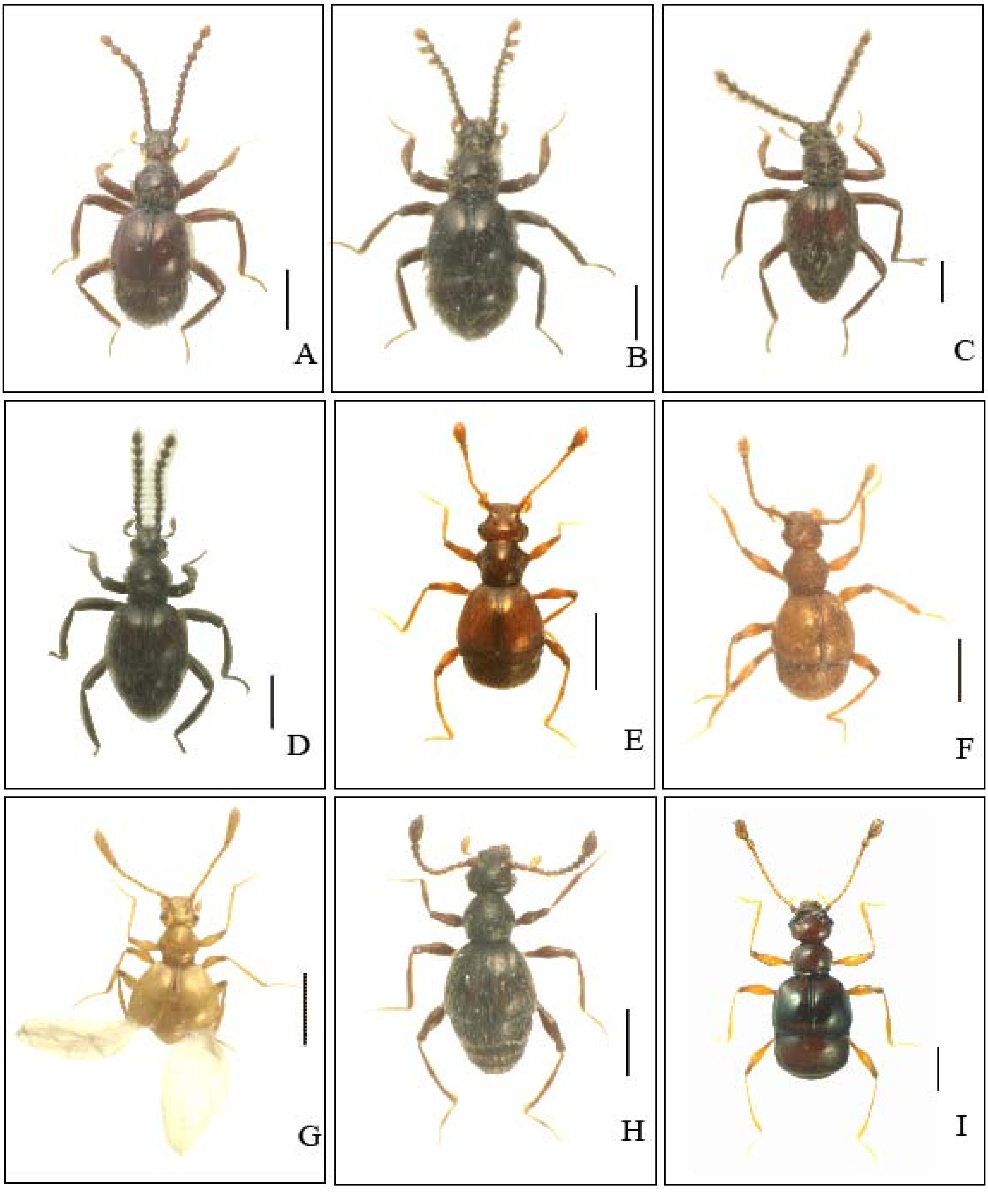


Figure 27 Supertribe Goniaceritae; *Harmophorus* sp. 1 (A), *H*. sp. 2 (B), *H*. sp. 3 (C), *H*. gibbioides (D), *Atenisodus* sp. 1 ♂ (E), *A*. sp. 2 (F), *A*. sp. 3 ♂(G), *Comatopselaphus puncticollis* (H) and *Batraxis doriae* ♂ (I).
All scales = 0.5 mm.

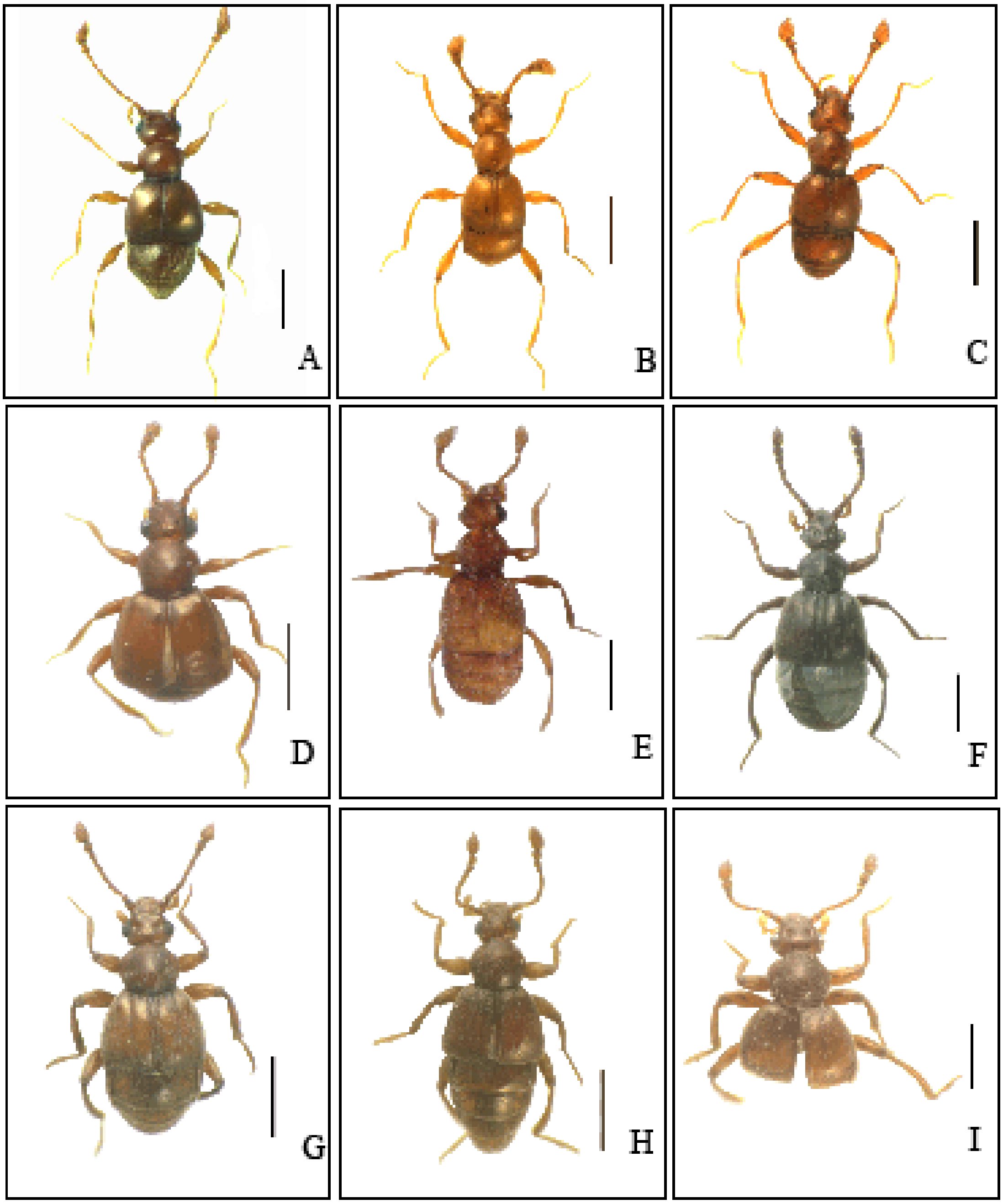


Figure 28 Supertribe Goniaceritae; *Batraxis brevis* ♂(A), *B.* sp. 3 ♂((B), *B.* sp. 4 ♂(C), *Eupines* sp. 1 (D), *E.* sp. 2 (E), *Rybaxis* sp. 1 (F), *Trissemus* sp. 1 (G), *T.* sp. 2 (H) and *T.* sp. 3 (I). All scales = 0.5 mm.

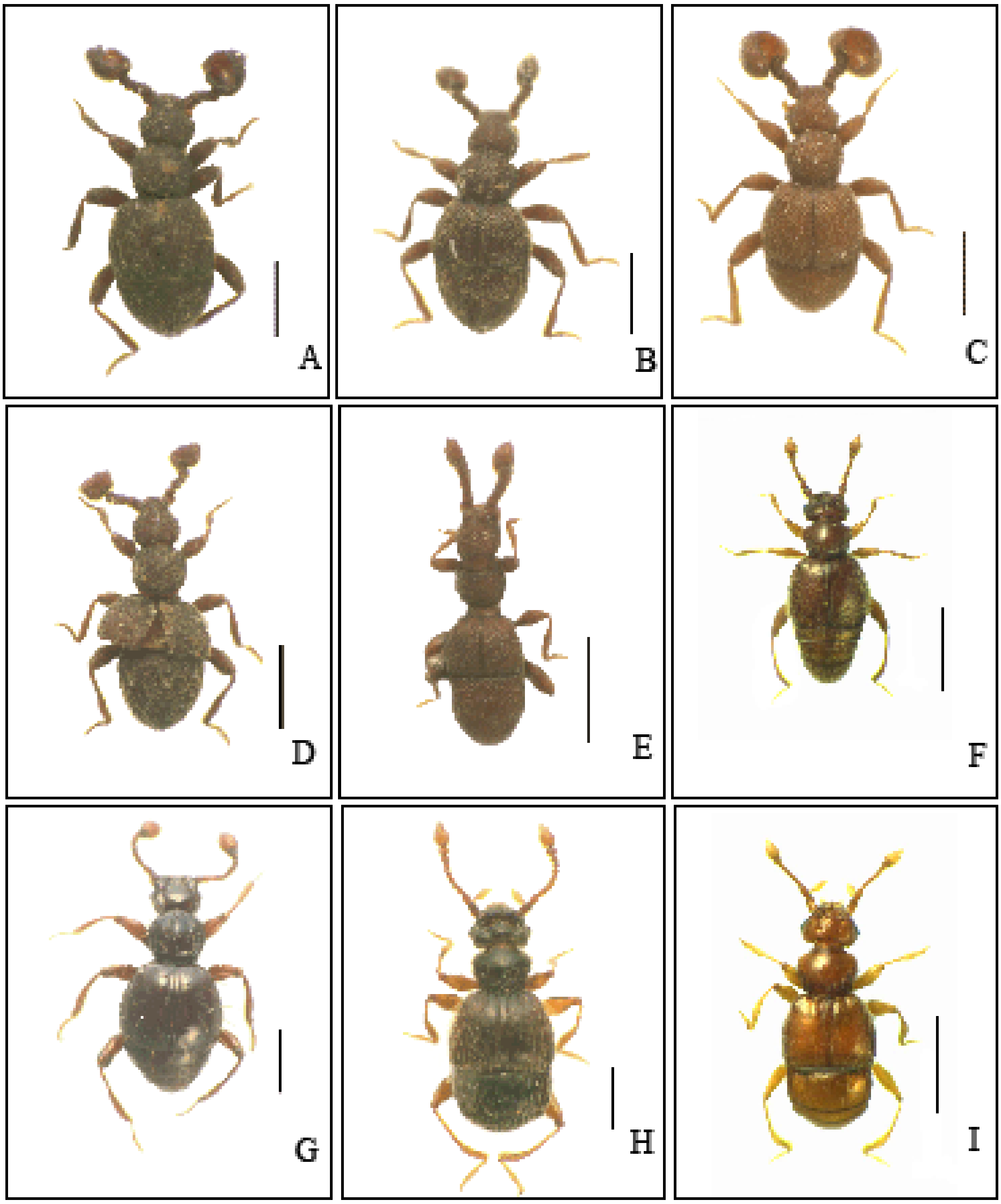


Figure 29 Supertribe Goniaceritae; *Plagiophorus* sp. 1 ♂(A) , ♀ (B), *P*. sp. 2 ♂ (C), ♀ (D), *P*. sp. 3 (E), *Sunorfa* sp. 1 ♀ (F), *Natyplerus* sp. 1 ♂ (G), Natyplerina gen.undet. sp. 1 ♂ (H) and *Morana* sp. 1 (I).

All scales = 0.5 mm.

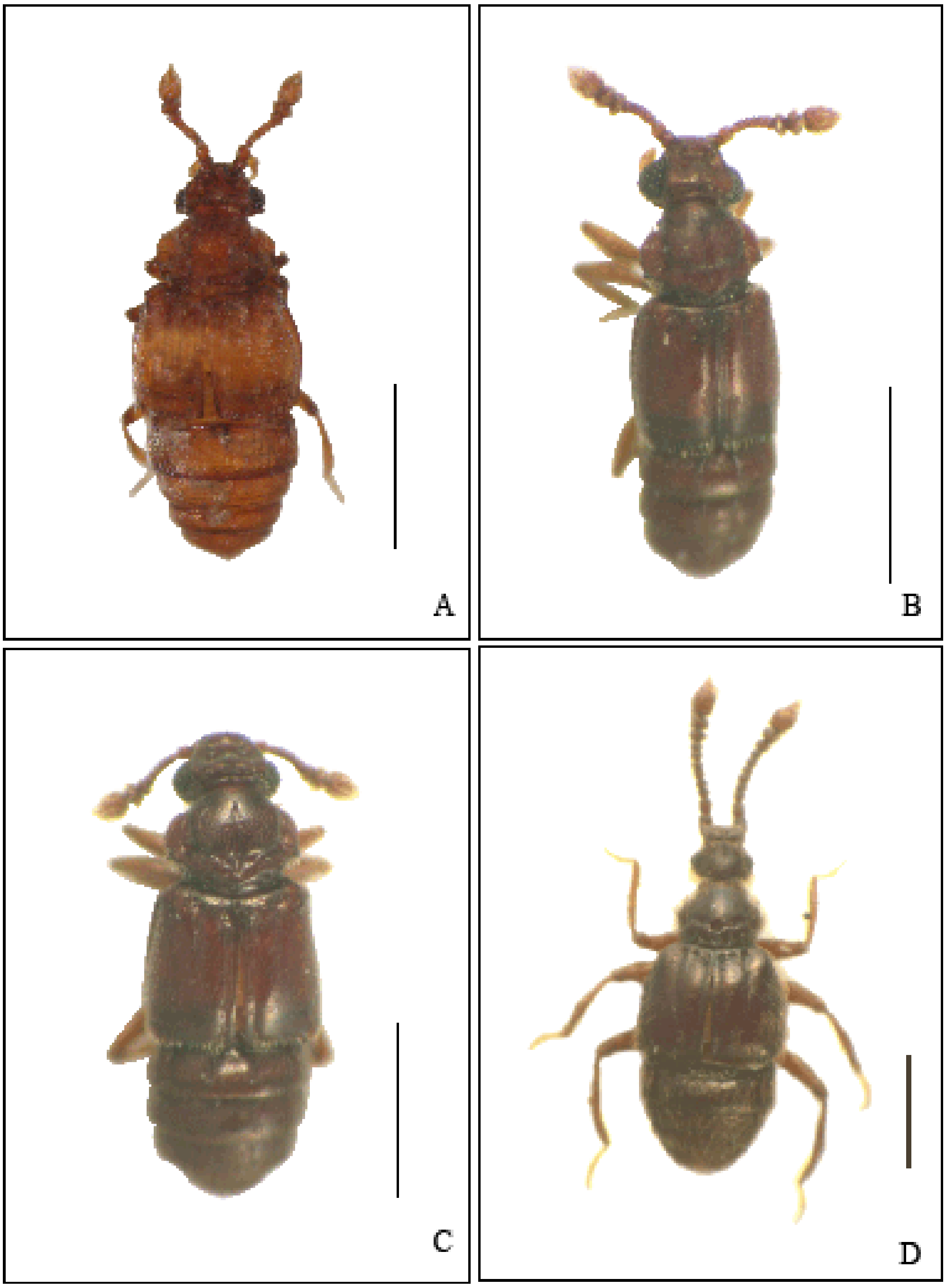


Figure 30 Supertribe Goniaceritae; *Mechanicus* sp. 1 (A), *Pareuplectops* sp. 1 ♂ (B), *P*. sp. 2 ♂ (C), *Atychodea* sp. 1 (D). All scales = 0.5 mm.

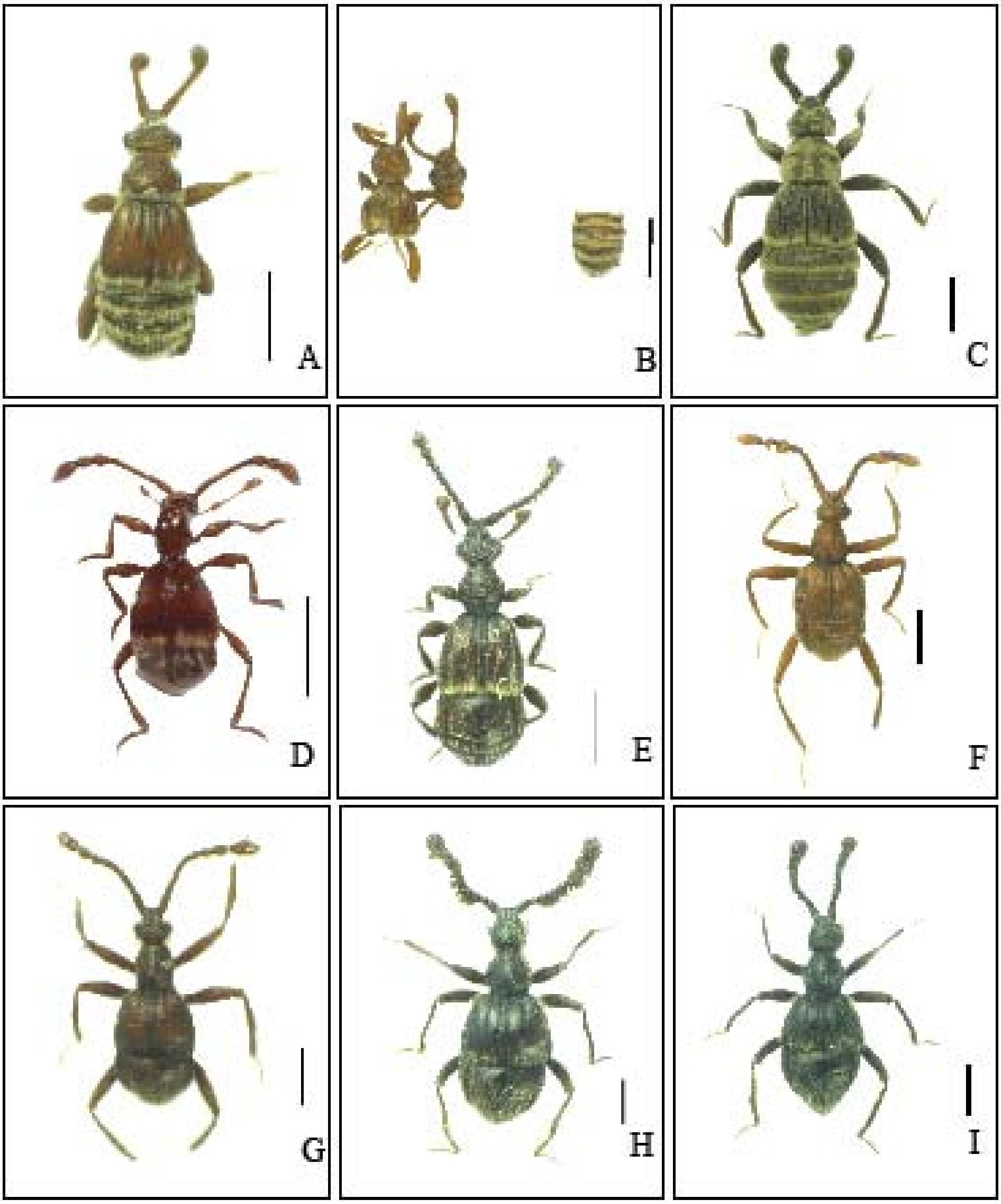


Figure 31 Supertribe Pselaphitae; *Apharina conicicollis* (A), *A*. sp. 2 (B), *Apharinodes* sp. 1 ♀ (C), *Pselaphidius* sp. 1 (D), *Tyraphus pilosus* (E), *Ancystrocerus* sp. 1 ♂ (F), ♀ (G), and *Pseudophanias* sp. 1 ♂ (H), ♀ (I). All scales = 0.5 mm.

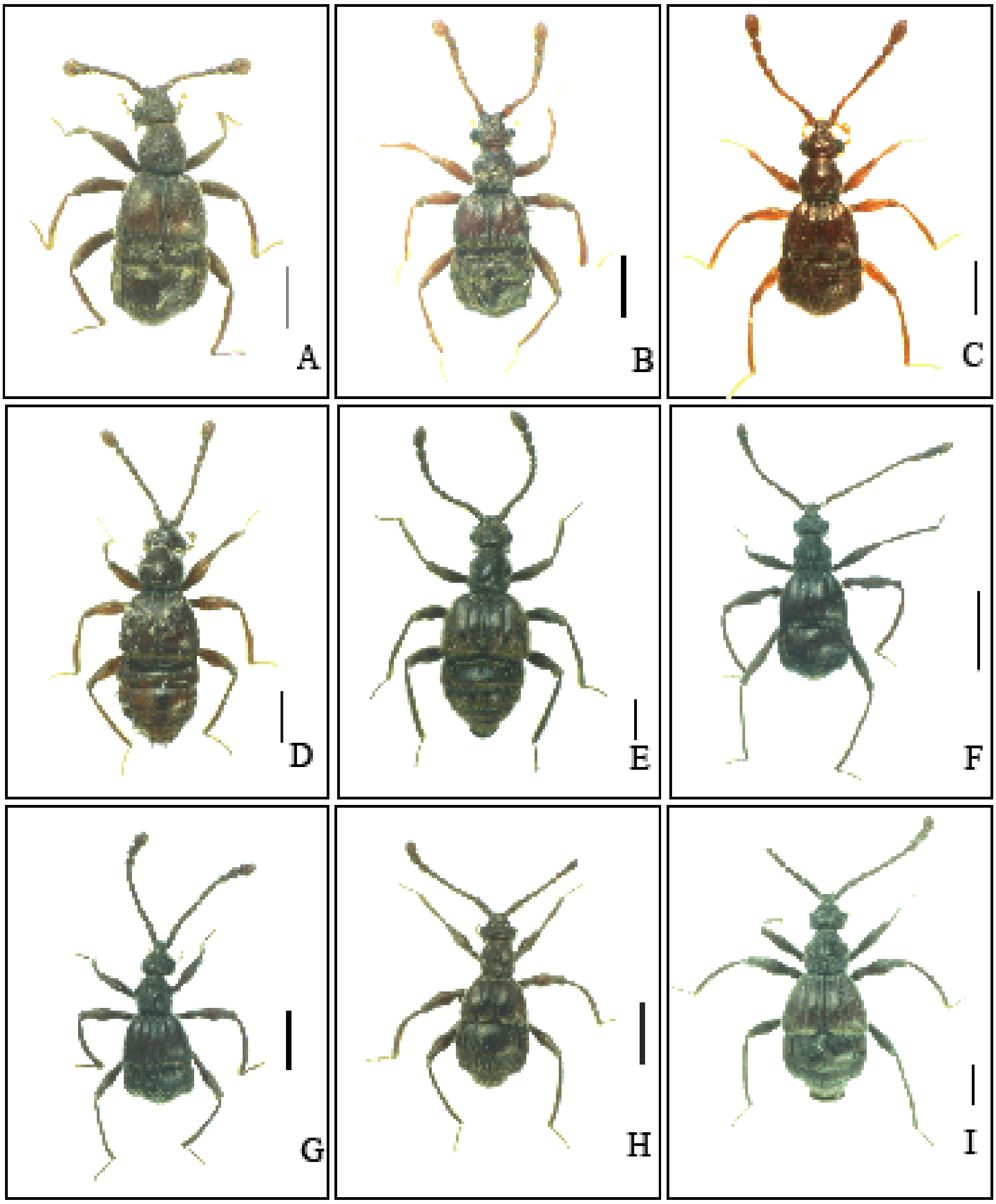


Figure 32 Supertribe Pselaphitae; *Tmesiphorus* sp. 1 (A), *T.* sp. 2 (B), *Centrophthalmus* sp. 1 ♂ (C), *C.* sp. 2 ♂ (D), *Hamotopsis* sp. 1 (E), *Labomimus* sp. 1 ♂ (F), *L.* sp. 2 ♂ (G), *L.* sp. 3 ♂ (H) and *Pselaphodes* sp. 1 ♂(I). All scales = 0.5 mm.

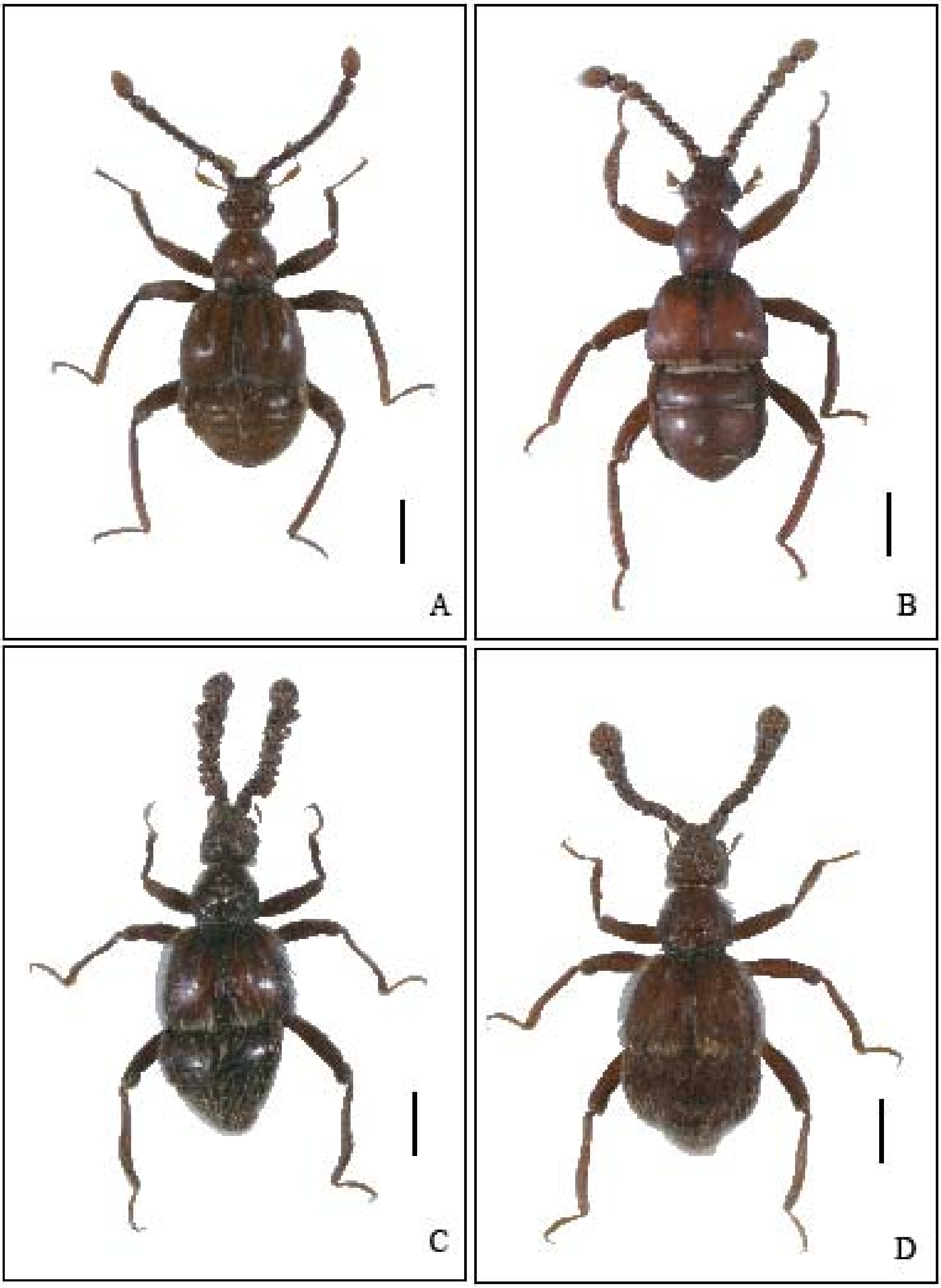


Figure 33 Supertribe Pselaphitae; *Megatyrus* sp. 1 ♀ (A), *Tmesiphorus* sp. 3 (B), *Pseudophanias* sp. 2 ♂ (C), ♀ (D). All scales = 0.5 mm.

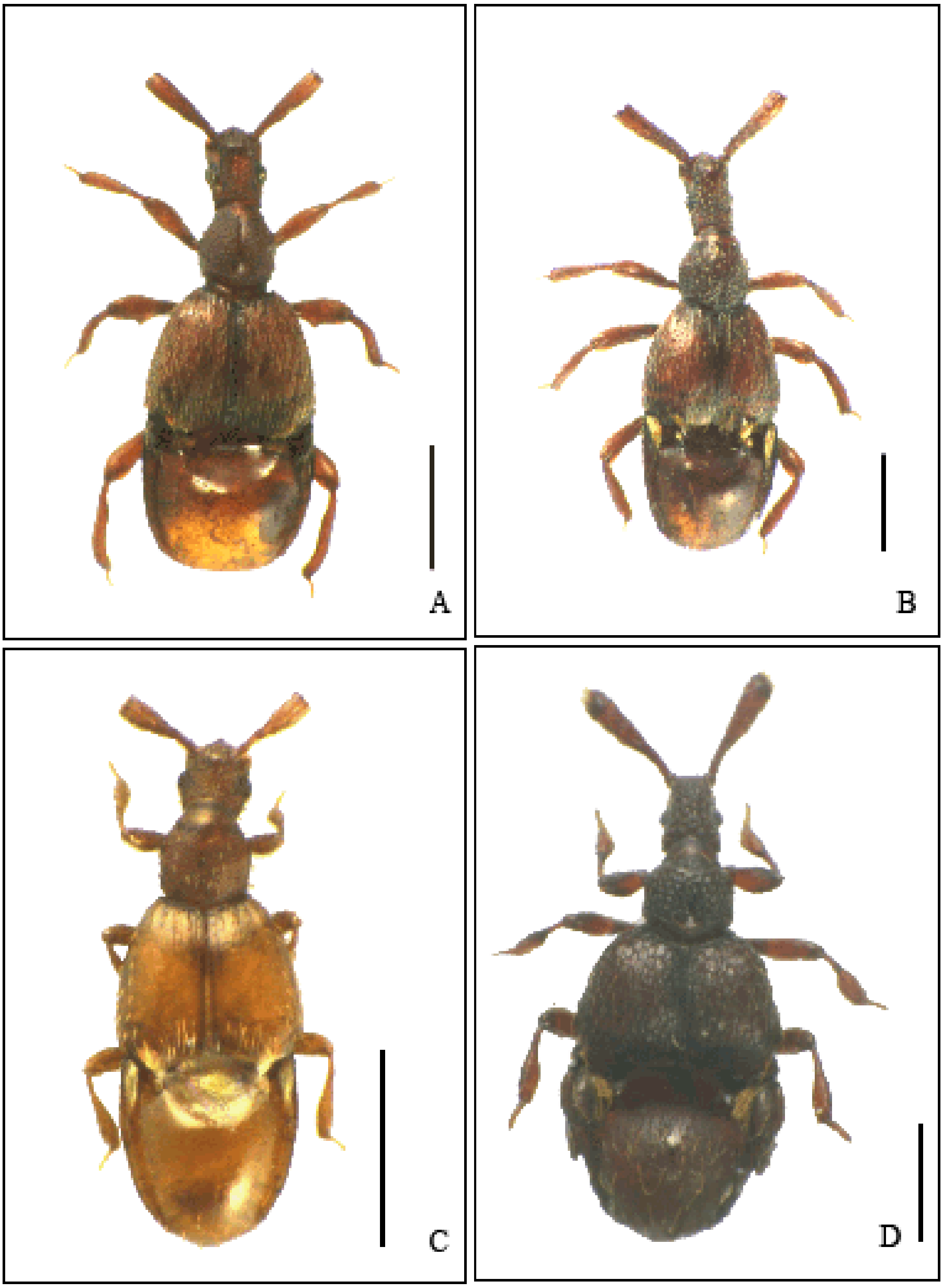


Figure 34 Supertribe Clavigeritae; *Articerodes ohmomoi* ♂ (A), *A. thailandicus* ♂ (B), *A. jariyae* ♀ (C) and *Cerylambus reticulatus* ♂ (D).

All scales = 0.5 mm.

Figure 35 Subfamily Protopselaphinae; *Protopselaphus* sp. 1.

3.2 Spatial and seasonal diversity pattern

3.2.1 Species richness

In total of 2006, 1,867 pselaphine beetle adults represented 6 supertribes and 114 species (Appendix Table 1). Species could be assigned to 51 described genera and several undescribed genera, most of which were in the supertribe Bythinoplectitae. One hundred and two species out of 114 were apparently undescribed. Nine species could be identified by comparison with type specimens in the Muséum National d' Histoire Naturella, Paris, France (MHNP). In this study, three species of the genus *Articerodes* were recently described by Nomura *et al.* (2008). Species in the supertribe Goniaceritae were numerically dominant, comprising 29 species (25%) and 919 individuals (49%) of the total collection, and was the dominant group in every forest habitat. The second most diverse supertribe was Euplectitae, with 29 species (25%) and 295 individuals (14%), followed by Batrisitae with 18 species (16%) and 363 individuals (17%), Bythiniplectitae with 18 species (16%) and 109 individuals (6%), Pselaphitae with 16 species (13%) and 193 individuals (10%), and Clavigeritae with 4 species (3%) and 24 individuals (1%) (Figure 36).

The six most abundant species present in all habitats accounted for about 58% (1,086 of 1,867) of the total individuals. *Plagiophorus* sp. 1 in the supertribe Goniaceritae was the most abundant species, representing with 431 individuals or 23% of the pselaphine beetles counted. *Mnia* sp. 1 represented 13%, *Batraxis doriae* represented 10%, followed by *Centrophthalmus* sp. 1, *Morana* sp. 1 and *Aphilia* sp. 1. At the other end of the abundance spectrum, 30 species (26% of total) were represented by three or two individuals, and 29 species (25 % of total) were represented by one individual.

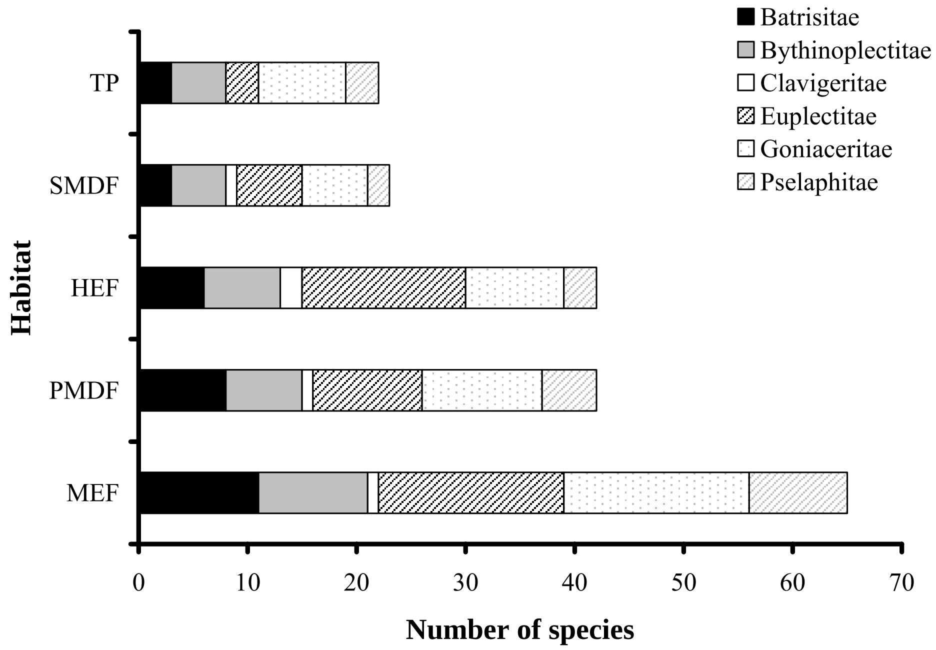


Figure 36 Species richness of pselaphine beetles in each supertribe in different forest habitats in eastern Thailand.

The species rank-abundance curves (Figure 37) showed that the TP had the steepest curve, followed by SMDF, HEF, PMDF and finally MEF. The TP and SMDF resembled the geometric series distribution where a few species were dominant with the remainder fairly uncommon (Magurran, 1988). This pattern is primarily found in species poor or degraded environments. While the primary forests, the curves resembled the lognormal distribution, indicating a large, mature and varied natural community. The pooled data was fitted the lognormal model (Magurran, 1988) (Figure 37).

Pselaphine beetle diversity among habitats was negatively related to the degree of disturbance and was several times higher in the three primary forest habitats than in secondary forest and teak plantation. Alpha species diversity among habitats varied in the following way: MEF (66 species) > MDF & HEF (42 each) > SMDF (23) > TP (21; Appendix Table 1). The mean number of pselaphine beetle species significantly decreased from moist undisturbed MEF to teak plantation (Kruskal-

Wallis test; H = 18.51, P = 0.001, df = 4; Figure 38). Pselaphine beetle communities were more species rich in the wet season than in the dry season, particularly in PMDF, SMDF and TP, but this trend was marginally non-significant when data from all sites were combined (Mann-Whitney U-test, U = 70.50, P = 0.08, df = 1).

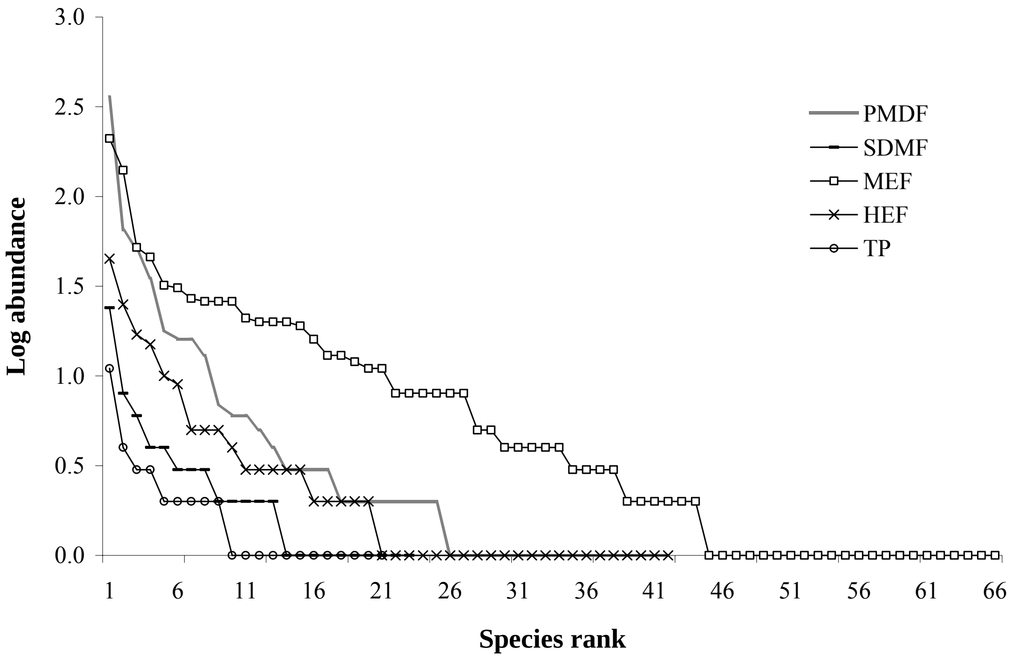


Figure 37 Species rank abundance curves for pselaphine beetles in different forest habitats in eastern Thailand. PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest, HEF, hill evergreen forest; and TP, teak plantation.

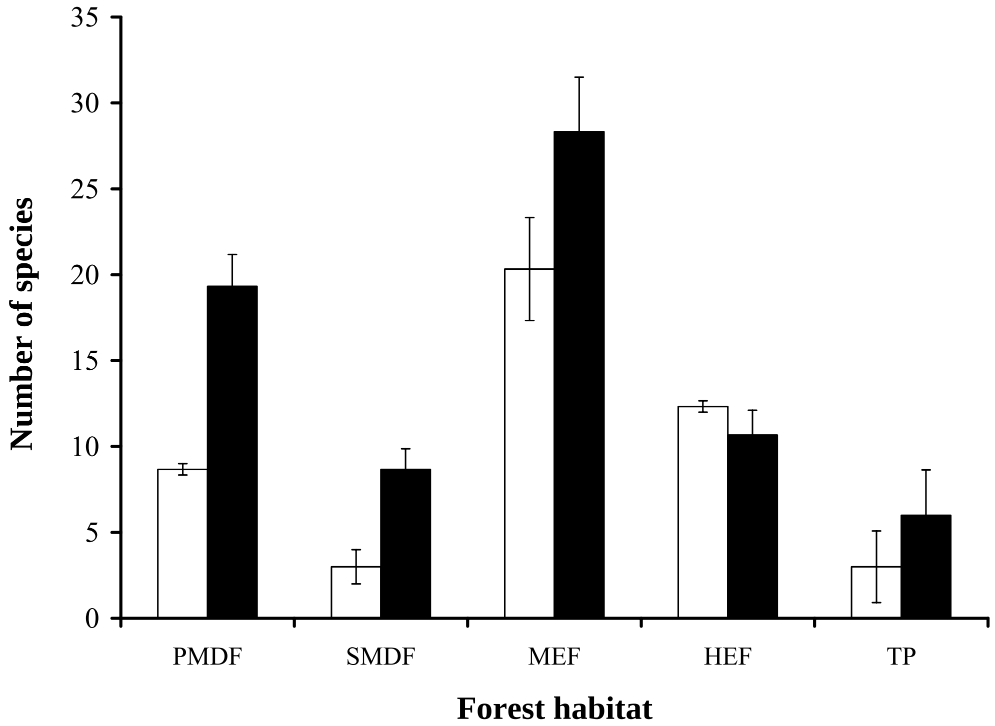


Figure 38 Species richness in different forest habitats in eastern Thailand. Bars showed mean ± SE (N = 3). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.☐ , dry season; ■, wet Season.

3.2.2 Abundance

Pselaphine abundance was also significantly greater in primary forests than in the secondary forest and teak plantation (H = 23.04, P = 0.01, df = 4; Figure 39). The number of individuals in primary forest habitats, particularly PMDF and MEF, was several times higher than in disturbed forest habitats. However, the number of beetles captured in HEF was not as high as the number of beetles collected in PMDF and MEF. When data from all sites was combined, seasonal differences in abundance were not significant (U = 82, P = 0.2, df = 1).

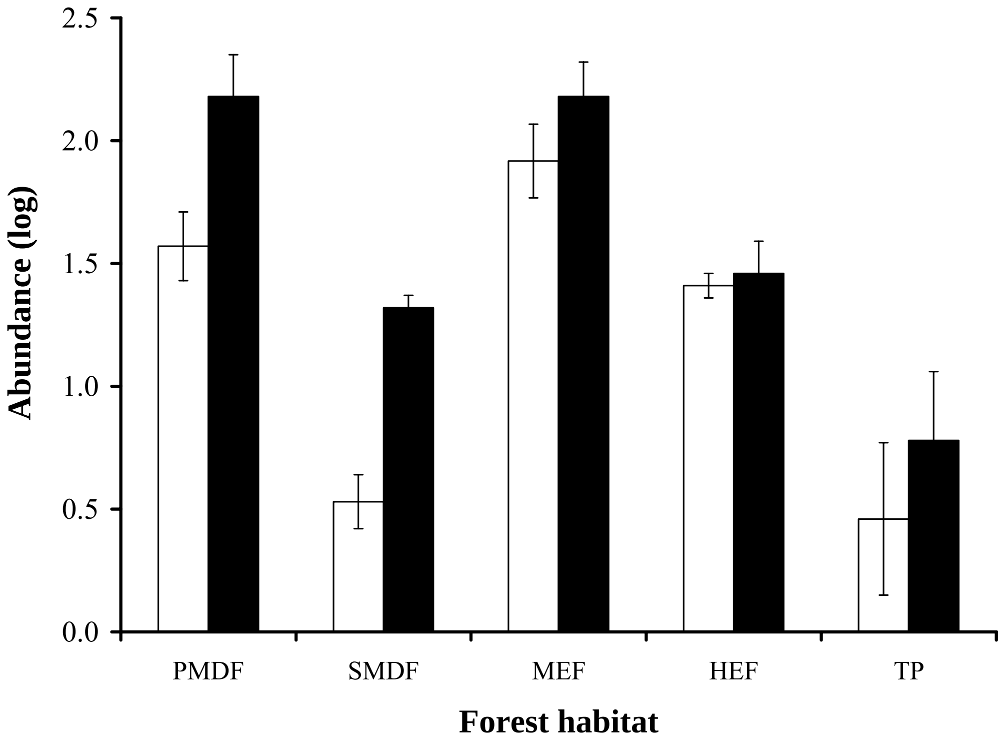


Figure 39 Abundance ($\log_{10}$) in different forest habitats in eastern Thailand. Bars Showed mean ± SE (*N* = 3). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.☐ , dry season;■ , wet season.

3.2.3 Shannon-Wiener's diversity (*H'*) and evenness (*J'*) indices

Shannon-Wiener diversity indices (*H*') were higher in primary forest habitats than in disturbed habitats. Moist evergreen forest had the highest diversity and decreased from HEF to TP (Figure 40). There were significant differences in the Shannon-Wiener diversity indices among habitats (H = 13.35, P = 0.01, df = 4), but seasonal differences in Shannon-Wiener diversity indices were marginally non significant when data from all sites were combined (U = 70, P = 0.07, df = 1).

On the contrary, the Pielou evenness index (*J*'), which quantified the relative abundance of species in each habitat, showed that beetle communities in disturbed habitats such as TP and SMDF were more even than those in primary forests (H = 10.21, P = 0.03, df = 4). Again, seasonal differences in evenness were not significant (U = 111.5, P = 0.77, df = 1; Figure 41).

When data from primary forests habitats (PMDF, MEF and HEF) were pooled and analyzed separately from pooled data from degraded forests (SMDF and TP), there were no significant differences in species richness, abundance, diversity nor evenness between seasons in primary forests: species richness: U = 23.5, P = 0.13; abundance, U = 25, P = 0.17; diversity (H') U = 31, P = 0.40; evenness (J'), U = 50, P = 0.40; all df = 1. However, most parameters were significantly different between dry and wet seasons in degraded habitats (SMDF and TP), except Pielou evenness (J') indices: species richness, U = 3, P = 0.01; abundance, U = 5, P = 0.03; H', U = 3, P = 0.01; J', U = 18, P = 1.00; all df = 1.

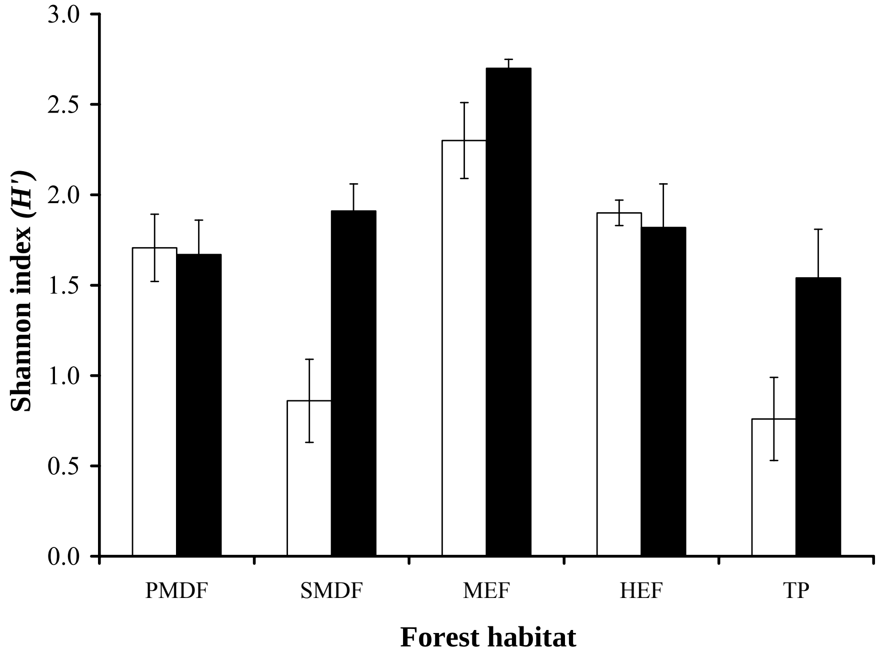


Figure 40 Shannon-Wiener index (*H*') in different forest habitats in eastern Thailand. Bars showed mean ± SE (*N* = 3). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation. □, dry season; ■, wet season.

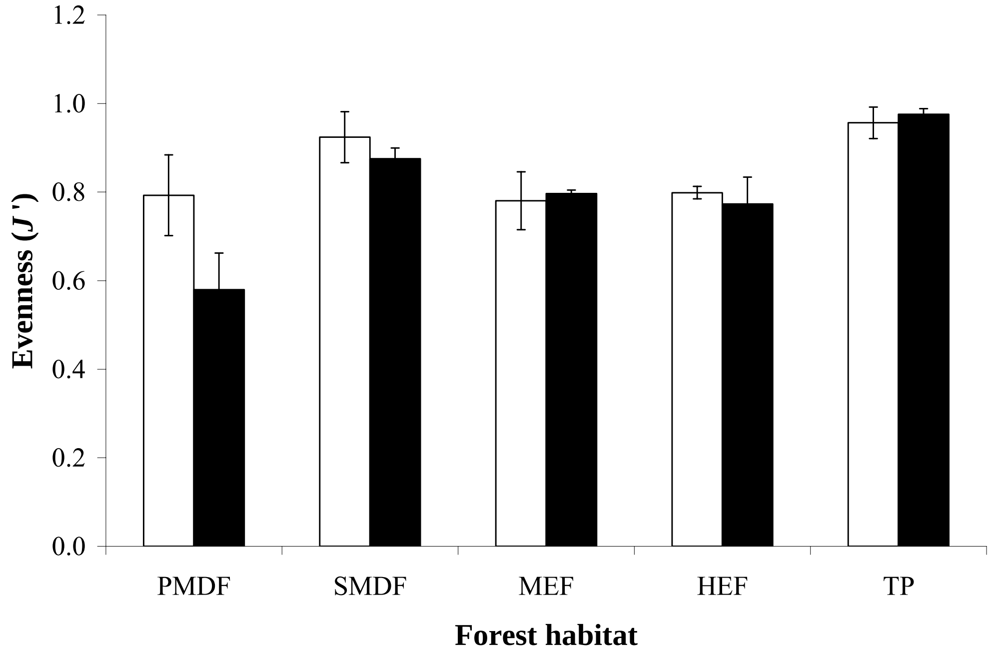


Figure 41 Evenness index (*J*') in different forest habitats in eastern Thailand. Bars showed mean ± SE (*N* = 3). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation. □ , dry season; ■ , wet Season.

3.3 Communities and indicator species of habitats

3.3.1 Species composition among forest habitats

The Sørensen similarity index (*QS*) was calculated based on the presence and absence species in each forest habitat. The similarity index showed that species collected in 2006 in MEF and MDF sites had higher QS value than other sites with the value of 0.50. Hill evergreen forest had *QS* of 0.31 both with MDF and MEF. Secondary mixed deciduous forest and TP had *QS* of 0.37. The *QS* between all primary forests and SMDF or TP ranged from 0.21 to 0.32 (Table 8).

Table 8 SØrensen matrix of similarity of the pselaphine species composition in the five forest habitats in eastern Thailand. Numerals in the top right are the number of species shared between each sites, and figures in the lower left are the indices of similarity (Sorensen index, *QS*). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation

	PMDF	HEF	MEF	SMDF	TP
PMDF	-	13	27	9	9
HEF	0.31	-	17	8	8
MEF	0.50	0.31	-	14	8
SMDF	0.28	0.25	0.32	-	8
TP	0.28	0.25	0.21	0.37	-

Site differences were also evident in the DCA ordination plot: axis 1 (eigenvalue 0.68) ranked the species composition among plots, while the axis 2 (eigenvalue 0.49) separated composition between the primary forests and degraded forests. Three distinct groups of pselaphine beetle composition were clustered as: (1) primary forest groups comprising PMDF and MEF, (2) hill evergreen forest, and (3) and degraded forest habitats (SMDF) and TP) (Figure 42).

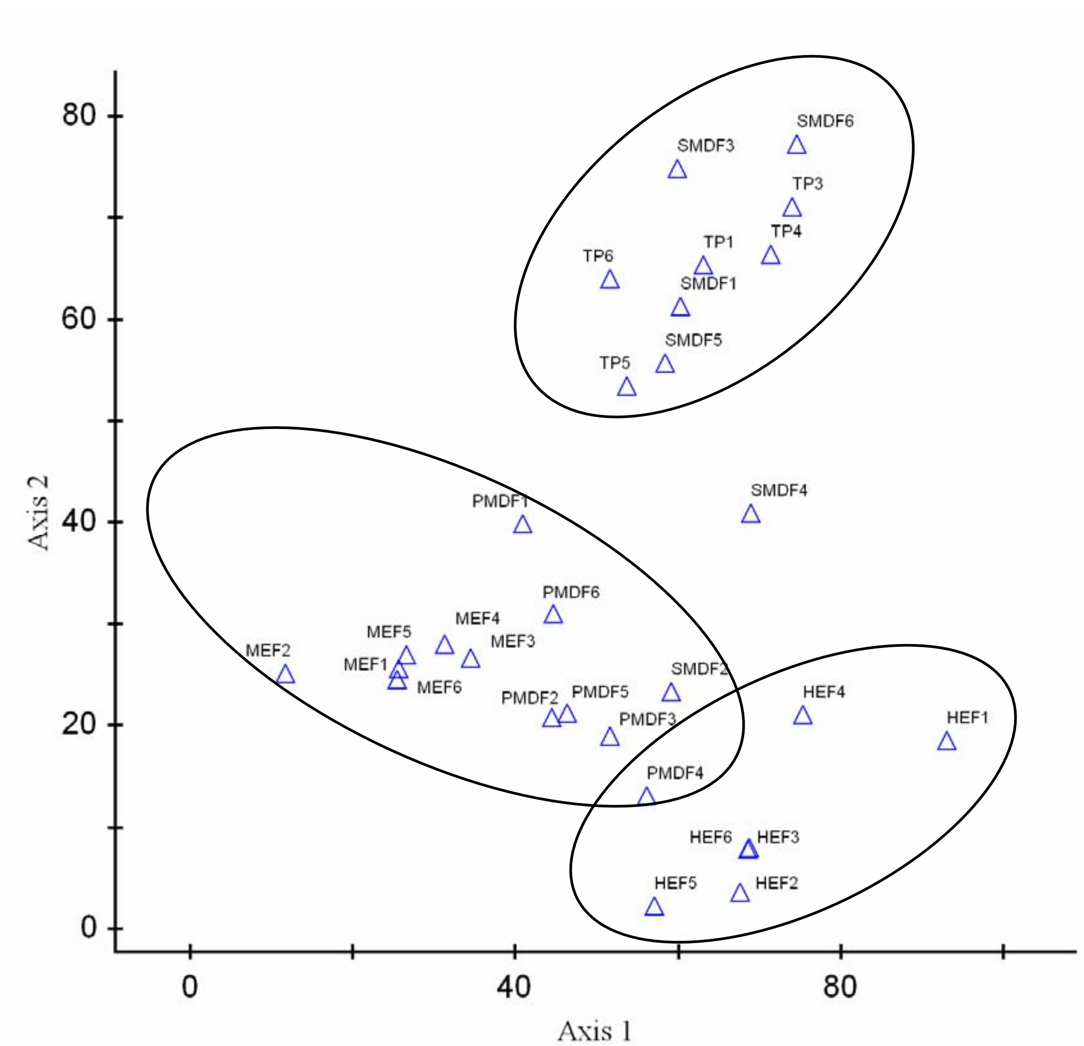


Figure 42 Detrended correspondence analysis (DCA) of sampling sites across six sampling periods in different forest habitats in eastern Thailand. PMDF1-6, MEF1-6, HEF1-6, SMDF1-6 and TP1-6 are the sequent samples during six sampling periods.

The direct gradient analysis (CCA) showed similar result as DCA. The ordination of pselaphine species in eastern forest resulted in an axis 1 (eigenvalue 0.51), axis 2 (eigenvalue 0.42) and axis 3 (eigenvalue 0.32). The eigenvalue of three axes are much higher than the range expected by chance with Monte Carlo test, $P < 0.05$. The CCA had indicated the result as the same as DCA. The beetle assemblages had divided three groups of species composition; (1) primary forests PMDF and MEF, (2) hill evergreen forest, and (3) and degraded forest habitats (SMDF) and TP) (Figure 43).

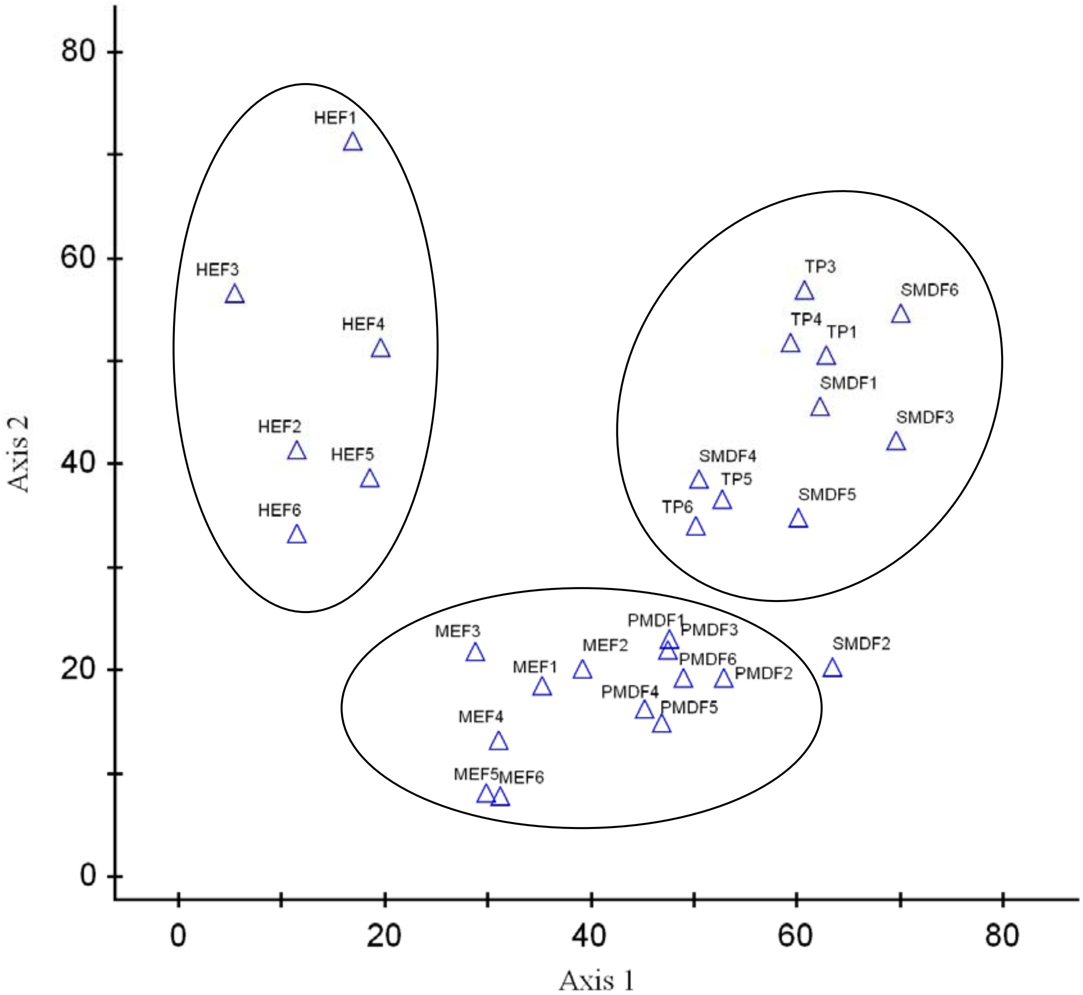


Figure 43 Caconical correspondence analysis (CCA) of sampling sites across six sampling periods in different forest habitats in eastern Thailand. PMDF1-6, MEF1-6, HEF1-6, SMDF1-6 and TP1-6 are the sequent samples during six sampling periods

3.3.2 Indicator species analysis

In indicator species analysis, data on the frequency and relative abundance of species in a particular habitat were simultaneously examined. The significance of the indicator was tested by generating a null distribution with a Monte-Carlo randomization. Moist evergreen forest had the highest number of indicator species followed by PMDF and HEF, respectively. Teak plantation had one indicator species, while no indicator species was found in SMDF (Table 9).

Table 9 Indicator species analysis (ISA) for pselaphine beetles in five different forest habitats in eastern Thailand.

Forest habitat/species	Supertribe	InVal (%)	*P*< 0.01
Primary Mixed deciduous forest			
Bythinoplectina genus undetermined 3	Bythinoplectitae	60	0.008
Hypochareus sp. 1	Batrisitae	38.3	0.004
Tribasodites sp. 3	Batrisitae	42.9	0.004
Harmophorus sp. 2	Goniaceritae	83.3	0.002
Plagiophorus sp. 1	Goniaceritae	83.3	0.001
Centrophthalmus sp. 1	Pselaphitae	73	0.001
Hill evergreen forest			
Leptoplectus sp. 1	Euplectitae	46.7	0.004
Cerylambus reticulatus	Clavigeritae	60.6	0.01
Tmesiphorus sp. 2	Pselaphitae	50	0.002
Moist evergreen forest			
Batriscenaulax sp. 1	Batrisitae	45.8	0.001
Mnia sp. 1	Batrisitae	89	0.001
Aphilia sp. 1	Euplectitae	44	0.005
Bibloplectus sp. 1	Euplectitae	50	0.002
Euplectodina sp. 1	Euplectitae	57.6	0.002
Pseudoplectus sp. 4	Euplectitae	46.4	0.003
Prophilus sp. 1	Euplectitae	63.5	0.004
Harmophorus sp. 1	Goniaceritae	68.3	0.001
Atenisodus sp. 1	Goniaceritae	66	0.003
Comatopselaphus puncticollis	Goniaceritae	50	0.003
Batraxis doriae	Goniaceritae	48.9	0.002
Batraxis brevis	Goniaceritae	66.7	0.002
Morana sp. 1	Goniaceritae	50	0.002

Table 9 (Continued).

Forest habitat/species	**Supertribe**	**InVal (%)**	***P*< 0.01**
Ancystrocerus sp. 1	Pselaphitae	83.3	0.001
Pseudophanias sp. 1	Pselaphitae	86.7	0.002
Teak plantation			
Parapyxidicerus sp. 1	Bythinoplectitae	60	0.007

No indicator species was found for secondary mixed deciduous forest.

3.4 Effects of microenvironmental variables on pselaphine assemblages

3.4.1 Weather data

Rainfall rates in KARN and KSD were obtained from the provincial meteorological stations located in Chachoengsao (KARN) and Chanthaburi (KSD). In 2006, rainfall rates in KARN and KSD were very different, as in KARN rainfall ranged from 0 to 404 mm and 2 to 705.9 mm in KSD. KARN had total rainfall of 1,541.7 mm and 3,833.4 mm in KSD respectively (TMD, 2006; Figure 44).

The mean relative humidity in sites was influenced by rainfall amount, as in KARN the humidity ranged from 60.5 to 71.5% and 67 to 81.5% in KSD (Table 10).

The mean temperature in KARN and KSD was not so different, as mean temperature ranged from 26.65 to 29.5 in KARN and 26.65 to 28.45 in KSD (Table 10).

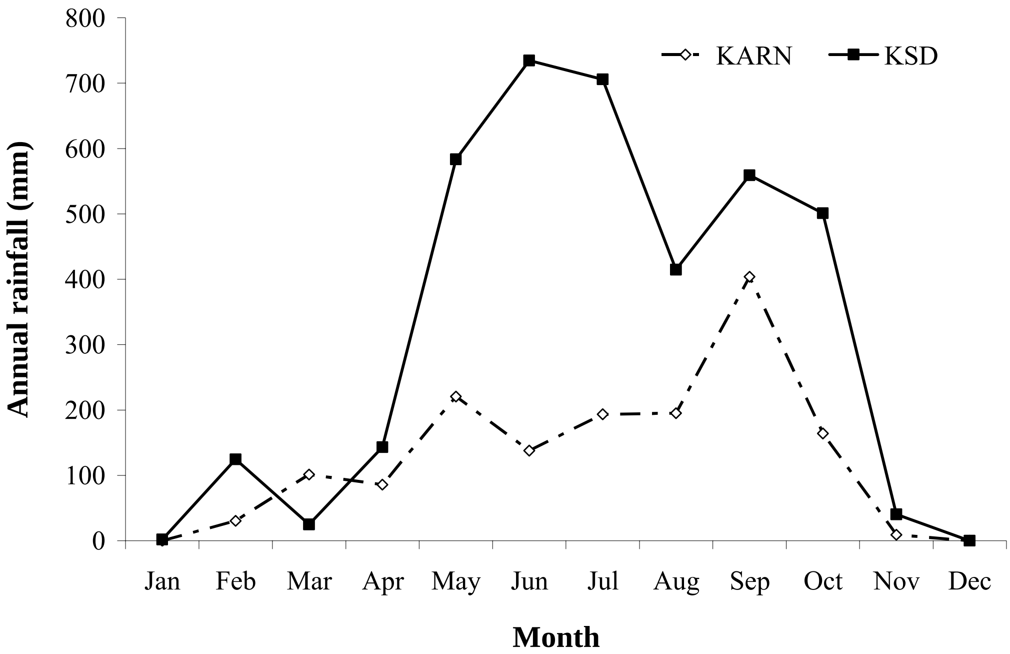


Figure 44 Monthly rainfall 2006 in KARN,KSD and KKK (TMD, 2007).

3.4.2 Microenvironmental variables

Table 10 and 11 show the weather and the mean microenvironmental variables collecting during six sampling periods. ANOVA comparison of environmental variables was given in Table 12. There was a significant difference among the environmental variables in different forest habitats and some environmental variables were significantly associated with pselaphine beetle species richness and abundance (Table 13). Comparing primary forest plots with secondary forest plot or teak plantation, many microenvironment variables were higher in primary forest (Figure 45 and 46). Secondary mixed deciduous forest had significantly less litter and soil moisture, while TP had significantly less litter, soil moisture and percentage of canopy cover. The details of each microenvironmental variable were shown as followed.

<u>Soil moisture</u>

Soil moisture was significant lower in degraded forests (SMDF and TP) than primary forests and also significant difference between seasons (*P* < 0.01; Table 12; Figure 45 a). Soil moisture ranged from 8.88% (TP) to as high as 23.15% (HEF) in dry season and ranged from 20.45% (PMDF) to as high as 45.31% (HEF) in wet season.

<u>Soil acidity (pH)</u>

Mean habitat pH ranged from 5.8 (HEF) to as high as 7.0 (SMDF). There was significant difference on pH in each habitat (*P* < 0.01; Table 12; Figure 45 b) but not significant between seasons. Soil acidity (pH) in HEF was the lowest (pH = 5.9). HEF had lowest pH with an average of 5.8, while SMDF had highest pH with an average of 6.7.

Canopy Cover

Mean percent canopy cover was also significant difference among habitats and between seasons (P < 0.01; Table 12; Figure 46a). Canopy cover ranged from 42.3% (TP) to as high as 95.26% (PMDF) in dry season and ranged from 85.33% (TP) to as high as 94.99% (HEF) in wet season. It was found that primary forests and SMDF had no seasonal effect to canopy change. However, teak plantation that had no leaf during the dry season resulted in the greatest variation between seasons.

Litter weight

Only litter mass was not affected by the seasonality effect. Litter mass was also significant difference among habitats (P < 0.01; Table 12; Figure 46 b) but not significant between season ((P > 0.05; Table 9; Figure 45b). MEF had the highest mean litter mass weight of 2.28 kg and followed by other types of primary forests (PMDF, HEF) with ranging from 1.37 to 2.03 kg. While TP and SMDF had lower litter mass ranging from 0.93 to 1.09 kg.

Tree species

There were higher tree species in the sampling areas of primary forests (10,000 m^2) than secondary and teak plantation as followed: 135 species in MEF,132 species in HEF and 109 species in PMDF respectively (Appendix Table 3.1-3.3). In secondary forest and teak plantation, there were 55 species in SMDF and 28 species in TP respectively (Appendix Table 3.4-3.5).

Table 10 Climatic data in the study sites in 2006 in eastern Thailand. Study sites were established in different climate condition. KARN, Khao Ang Rue Nai Wildlife Sanctuary; KSD, Khao Soi Dao Wildlife Sanctuary; KKK, Khao Kitchakut National Park; * = dry season, ** = wet season (TMD, 2007)

Site	**Climate**	**Jan***	**Mar***	**May****	**July****	**Sep****	**Nov***
KARN	Rainfall (mm)	0	101.2	220.5	193.6	404	9
	Humidity (%)	60.5	64.5	65	68	71.5	54
	Temperature (ºC)	26.6	29.5	29.1	28.7	28	28.1
KSD	Rainfall (mm)	2	24.9	583.4	705.9	559.1	40.3
KKK	Humidity (%)	67	75	74.5	81.5	80	67
	Temperature (ºC)	26.6	28.4	28.4	27.8	27.5	28.2

Table 11 Microenvironmental variables collected in the study sites and plots. KARN, Khao Ang Rue Nai Wildlife Sanctuary; KSD, Khao Soi Dao Wildlife Sanctuary; KKK, Khao Kitchakut National Park; PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation**.**

Site/ Forest type	**Microenvironmental Variables (n = 10)**	**Jan**	**Mar**	**May**	**July**	**Sep**	**Nov**
KARN/ PMDF	Soil moisture (%)	10.0	8.0	20.6	18.4	22.3	11.7
	Soil acidity (pH)	6.5	6.8	6.7	6.9	6.4	6.1
	Canopy cover (%)	95.94	94.64	95.16	96.9	92.8	95.4
	Litter wet mass (kg)	1.67	1.37	1.37	2.43	1.83	1.87
KARN/ SMDF	Soil moisture (%)	8.00	7.80	28.76	28.69	16.59	7.41
	Soil acidity (pH)	6.7	6.7	7.0	6.4	6.4	6.9
	Canopy cover (%)	84.2	89.4	88.4	91.7	86.8	83.9
	Litter wet mass (kg)	0.65	1.19	0.98	1.25	1.04	0.82
KSD/KKK MEF	Soil moisture (%)	15	10.7	48.5	44.5	35.9	18.5
	Soil acidity (pH)	6.2	6.3	6.7	6.6	6.4	6.4
	Canopy cover (%)	93.6	92.3	93.7	94.6	92.5	89.9
	Litter wet mass (kg)	2.3	1.5	1.6	2.1	2.4	3.0
HEF	Soil moisture (%)	22.0	25.9	52.3	47.6	35.9	21.5
	Soil acidity (pH)	5.9	5.8	5.7	5.9	6.1	5.8
	Canopy cover (%)	86.6	94.6	93.6	92.3	89.9	92.6
	Litter wet mass (kg)	1.4	2.1	0.91	1.6	1.5	2.6
TP	Soil moisture (%)	9.1	8.0	40.8	25.9	15.7	9.6
	Soil acidity (pH)	6.1	6.3	6.4	6.3	6.1	6.3
	Canopy cover (%)	39.4	37	86.8	80.8	88.4	50.5
	Litter wet mass (kg)	0.9	0.8	0.7	0.9	1.2	1.4

Table 12 Two-way ANOVA on the mean number of microenvironmental variables in different forest habitats in eastern Thailand.

Source of variation	**df**	***F*-ratio**			
		Soil moisture (%)	**Soil acidity (pH)**	**Canopy cover (%)**	**Weight of litter**
Habitat	4	16.97**	14.51**	86.29**	8.33**
Season	1	80.24**	0.97ns	61.15**	0.55ns
Habitat*Season	4	2.96*	1.02ns	46.08**	1.06ns

* $P \leq 0.05$,** $P \leq 0.01$. ns, non significant

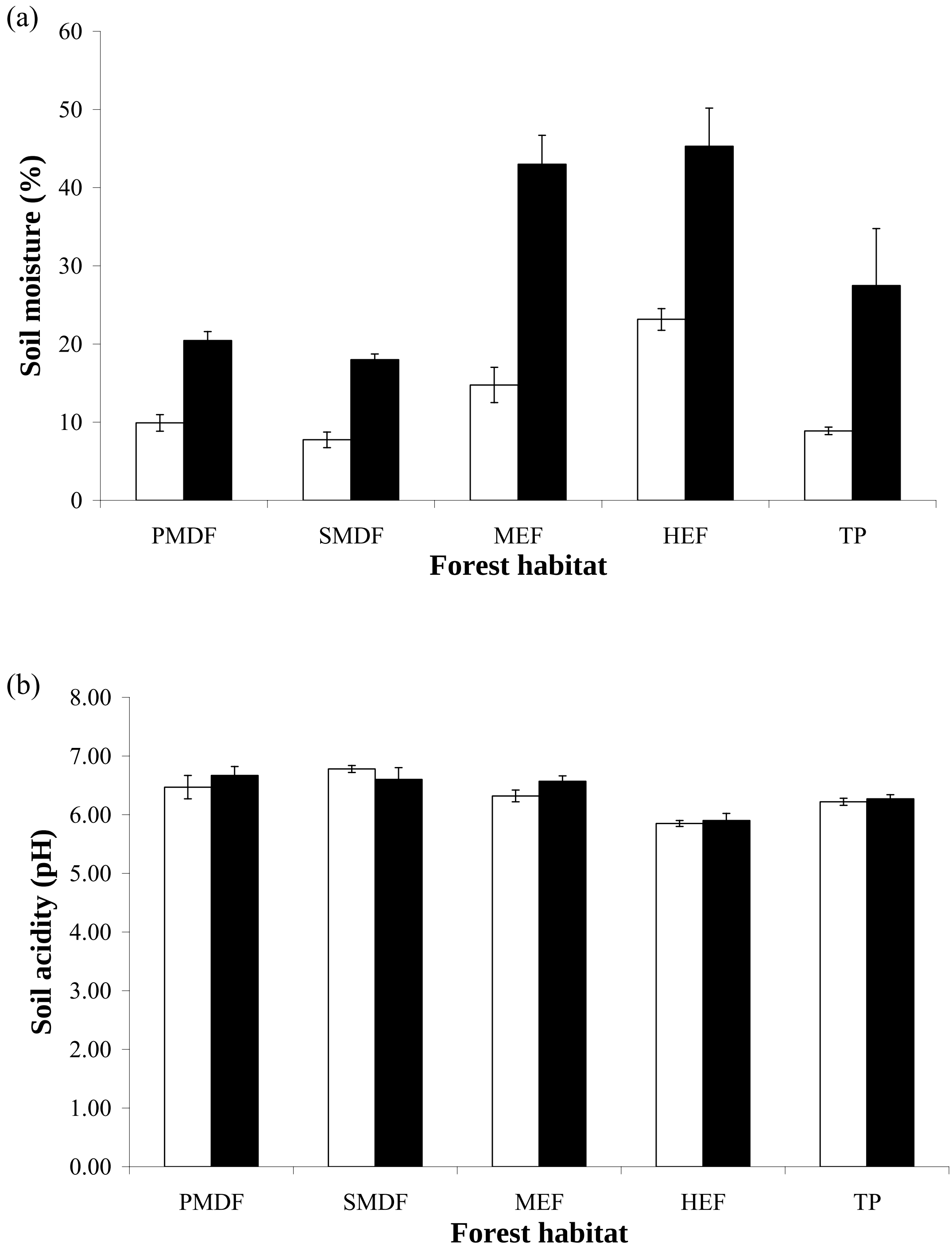


Figure 45 Measured microenvironmental variables in different forest habitats in eastern Thailand. Bars showed mean ± SE (*N* = 3). a, soil moisture; b, soil acidity (pH). □, dry season; ■ , wet season. PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.

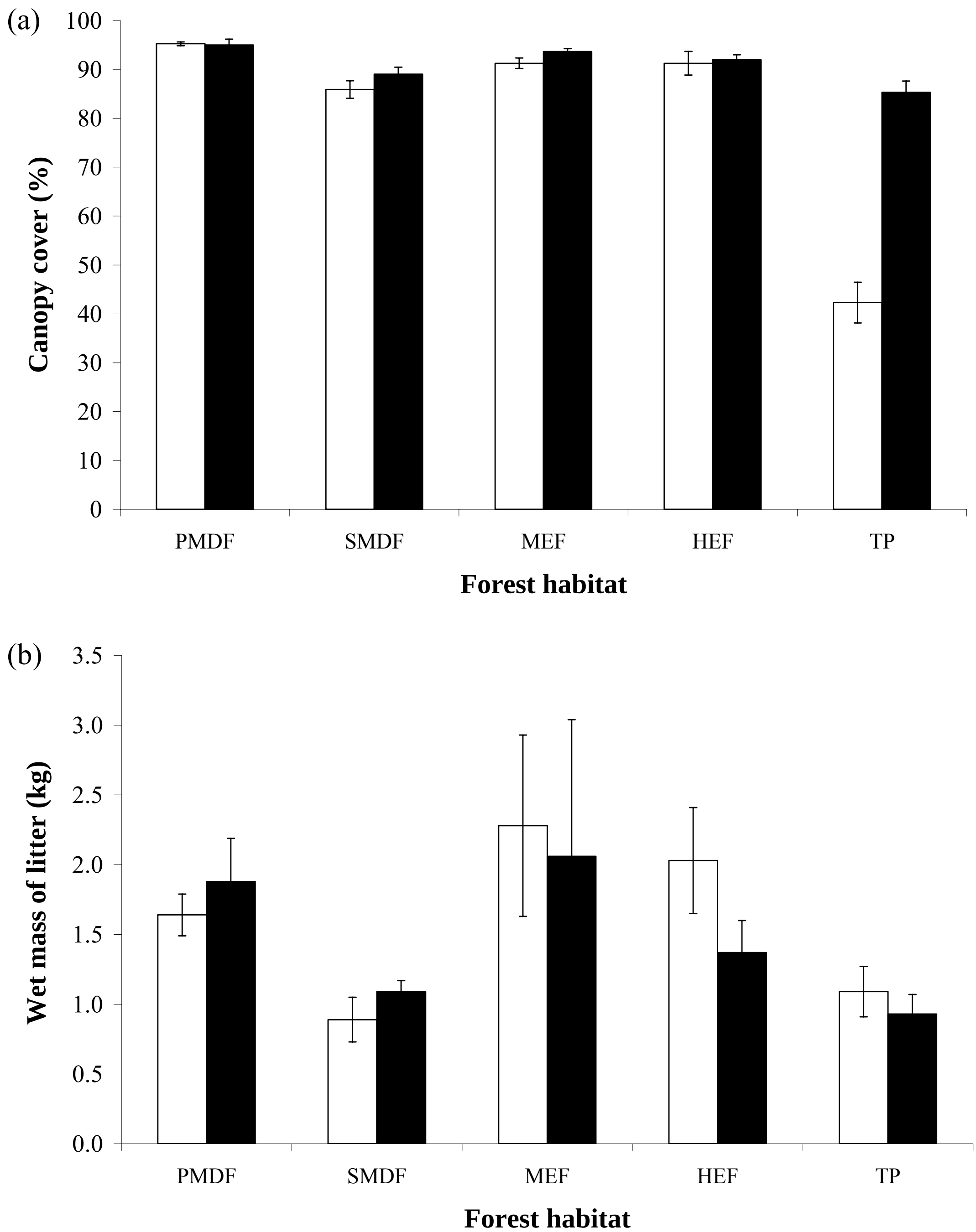


Figure 46 Measured microenvironmental variables in different forest habitats in eastern Thailand. Bars showed mean ± SE ($N = 3$). a, canopy cover; and b, weight of litter□ , dry season;■ , wet season. PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.

3.4.3 Relationship between microenvironmental variables and species richness and abundance of pselaphine beetles

Several environmental variables were significantly correlated with species richness and abundance. Leaf litter was most strongly correlated with species diversity (r = 0.724) and abundance (r = 0.705, Table 13). Soil moisture and canopy cover were correlated with species richness (r = 0.379, r = 0.397, respectively) but not significantly correlated with abundance (Table 13).

The regression analysis predicted that litter volume was the most important variable for determining the presence of pselaphine beetles, which accounted for 52 % (r^2 = 0.524) ($F_{1, 27}$ = 26.72, P < 0.01) and 50% of the variation in abundance (r^2 = 0.497) ($F_{1, 27}$ = 26.72, P < 0.01). Soil moisture and canopy cover only accounted for 14% (r^2 = 0.144) ($F_{1, 27}$ = 4.54< 0.05) and 16% of the variation in species richness (r^2 = 0.158 ($F_{1, 27}$= 5.061, P < 0.05), respectively (Figure 47-50).

Table 13 Pearson's correlation coefficient (r) between species richness, abundance of pselaphine beetles and the environmental variables in five different forest habitats in eastern forest of Thailand. KARN, Khao Ang Rue Nai Wildlife Sanctuary; KSD, Khao Soi Dao Wildlife Sanctuary; KKK, Khao Kitchakut National Park.

Environmental variables	All sites		KARN [1]		KSD and KKK[2]	
	Species	Abundance	Species	Abundance	Species	Abundance
Soil moisture	0.379*	0.116	0.772**	0.6564*	0.221	0.91
Soil pH	0.77	0.117	-0.51	-0.30	0.515*	0.444*
Canopy cover	0.397*	0.279	0.414	0.492	0.520*	0.291
Leaf litter	0.724**	0.705**	0.714**	0.768**	0.707**	0.696**
Precipitation	0.234	0.115	0.561*	0.492	0.82	0.11

[1] and [2] were sites located in different climates. * $P \leq 0.05$,** $P \leq 0.01$.

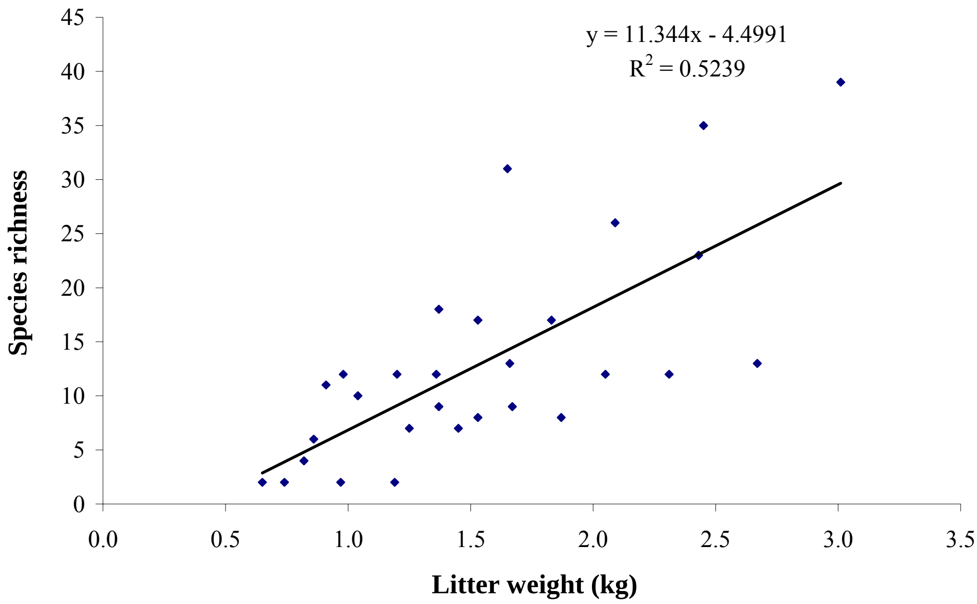


Figure 47 Relationship between litter mass and pselaphine species Richness.

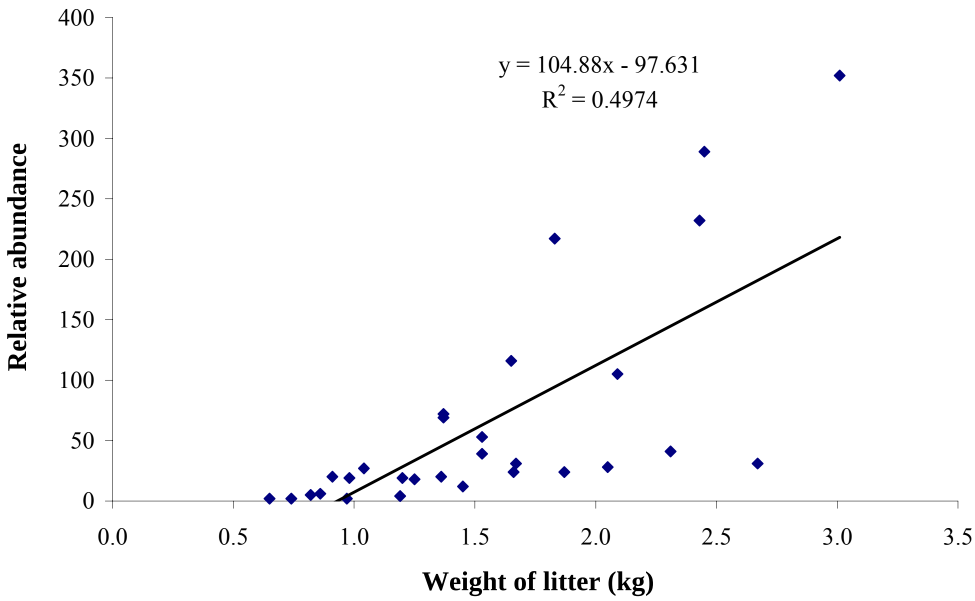


Figure 48 Relationship between litter mass and pselaphine relative Abundance.

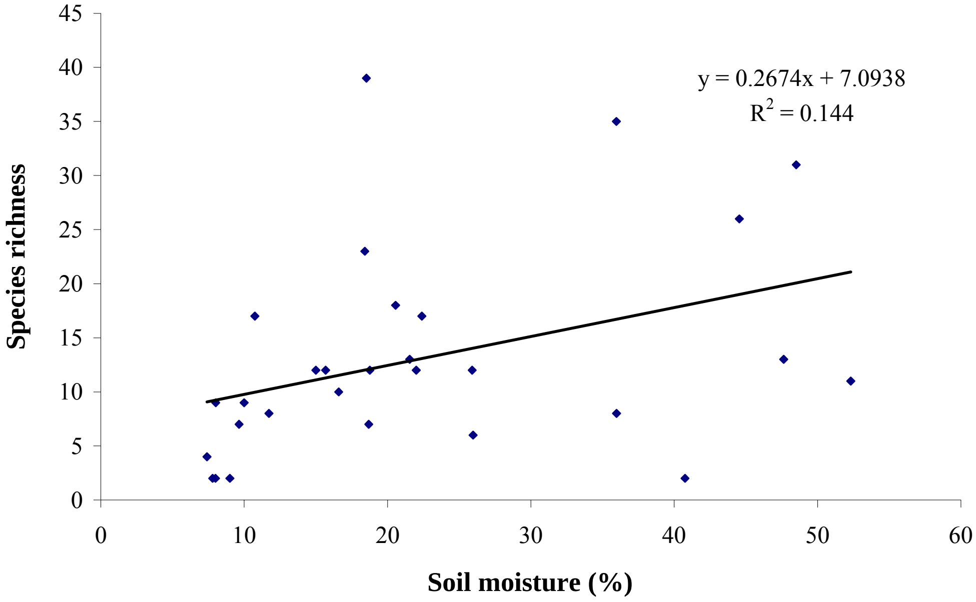


Figure 49 Relationship between soil moisture and pselaphine species Richness.

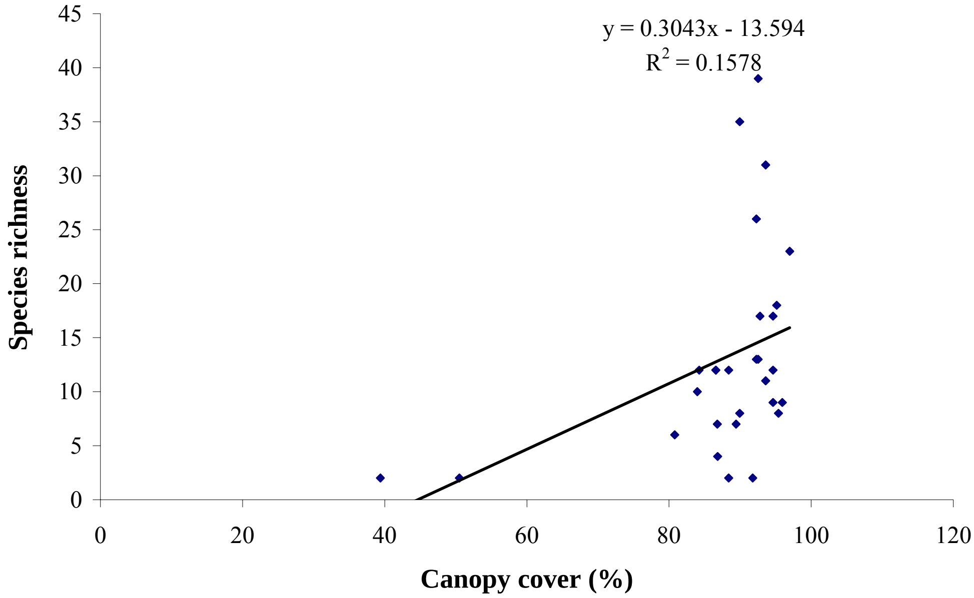


Figure 50 Relationship between canopy cover and pselaphine species Richness.

3.4.4 Ordination of species communities and microenvironmental variables

The CCA biplot of species and environmental variables was shown in Figure 51. After exclusion of species that occurred less than 3 times of the total catch (6 samplings), only 48 species were remain in analysis. Abundant species *i.e. Plagiophorus* sp. 1 *Mnia* sp. 1, *Batraxis* sp. 1, *Tribasodites* sp. 1 were clustered in the center of ordination which were the plots of MEF and PMDF, The ordination of species-abundance and five environmental variables resulted in an axis 1 (eigenvalue 0.51) differentiated by a combination of soil moisture (inter-set correlation IC = -0.56), weight of litter (IC = -0.41), soil acidity (IC = 0.63) and a small extent to canopy cover (IC = - 0.24). Second axis (eigenvalue 0.42) was related to a greater extent of weight of litter (IC = - 0.73), soil acidity (IC = - 0.42) and the small extent of canopy cover (IC = - 0.29), and soil moisture (IC = 0.04). Only rainfall variable showed no significance in analysis (not presented in CCA graph). The total inertia in the species data was 5.97 and the amount of variance explained along the first three axes was 20.9%. The Monte Carlo test of eigenvalue of three axes was significant at P = 0.01. Most species were clustered in the center of the ordination which located in PMDF and MEF habitats.

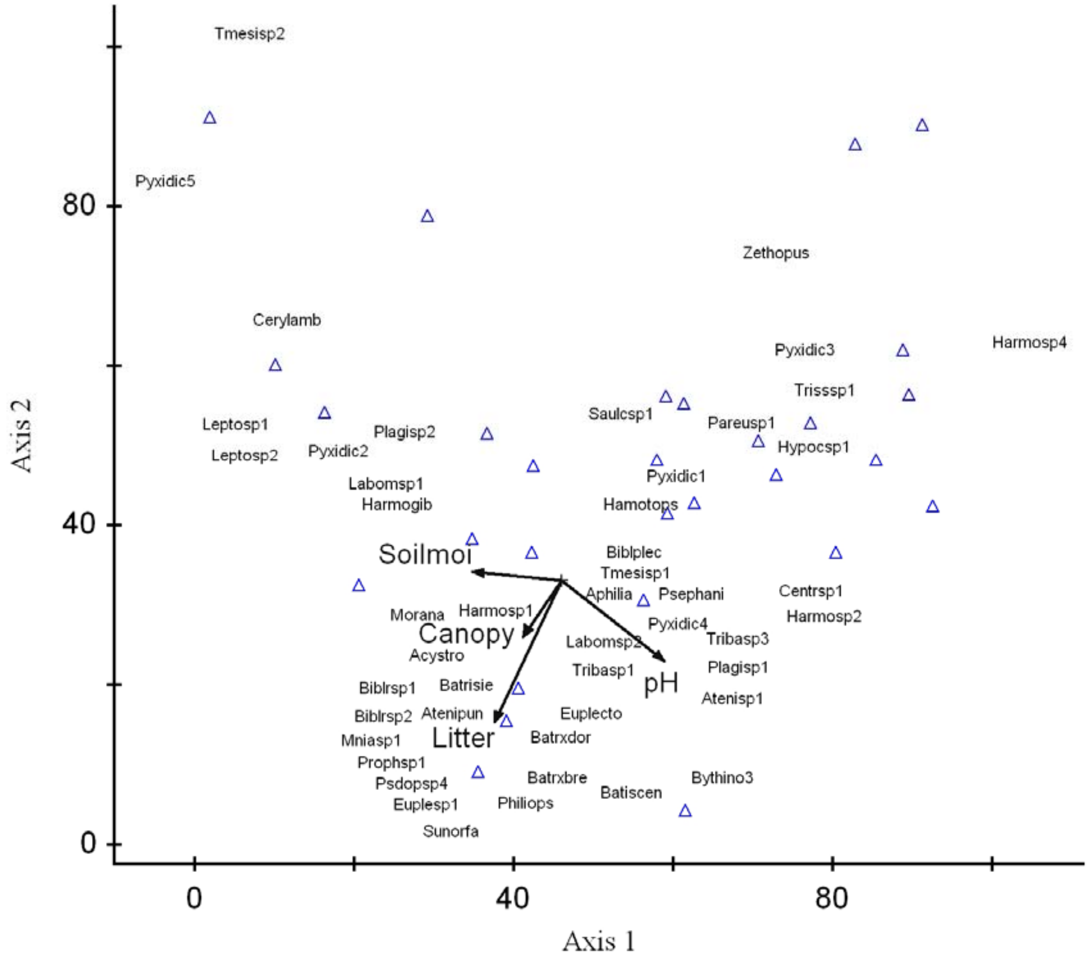


Figure 51 CCA-biplot for pselaphine species and environmental variables. Pselaphine species are named with the genus and morphospecies. Microenvironmental variables are Soilmoi, soil moisture; Canopy, canopy cover; Litter, weight of litter and pH, soil acidity (pH).

3.5 Estimating pselaphine beetles species richness in different forest habitats in eastern Thailand

3.5.1 Estimate species richness by species-abundance distribution model

A total of 1,867 adults of pselaphine litter beetles representing 114 species in all five habitats were presented in 300 sample collections in this study (Appendix. Table 1). The pooled data was fitted the lognormal model (Magurran, 1988) (Figure 52). Figure 37 and Table 14 showed the octaves falling to the left of the zero octave represented species that could have been collected if more sampling had been added, while octaves to the right represented actual sampling results.

Table 14 Chi-square goodness of fit χ^2 (GOF) test for the agreement between the observed frequency distribution of pselaphine beetles and the expected frequency distribution arranged in octaves ($\chi^2 = 4.14$, $df = 9$, $P = 0.90$).

Octave	Limits	Observed	Expected	X^2
0	0 - 0.5	-	24.27	-
1	0.5 - 1.5	29	27.93	0.04
2	1.5 - 3.5	30	26.08	0.59
3	3.5 - 7.5	16	21.93	1.60
4	7.5 - 15.5	18	16.36	0.16
5	15.5 - 31.5	11	10.69	0.01
6	31.5 - 63.5	5	6.08	0.19
7	63.5 - 127.5	2	2.99	0.33
8	127.5 - 255.5	2	1.27	0.42
9	255.5 - 511.5	1	0.47	0.60
10	511.5 - 1023.5	0	0.15	0.15
11	1023.5 - 2047.5	0	0.04	0.04
12	2047.5 - ∞	0	0.01	0.01
			$\Sigma\chi^2$	4.14

The area under the normal curve estimates the number of species in the universe being sampled (Figure 52). In the data, 24 species could have been collected if more sampling had been done and the total of 138 species was estimated by lognormal model. The species abundance distribution for the total data set span nine octaves (*df* = class – 3). Acceptable fits was obtained as judged by a chi-square goodness of fit test (χ^2 = 4.14, df = 9, P = 0.90).

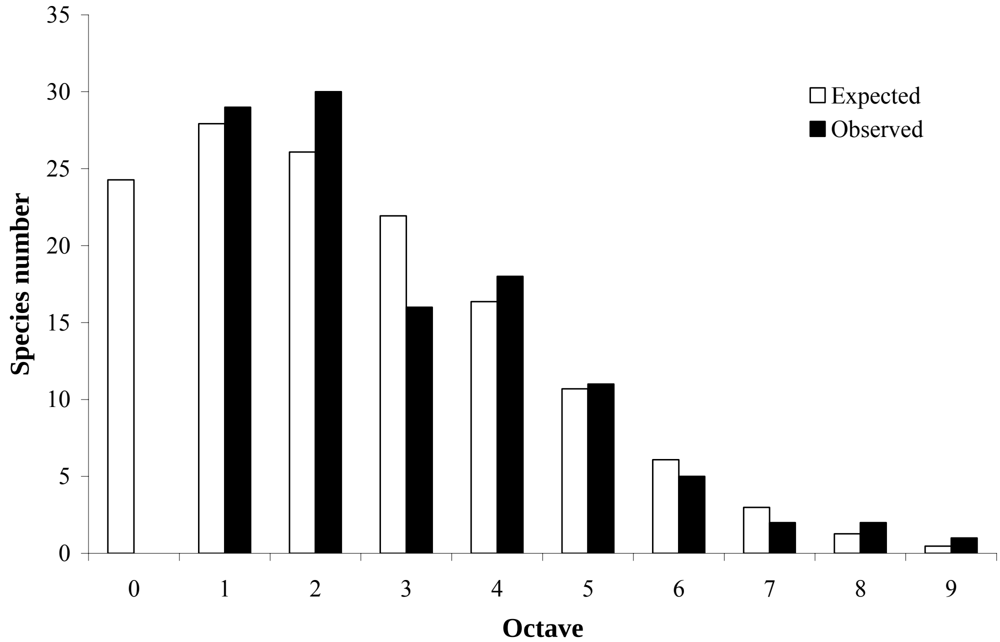


Figure 52 Frequency distribution of pselaphine beetle data (Appendix 1) to the continuous lognormal distribution (expected). χ^2 = 4.14; df = 9; P = 0.90).

3.5.2 Estimated species richness using EstimateS Program (Extrapolation).

The number of adult collected, observed species richness, singleton and doubleton were much higher in primary forests (PMDF, MEF and HEF) than in degraded forest (SMDF and TP). Sampling intensity ratio (the ratio of number of adults to species collected in each habitat) in primary forests (13.88 and 15.38) except in MEF (4.45) was higher than those in degraded forests. The inventory completeness index (the percentage of species that is not singletons) is indication of how well a community has been sampled, the inventory completeness index was slightly lower in degraded forests (42-56%) than those in primary forest (57-68%) (Table 15). Moist evergreen forest had the highest inventory completeness index (68.18%), while TP had lowest inventory completeness index (42.86%) (Table 15). This indicated that the samples were better collected in primary forests (PMDF, MEF, and HEF) than those in degraded forests (SMDF and TP).

The species accumulation curves (observed and expected) for all habitats (Figure 53 – 57) were still rising when sampling stopped. The asymptote had not been reached except ACE for SMDF and TP that showed saturation when stopped sampling (Figure 56 and 57). In all five estimators, MMMeans and Bootstrap appeared to be more closely approached an asymptote than those other estimators in the rich diversity habitat (PMDF, MEF and HEF). MMMeans and Bootstrap gave low value of species estimates, particularly Bootstrap estimates were consistently the lowest of the remaining five estimators. While the first order jackknife, second order jackknife and ACE climbed more steeply for all habitats except for ACE that reached asymptote in SMDF and TP as mention. The second order jackknife and ACE estimates were occasionally produced the highest estimates.

The six estimate indices estimated the number of pselaphine species in primary forests were higher than those in degraded forests; for PMDF between 56-99 (estimates) and 42 (observed species), MEF between 79-112 (estimates) and 66 (observed species), and HEF between 53-97 (estimates) and 42 (observed species). While in degraded forests, the numbers of estimate species are lower; for SMDF there were between 26-40 (estimates) and 23 (observed species), and for TP between 23-45 (estimates) and 21 (observed species). This indicated that more pselaphine beetles lived in the primary forest communities than those in degraded forest communities (Table 15).

Table 15 Summary values and richness estimates in five different forest habitats in eastern forest of Thailand. Forest habitats: PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.

	Forest Habitat				
	PMDF	**SMDF**	**MEF**	**HEF**	**TP**
Summary values					
No. of samples	60	60	60	60	60
No. of individuals	646	75	916	187	43
Observed richness	42	23	66	42	21
No. of singletons	8	4	7	4	5
Sampling intensity	15.38	3.26	13.88	4.45	2.05
Inventory completeness	59.52	56.52	68.18	57.14	42.86
Richness estimators					
ACE	69.46	32.29	104.98	97.7	34.86
First-order jackknife	63.67	32.82	94.55	68.55	33.78
Second-order jackknife	74.45	40.6	112.1	89.9	41.6
Bootstrap Mean	52.7	26.62	79.53	53.32	26.49
MM mean	56.01	33.76	86.88	68.52	45.75
Lognormal	99	26	83	64	23

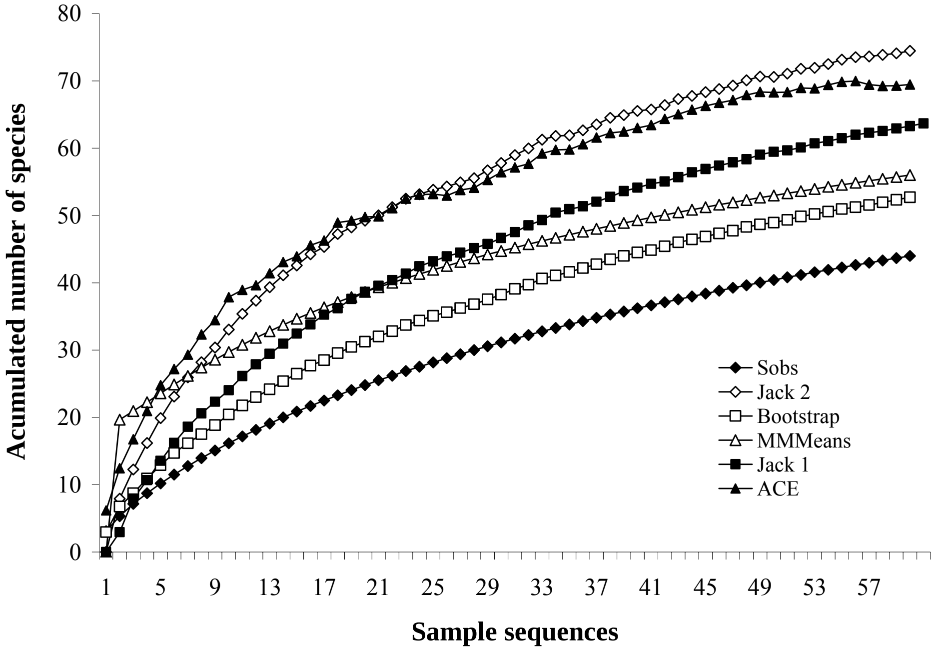


Figure 53 Mean values of observed species richness (Sobs), and richness estimators; 2nd jackknife, bootstrap and MMMeans for PMDF at each sample increment for 100 random order of sample addition.

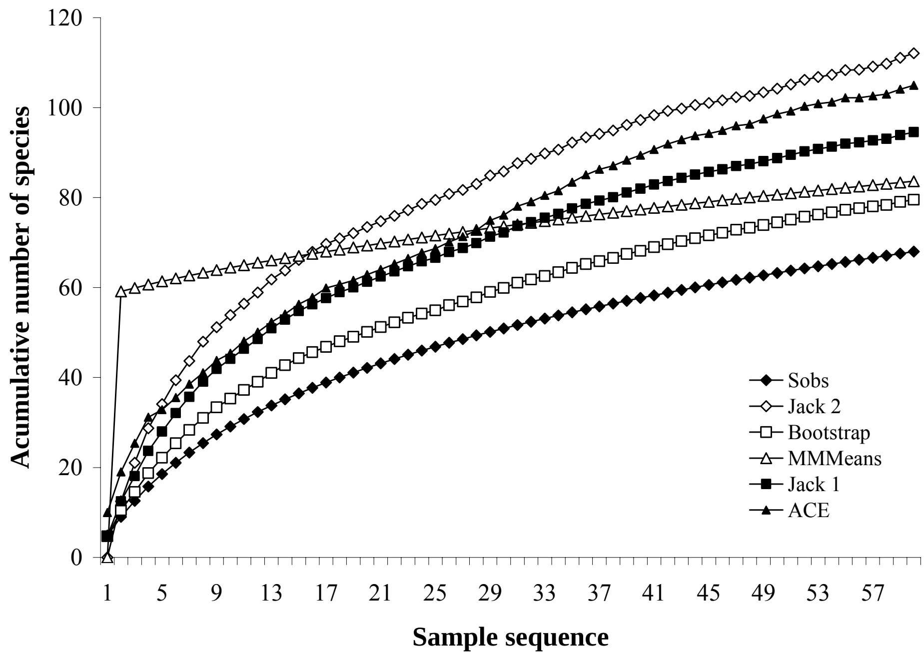


Figure 54 Mean values of observed species richness (Sobs), and richness estimators; 2nd jackknife, bootstrap and MMMeans for MEF at each sample increment for 100 random order of sample addition.

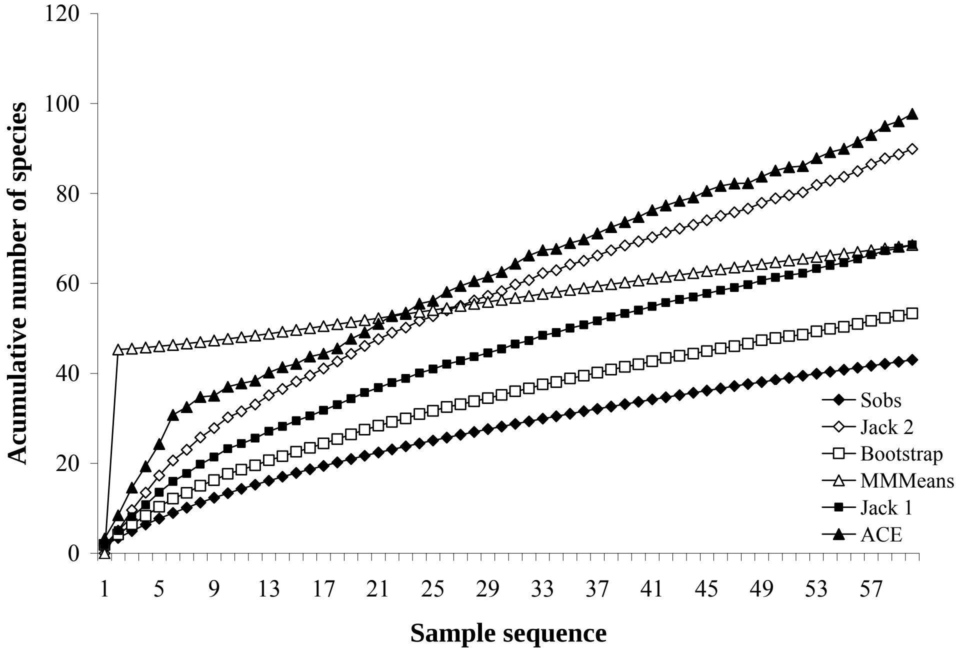


Figure 55 Mean values of observed species richness (Sobs), and richness estimators; 2nd jackknife, bootstrap and MMMeans for HEF at each sample increment for 100 random order of sample addition.

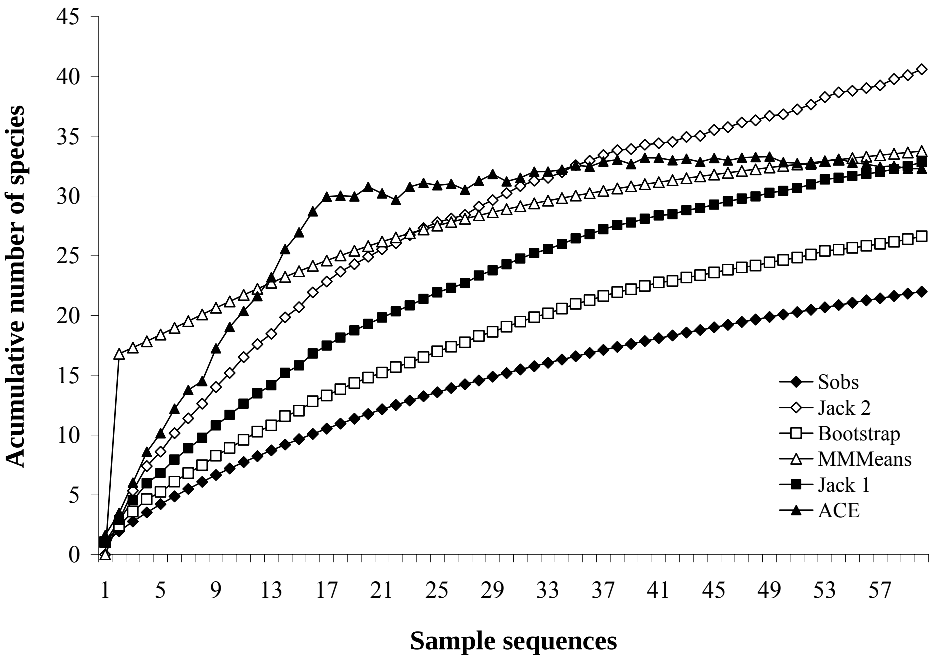


Figure 56 Mean values of observed species richness (Sobs), and richness estimators; 2nd jackknife, bootstrap and MMMeans for SMDF at each sample increment for 100 random order of sample addition.

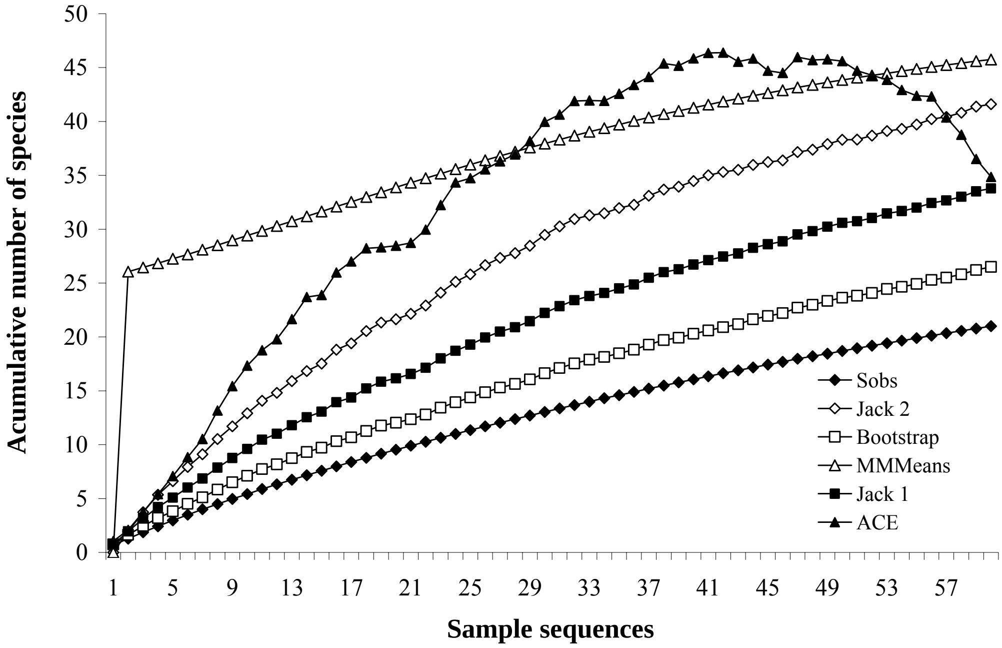


Figure 57 Mean values of observed species richness (Sobs), and richness estimators; 2nd jackknife, bootstrap and MMMeans for TP at each sample increment for 100 random order of sample addition.

3.6 Diversity pattern between pselaphine beetles and dwelling ants

3.6.1 Pselaphine beetles and ant species richness

A total of 44,135 individuals, 142 species in nine subfamilies of ants were collected in all habitats in 2006. The numbers of ant species in 2006 in each habitats from the highest to lowest were as following: MEF with 85 species and followed by 77 species in PMDF, 68 species in SMDF, 61 species in HEF and 56 species in TP, respectively (Appendix Table 2). While the numbers of pselaphine species were slightly differed from the rank number of species in ants as SMDF had situated in the fourth rank as followed; MEF (66 species), PMDF (42), HEF (42), SMDF (23) and TP (21).

Species richness of ants showed a significant response to habitat types (Kruskal-Wallis one-way analysis of variance; H = 21.17, P < 0.01; Figure 58). Mean number of ant species decreased from moist evergreen forest to teak plantation. This trend of species reduction along habitat gradients was the same as pselaphine species richness that significantly responded to habitats types (Kruskal-Wallis, one-way analysis of variance; H = 18.51, P < 0.01; Figure 59).

There were not significantly different on mean number of ants species and pselaphine beetles species between wet and dry season (ant; Mann-Whitney U-test, U = 112, P = 0.98 (Figure 58) and pselaphine beetles; U = 70.50, P < 0.08; Figure 38).

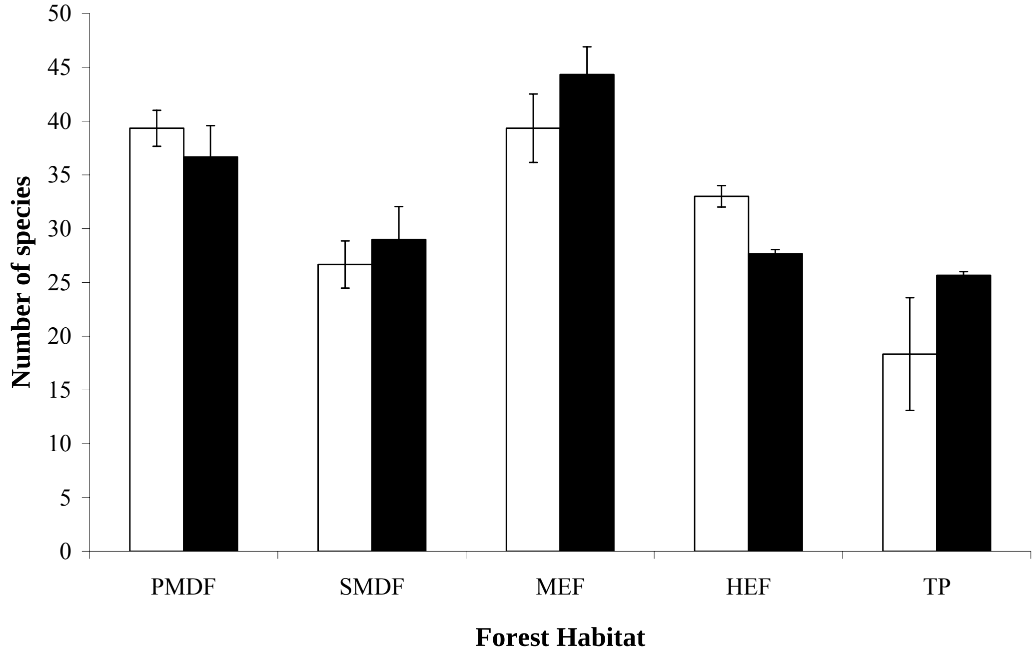


Figure 58 Ants species richness in different forest habitats in eastern Thailand. Bars showed mean ± SE (N = 3). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation. □, dry season; ■ , wet season.

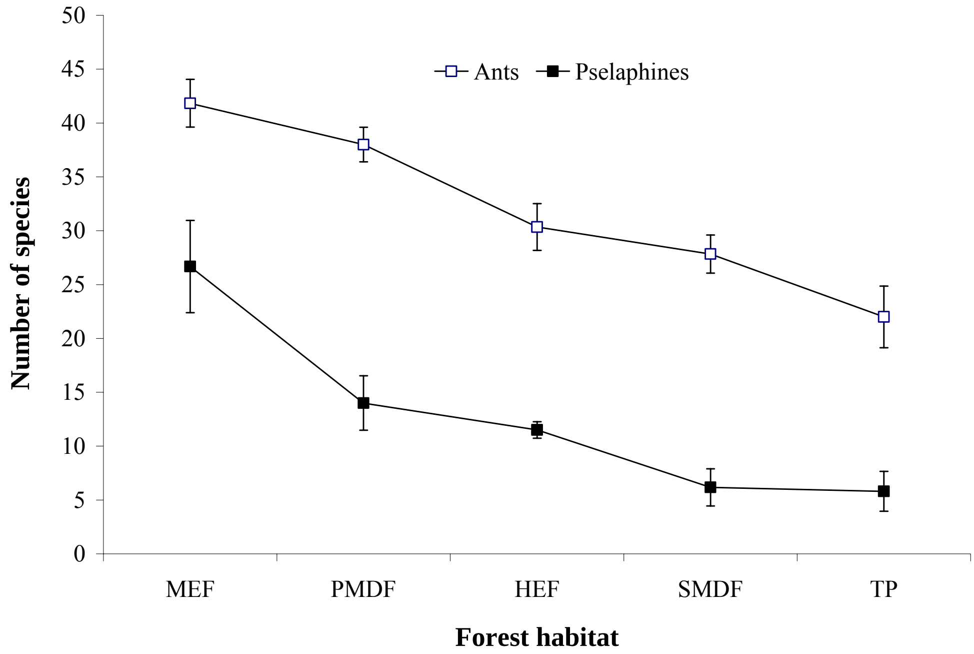


Figure 59 Pselaphine beetles and ants species richness in different forest habitats in eastern Thailand. Points showed mean ± SE (*N* = 6). MEF, moist evergreen forest; PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; HEF, hill evergreen forest ; TP, teak plantation.

3.6.2 Abundance

Both pselaphine beetles and ants abundances were also significantly greater in primary forests than those in the secondary forests and teak plantations (Figure 61) (ants; H = 20.62, P < 0.01; pselaphine beetles; 23.04, P < 0.01). The number of individuals of pselaphine beetles and ants in primary forests particularly PMDF and MEF were several times higher than those in disturbed forest habitats (SMDF and TP).

Similarly, combination of all sites showed that there was no significant difference between seasons for these two taxa (ants; U = 89, P = 0.33, Figure 60; pselaphine beetles' U = 82, P = 0.2; Figure 39).

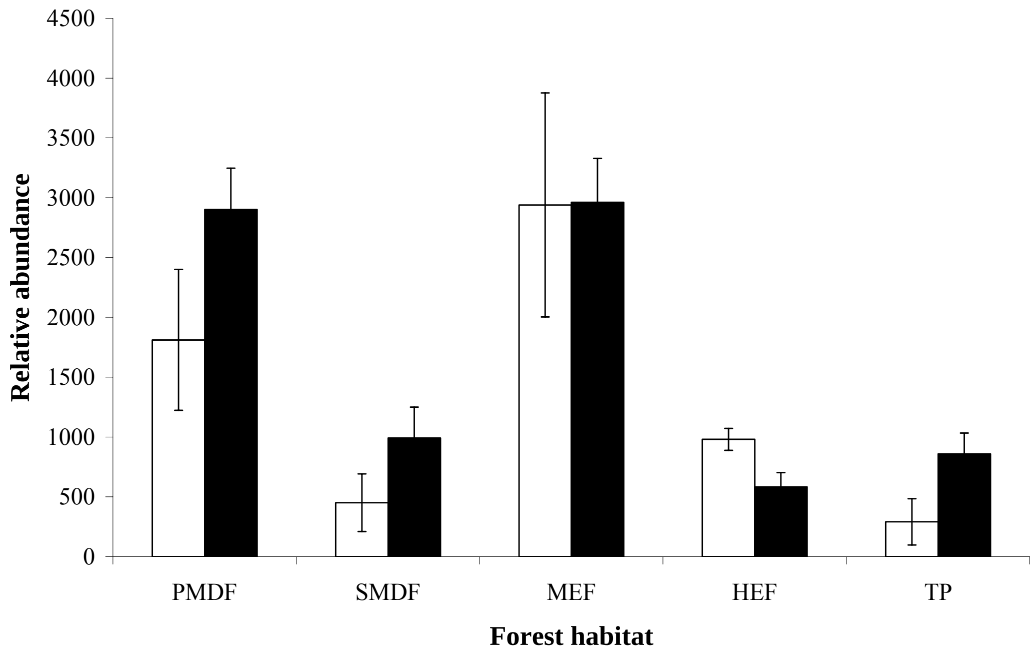


Figure 60 Ants abundances in different forest habitats in eastern Thailand. Bars showed mean ± SE (N = 3). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation. □ , dry season; ■ , wet season.

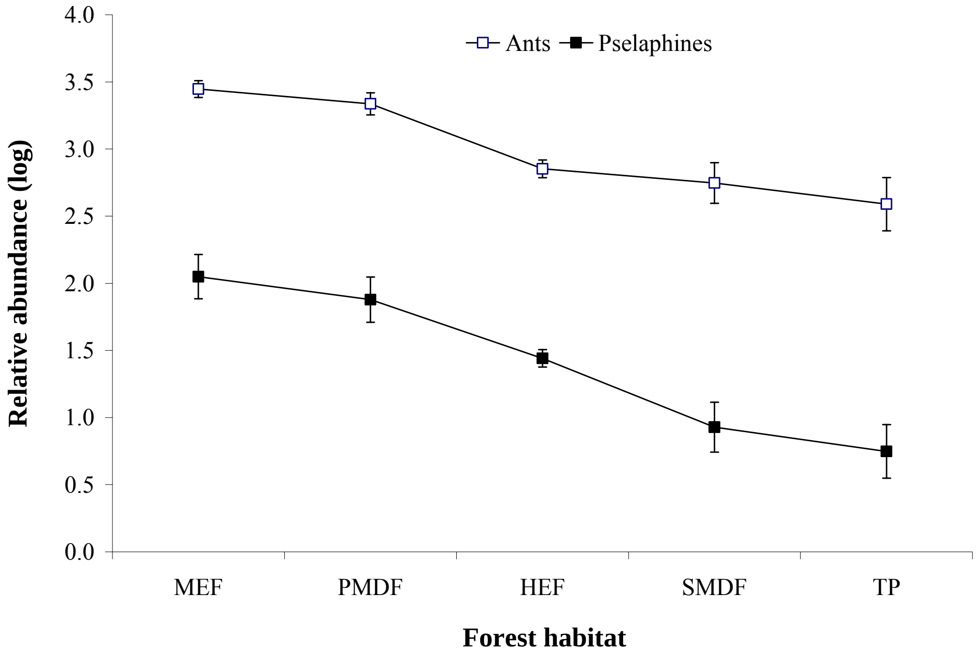


Figure 61 Pselaphine beetles and ants abundance in different forest habitats in eastern Thailand. Points showed mean ± SE ($N = 6$). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.

3.6.3 Shannon-Wiener's diversity indices (*H*') and evenness (*J*') indices of pselaphine beetles and ants

Shannon-Wiener's diversity (*H*') indices of pselaphine beetles and ants were higher in primary forest habitats than those in disturbed habitats. Moist evergreen forest had highest diversity and decreased from HEF to TP (Figure 63). Significance in Shannon-Wiener's diversity index was found among habitats for both taxa (ants, $H = 16.35$, $P < 0.01$; pselaphine beetles, $H = 13.35$, $P < 0.01$).

Again there was no significant difference between season of Shannon-Wiener's diversity index of ants and pselaphine beetles in combining all the sites (ants, $U = 109$, $P = 0.88$, Figure 62; pselaphine beetles, $U = 70$, $P = 0.07$, Figure 40).

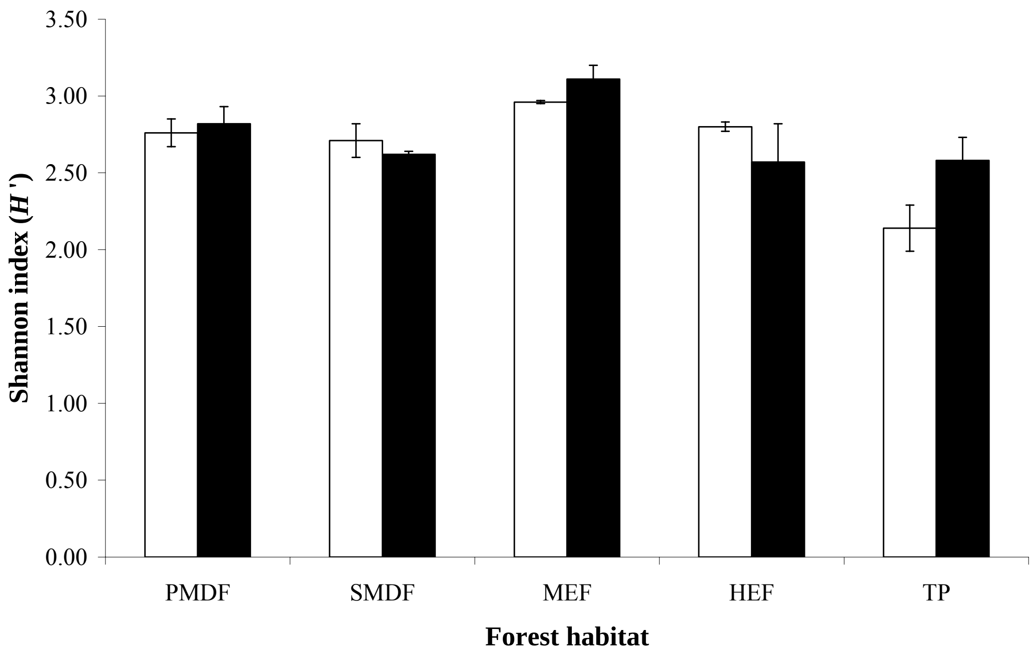


Figure 62 Shannon-Wiener's index of ants in different forest habitats in eastern Thailand. Bars showed mean ± SE ($N = 3$). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation. ☐ , dry season; ■ , wet season.

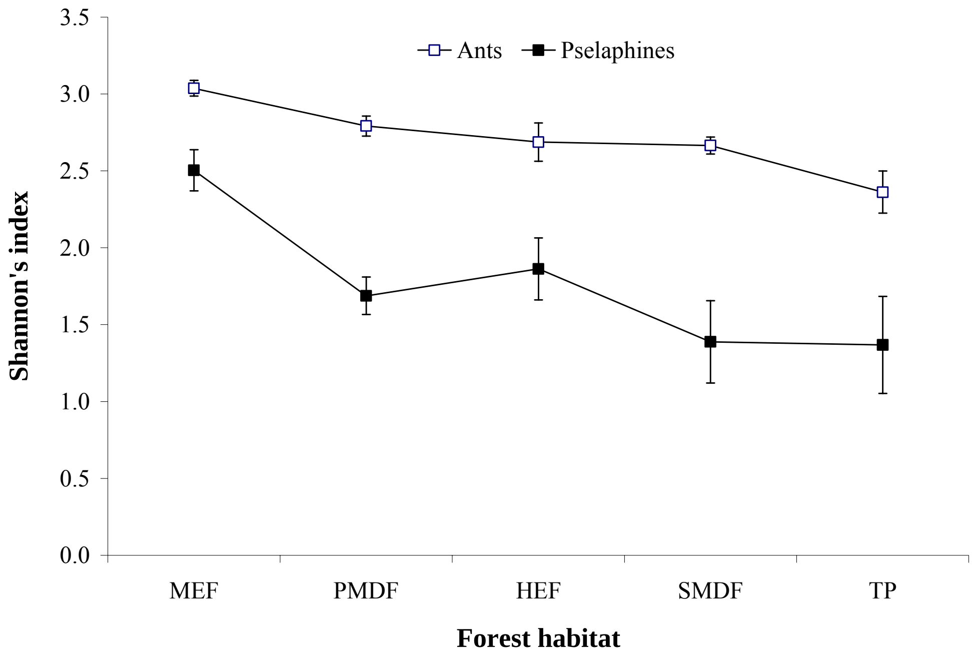


Figure 63 Shannon-Wiener's indices of ants and pselaphine beetles in different forest habitats in eastern Thailand. Points showed mean ± SE ($N = 3$). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.

However, the Pielou's evenness index (*J'*) which expresses the equality of species in each habitat was not significantly different for ants ($H = 1.78$, $P = 0.77$) but it was significantly different for pselaphine beetles ($H = 10.21$, $P < 0.05$) (Figure 65). It was found that Pielou's evenness index (*J'*) for pselaphine beetles was higher in SMDF and TP than those in primary forests.

Similar to previous results that there were no significant differences of evenness index between season for both ants and pselaphine beetles (ants, $U = 91$, $P = 0.37$, Figure 64; pselaphine beetles, $U = 111.5$, $P > 0.05$, Figure 41).

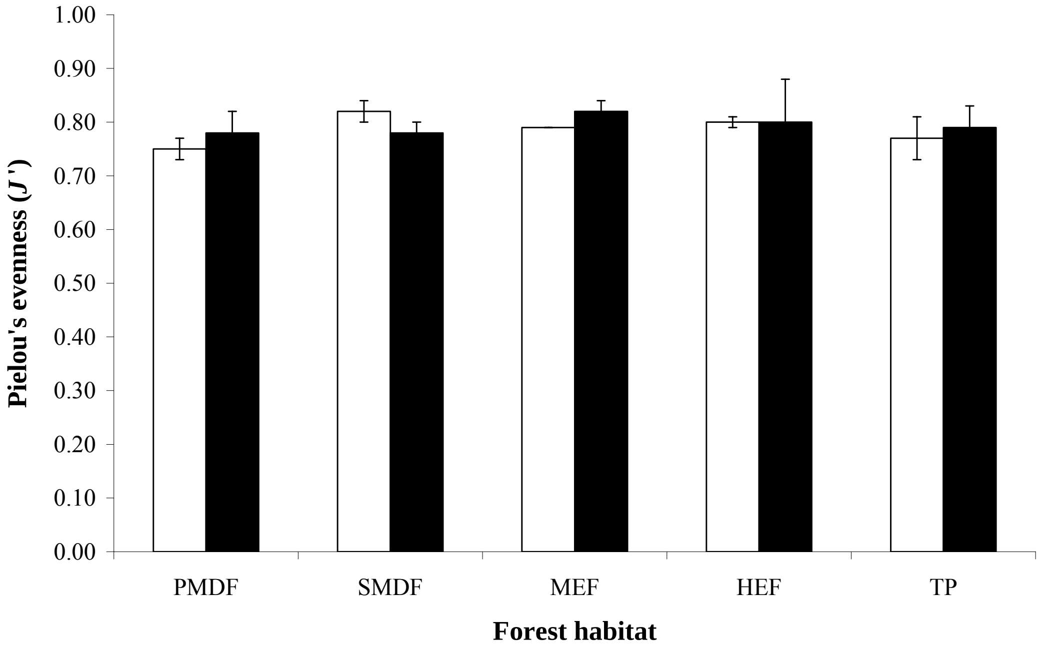


Figure 64 Pielou’s evenness index of ants in different forest habitats in eastern Thailand. Bars showed mean ± SE (N = 3). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.

☐ , dry season; ■ , wet season.

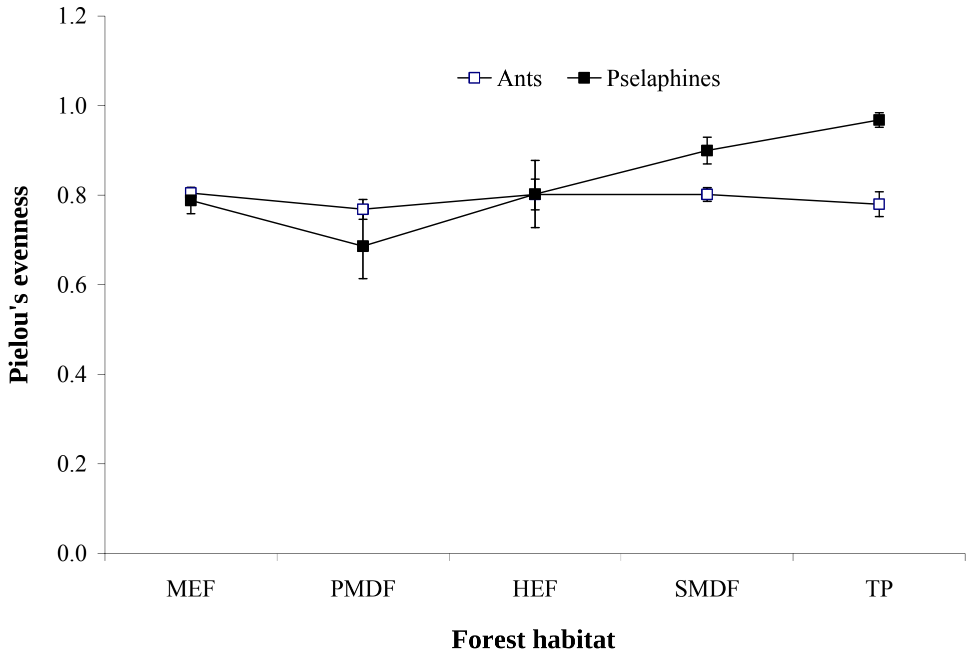


Figure 65 Pielou’s evenness index of ants in different forest habitats in eastern Thailand. Points showed mean ± SE ($N = 3$). PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.

3.6.4 Correlation between pselaphine beetles and ants

Correlations of pselaphine beetles and ants were undertaken between the variables on species richness, number of individuals, Shannon-Wiener's diversity indices and Pielou's evenness indices and also separately analysed for different seasons (Table 16). There was a strong relationship of parameters between the two taxa. Almost all parameters between pselaphine beetles and ants were significantly correlated except for Pielou's evenness index which was not significantly correlated. All these relationship had a Spearman's (r) higher than 0.50 (50%), *i.e.* species richness for all season (r = 0.619, $P < 0.001$; Figure 66); individuals (r = 0.768, $P < 0.001$; Figure 67) and Shannon-Wiener diversity index (r = 0.515, $P < 0.001$; Figure 68) and also reached a level of highly significance ($P < 0.01$) and can be described sufficiently by a linear regression model. However, there was no correlation between pselaphine beetles and ants found in Pielou's evenness index (*J'*) (Figure 69).

Table 16 Relationship (Spearman's correlation) between pselaphine beetles and ants surveyed across sites; the top and right portion of the table presents correlations of parameters (Spearman's (r)), a level of significance, and the number of sites available for pairwise comparison, *N* (in square brackets).

	Dry season [15]	Wet season [15]	All season [30]
Species richness	0.600**	0.819***	0.619***
Individuals	0.879***	0.627**	0.768***
Shannon's diversity (*H'*)	0.581*	0.510*	0.515**
Pielou's evenness (*J'*)	0.205	-0.168	-0.70

Level of significance * = P < 0.05, ** = P < 0.01, *** = P < 0.001.

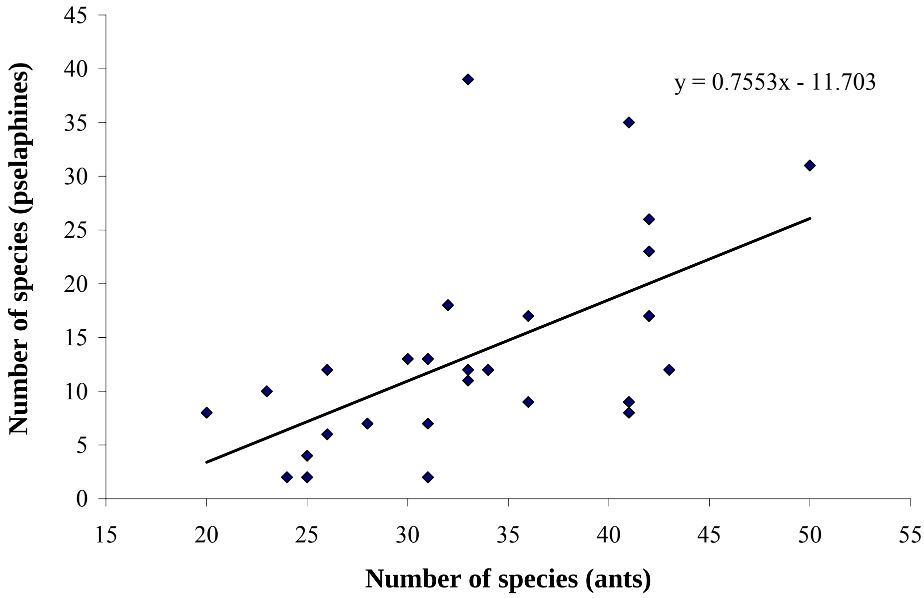


Figure 66 Relationship between number of species of pselaphine beetles and ants across the habitat gradient.

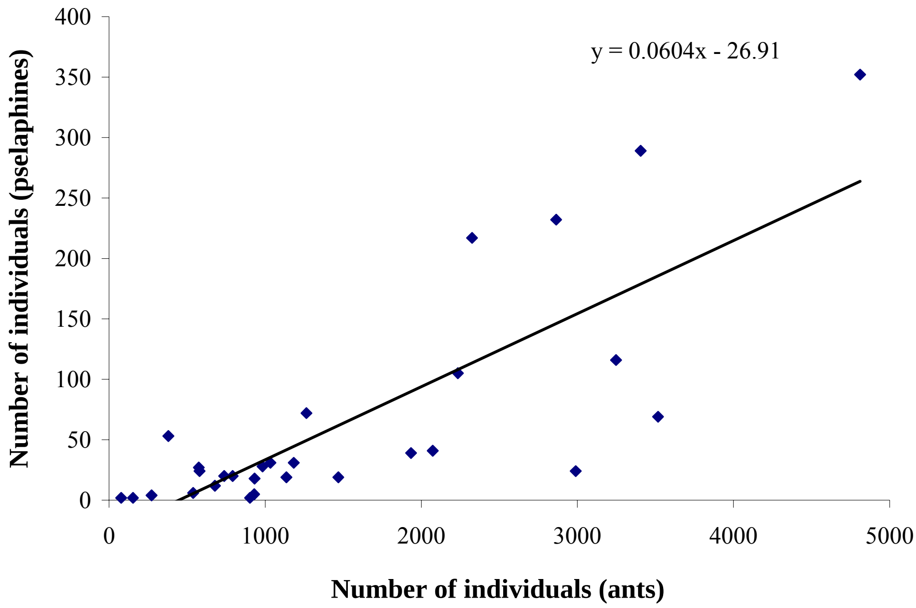


Figure 67 Relationship between numbers of individuals of pselaphine beetles and ants across the habitat gradient.

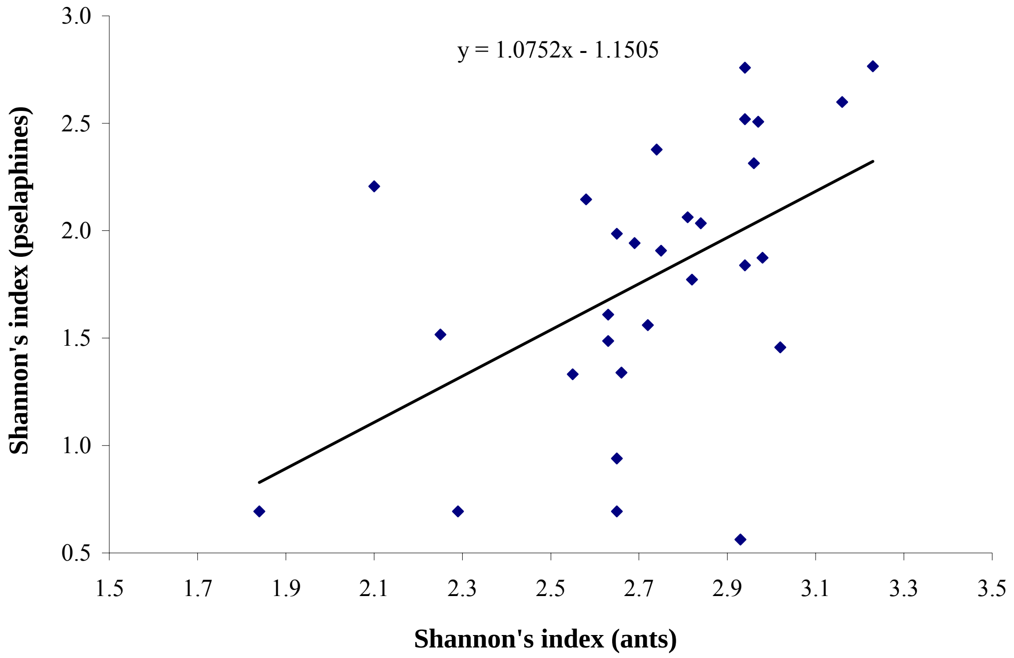


Figure 68 Relationship between Shannon-Wiener's index of pselaphine beetles and ants across the habitat gradient.

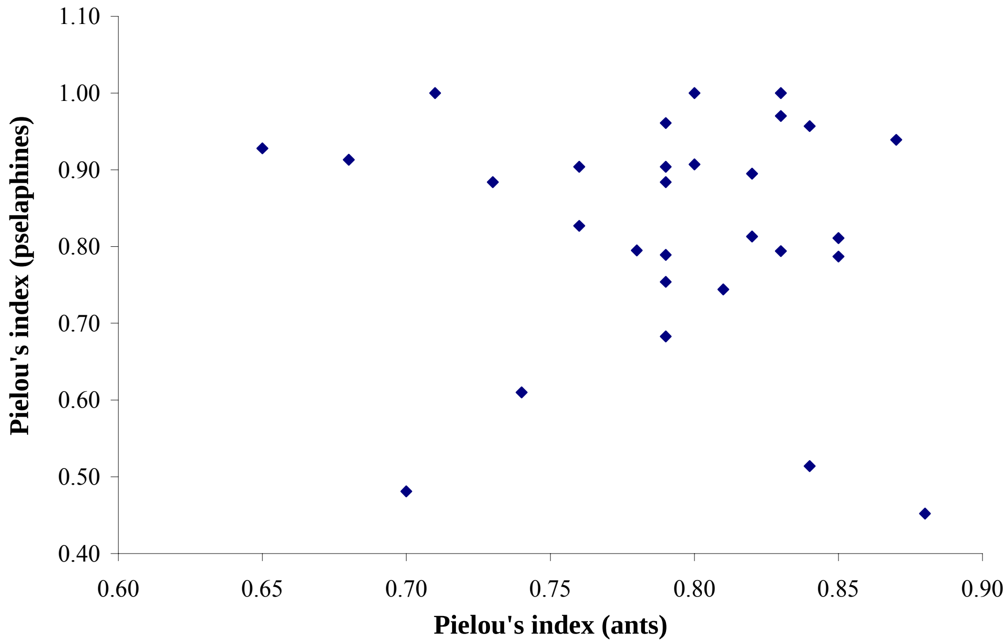


Figure 69 Relationship between Pielou's evenness index (*J*') of pselaphine beetles and ants across the habitat gradient.

Discussion

1. Extraction efficiency of Winkler and Tullgren devices

Tullgren extraction is more efficient in extracting of soil-litter macro-arthropods than Winkler extraction for both qualitative and quantitative extraction. The number of specimen collected by Tullgren extraction is absolutely higher than Winkler extraction for all of arthropod groups except for Lepidoptera larvae that number of specimens was not much different between the two types of extractors (n = 37, Winkler; 46, Tullgren).

The results showed that the species number of pselaphine beetles extracted by Winkler was half of the total species extracted by Tullgren and the number of all beetle families was very low when using Winkler (15 families) or 66% of total family numbers extracted by Tullgren (22 families). It was found that in the certain period of extraction, Tullgren extraction is more suitable to extract all abundant soil-litter arthropods and rare arthropods but Winkler found to be less efficient in extracting arthropods as only the abundant groups of arthropods were extracted.

The species accumulation curve for pselaphine beetles produced by Winkler samples had saturated as well as the accumulation curve produced by Tullgren samples but the number of specimens and species were excessively difference. We would get lower estimating of species richness and diversity values if using Winkler method, because some diversity and estimate indices employ the number of specimens (individuals) in formula *e. g.* Shannon-Wiener's diversity, Evenness, ACE, Chao1 and etc (Colwell, 2005; Magurran, 1988). In this study we would have only nine species of pselaphine beetles if we used only Winkler method. On the contrary, we would have 19 species from using Tullgren method in the same habitat.

The efficiency of Winkler extraction was very low when comparing with Tullgren extraction. Several reasons could be explained as (1) the effects of desiccation in Winkler extractor made soil-litter arthropods stay in soil samples instead of failing to alcohol bottles, this was supported by Scheerpeltz (1968) found that alcohol in collecting bottle makes beetles stay in the substratum rather than falling into the bottles. (2) Figure 70, showed clearly the inside view of the Winkler extractor environment, the average soil moisture at starting time was 35.22% and after 7days of extraction periods, the average soil moisture was slightly dropped to 31.60%. Meanwhile, soil temperature was slightly increased from 26.31°C at starting time to 28.61°C at the final extraction. These little changes in micro-environmental conditions in Winkler extractor (cloth bag) did not have much effect on organisms, because the sifted soil samples had dried out slower in the core than outside. This may cause some organisms moved to the center part and still were alive after finishing extraction periods, and (3) since the extraction of predators such as Arachnida and particularly Chilopoda are relatively slow with Winkler and Tullgren extractors, the influence of predation might be increased under longer extraction time. Krell *et al*., (2005); Chung and Jones (2003) using Winkler method reported that Chilopoda and Araneae were very slowly extracted at the staring time and were extracted high proportion in longer period which meant increasing their chances to prey on smaller organisms in the substrate. Additionally, predacious beetles (*i.e.* family Staphylinidae, Scydmaenidae, Hydrophilidae, Histeridae and so on) are the majority groups of beetles in soil and litter in our samples (58% of total specimens), they would feed on small organisms in Winkler bag (Table 2). Chung *et al*. (2000) also found that predacious beetles were the most abundant and diverse group, representing more than 40% of soil beetles in the forests of Sabah, Malaysia.

Tullgren extraction works by the heat in Tullgren extractor (60W bulk light) which gradually changed the soil samples humidity and slightly increased the temperature in our experiment. The starting temperature was 26.32°C and the end of extraction was 42.12°C and the moisture was decreased from 37.46% to 3.62% at the end of 7 days extraction (Figure 71). Temperature and moisture gradients in Tullgren extractor slowly changed soil sample conditions that would activate arthropods to migrate through the soil sample in order to escape the increasing unfavorable conditions as extraction time increased. Some large-sized beetles *i.e.* beetles in family Tenebrionidae, Carabidae and Scarabaeidae which many of them have strong structural body (hard elytra), they were found relatively in low numbers when extracted by Winkler bags. The data showed that nine specimens of tenebrionid were collected by Winkler method but 319 specimens were collected by Tullgren method (Table 5).

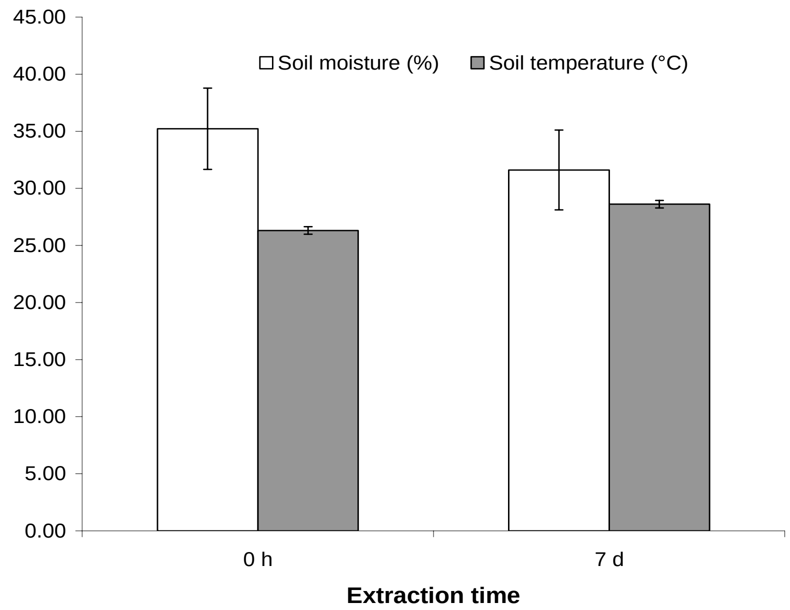


Figure 70 Temperature and moisture of soil samples change in Winkler extractors following extraction time from starting (0 h) and after 7 days (7 d). Bars showed mean ± SD (N = 10).

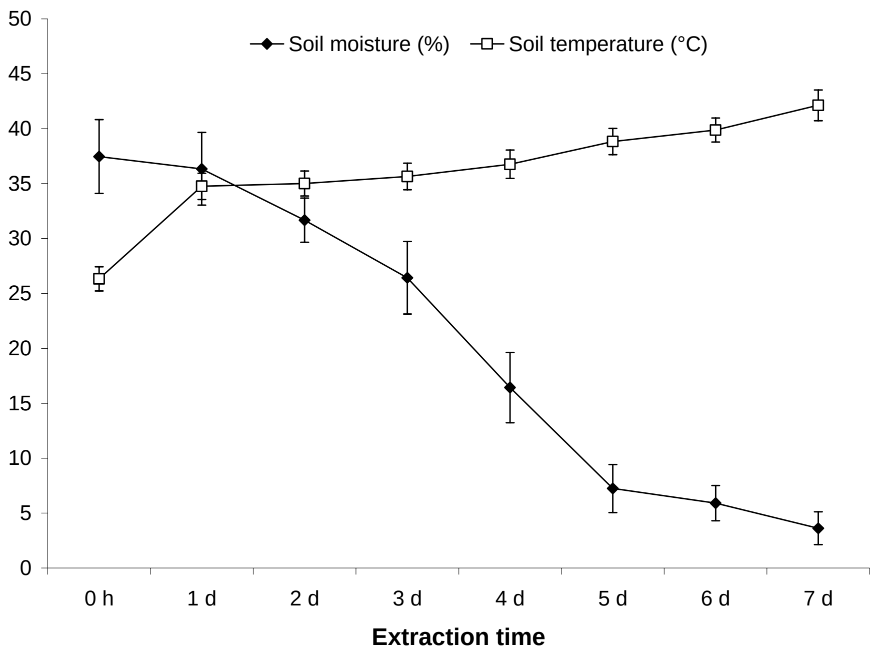


Figure 71 Temperature and moisture of soil samples change in Tullgren extractors following extraction time from 0 h (starting) up to 7 d. Points showed mean ± SD (N = 10).

Although, Winkler extractions showed insufficient data especially for species numbers comparing to Tullgren extraction in our study. Winkler extraction is still considered a good method for extracting macroarthropods in soil litter. Krell *et al.* (2005) recommended three days extraction by Winkler was sufficient to get 70% of the individuals and nearly all species of ants and also sufficient to recover the rank abundance order of beetle families.

Tullgren extraction showed suitable for community, diversity or functional studies of soil macro-arthropods which required both quantitative and qualitative data. Additionally, for taxonomic study, Tullgren extraction is a better method to get rare species than Winkler extraction method. Longino *et al*., (2002) reported that Berlese extraction (one type of Tullgren apparatus) is the most efficient method for soil-litter ant sampling it collects nearly or entirely absent species from all other collecting method, including Winkler extraction, and many of the unique species (those species found only one sample) were either manually excavated from soil were obtained in a Berlese (Tullgren) sample.

Both methods have theirs own advantages and disadvantages, Winkler extraction is a simple method which does not required any electricity in the extraction process itself, while Tullgren extraction is an easy applicable tool in the field station. Based on our study, we experienced that loading soil samples into funnel is much better in preventing escape of swift insects (*i.e.* ants, spiders, carabid beetles, etc.) than loading soil samples into Winkler mesh bags. The disadvantage of Tullgren extraction method is that it needs the source of electricity in extraction process which may not available in some areas.

However, Tullgren extraction is the most popular device for extracting soil micro-arthropods. In the period of 1993 – 1997, active methods (Berlese and Tullgren) had been used about 87%, high-gradient methods were nearly used 35%, flotation methods (passive method) were rarely used only 4% of study and other methods (including hand sorting and pitfall trapping) represented 22% of the methods used (André *et al*., 2002).

2. Survival time of macroarthropods and pselaphine beetles in the ventilation cloth bags.

There were slightly changes in temperature and moisture in soil samples during stored in the room. Temperature of soil samples had gradually drop from 28.32°C to 27.06° C at 12 hrs-storage time and soil moisture slightly reduced from 38.36% to 35.03% in the 24 hrs-storage samples. These little changes of microclimate had less effect to the larger arthropods such as ants, soil bugs, spiders and some beetles. These large arthropods are mostly predators and mobilized heavily in soil sample which provide chances for them to prey on other arthropods. Predation activity could be accounted for the reduction of number of arthropods extracted from cloth bag where they were kept in longer period of time.

In soil environment, many soil animals are predators which feed on other animals. Soil predators such as Arachanida, Chilopoda, ants, soil beetles and Hemiptera represent high proportion of soil arthropods (IBOY, 2000). In the samples, the soil assassin bugs were the high proportion of Hemiptera. Additionally, predacious beetles are a majority group of beetles in soil and litter. Chung *et al*., (2000) found that the beetle predators were the most species rich and abundant group, with representing more than 40% of soil beetles in forests in Sabah, Malaysia. In this study, soil sample were kept in a 30 x 40 cm cloth bag within limited area such a cloth bag, predation would occur easily. Thus, the results confirmed that keeping samples in longer time in cloth bags had some effect on animal survival.

Therefore, extraction is best conducted within 3 hrs for pselaphine beetles. There was a marginally significant difference in statistical analysis of the number of specimen extracted at 3 and 24 hrs (H = 7.5, P = 0.057, df = 3) but no significant difference on number of pselaphine species. However, significantly differences were found on the total number of pselaphine species extracted among the 5 sets of the Tullgren funnels at 3 hours (28 species) and 24 hours (20 species) (Table 4). In general, soil samples should be extracted fresh or as soon as possible after collecting in the field while the soil organisms still strongly mobilise and actively respond to the changes of heat and humidity inside the Tullgren extractors.

3. Spatial and seasonal diversity pattern of pselaphine beetles in eastern Thailand

3.1 General aspect

Most of the specimens of our collection were undescribed species and included some undescribed generic name. In the tropics, pselaphine beetles are one of the most diverse within which most species have not been formally described (Carlton 1999). In Thailand, less than 40 species have been recorded in this group, most of which were collected in Bangkok and nearby areas starting in the last century (Hlavac, 2002; Motschulsky, 1851; Raffray, 1904a, b; Schaufuss, 1877).

The list of collected species includes many unidentified taxa. Only 8% of the total distinguishable species was identifiable to the specific names. Taxonomic difficulties were most pervasive at the generic level within the supertribe Bythinoplectitae. Undescribed species and genera of this collection will be studied in the separate taxonomic works in the future with Coleoptera taxonomist.

3.2 Effects of habitat types and seasonal differences

Significant differences in species richness, abundance and diversity were found among forest habitats. Species richness, abundance and diversity value were several times higher in primary forests (MEF, PMDF and HEF) than in secondary forests or teak plantation (Figs 38-40). This is not surprising, as pselaphine beetles inhabit moist habitats under leaf litter (Chandler 2001). Secondary forest and teak plantation had relatively lower soil moisture and less leaf litter than primary forest, resulting in lower pselaphine beetle species, abundance and diversity.

There were no significant differences in species richness, abundance, diversity nor evenness between seasons. However, the effect of increased rainfall in the wet season increased soil moisture more markedly in degraded forests (SMDF and TP) than in undisturbed forests (MEF, PMDF and HEF). Thus, human disturbance increased moisture loss from previously forested areas. The severity of the dry season is regarded as the most significant factor determining a species ability to survive in a tropical forest (Whitmore, 1998), and the depressed species diversity in disturbed forests may very well result from this effect of increasing the severity of the dry season.

Species richness and diversity (*H*') clearly increased in secondary forest and teak plantations in the wet season (Figs 38, 40). Interestingly, secondary forest and teak plantation had higher values of the evenness index (*J*') than those in the primary forests. This indicates that natural forests have higher diversity, while disturbed forests are more spatially homogenous. Primary forests were home to a greater number of species, resulting in higher diversity value (*H*'), but a few dominant species, *i.e. Plagiophorus* sp. 1, *Harmophorus* sp. 1 and *Centrophthalmus* sp. 1, were all common in samples from PMDF, and its evenness index was therefore lower than those of SMDF and TP.

Many reports supported that species richness of vertebrate and invertebrate faunas are generally declined when increasing disturbance (Lawton *et al*., 1998; Jones *et al*., 2003; Harvey and Gonzalez 2006).

3.3. Community and indicator species of habitats

3.3.1 Beetle communities

The Sørensen's similarity index (*QS*) was 0.50 which is the highest index for MEF and PMDF, and the *QS* between MEF, HEF and HEF, PMDF both pairs were 0.31. The *QS* between SMDF and TP was 0.37 which higher than *QS* of primary forests and SMDF, or TP. These generally indicated that pselaphine communities of the primary forests were more closely than those in SMDF and TP. This is not surprising that the fauna is common between these two primary forests. Interestingly, the TP and SMDF were connected to primary forest at our sites, and each had fewer species and individuals, but species composition between SMDF and TP was found higher proportion of common species (*QS* = 0.37) than the other pairs between primary forests and disturbed forests.

The DCA and CCA emphasized the difference of species composition in SMDF and TP from those of the primary forest types. But, SMDF2 was located in the group of primary forest. This was due to the highly abundant of *Centrophthalmus* sp. 1 collected in the second sampling of SMDF plot. In fact, *Centrophthalmus* sp. 1 was the most abundant species collected and was analyzed as one of indicator species for PMDF, but it was rarely collected in SMDF, thus when the data (high numbers of *Centrophthalmus* sp. 1) was encountered in DCA analysis, the SMDF2 was then grouped in PMDF and MEF.

3.3.2 Indicator species of habitat

Indicator species have been defined as taxa that response to environmental changes and that reflect overall diversity and complexity of an assemblage (Samways 2005). Many beetle groups have often been used as indicator, *i.e.* dung beetles, ground beetles, and curculionid beetles (Goehring *et al*., 2002; Larsen and Work, 2003; Ødegaard, 2006). Except some pselaphine group's exhibit taxonomic difficulty, pselaphine beetles show many criteria for using as indicator species (New, 1998), *i.e.* they are well-known defined habitat (forest litter), respond to environmental changes, and can be easily accessible to sampling by Tullgren extraction.

In the data, pselaphine beetles responded to habitat change in a consistent manner. Species richness and abundance declined along forest disturbance gradient.

Notably, the highest numbers of indicators were found in MEF and followed by MEF and HEF. Teak plantation had only one indicator and SMDF was no indicator.

Pselaphine beetles are habitat specific; our study showed that only two of the 114 species were found in all habitats. Four species were found in seven habitats, forty-three species were found to be specific to two to three habitats, and 64 species found only one habitat. The higher indicator value (%) indicated the more important of indicator for habitat, *i.e.*, *Plagiophorus* sp. 1 with 83.3% indicator value was a potential indicator for MDF, *Mnia* sp. 1 with 89% value was a potential indicator for MEF.

3.3.3 Effects of environmental variables on pselaphine assemblages

The micro environmental variables were apparently less variable in secondary forest and teak plantation compared to the two primary forest sites. Leaf litter amount was most strongly correlated with species (r = 0.724) and abundance (r = 0.705) for all sites, and was also strongly correlated with species diversity and abundance in all plots in KARN and KSD and only litter amount affected beetle abundance (Table 11). Precipitation and soil moisture were correlated with species richness in KARN, but were not correlated with species richness in KSD. On the other hand, rainfall and soil moisture were not correlate with species richness in KSD. This was not surprising, as the sites in KARN which had less precipitation was more influence by the rainy season (Figure 72-74), but in KSD, higher rainfall year round increased humidity at KSD, accounting for the lack of correlation between species richness and season. Thus, the results indicate that the most important factors for pselaphine beetles are leaf litter and soil moisture.

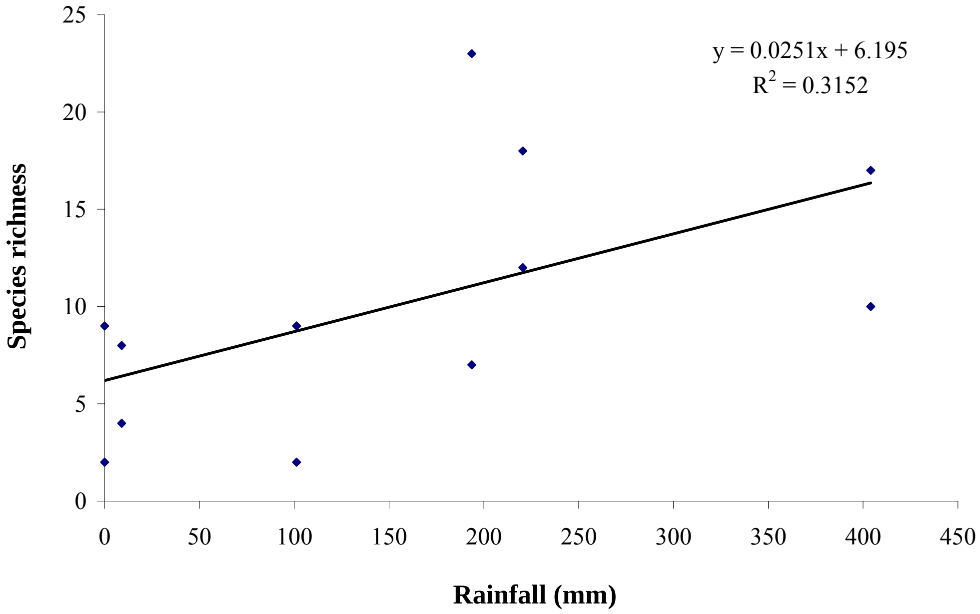


Figure 72 Relationship between rainfall and number of pselaphine species in KARN.

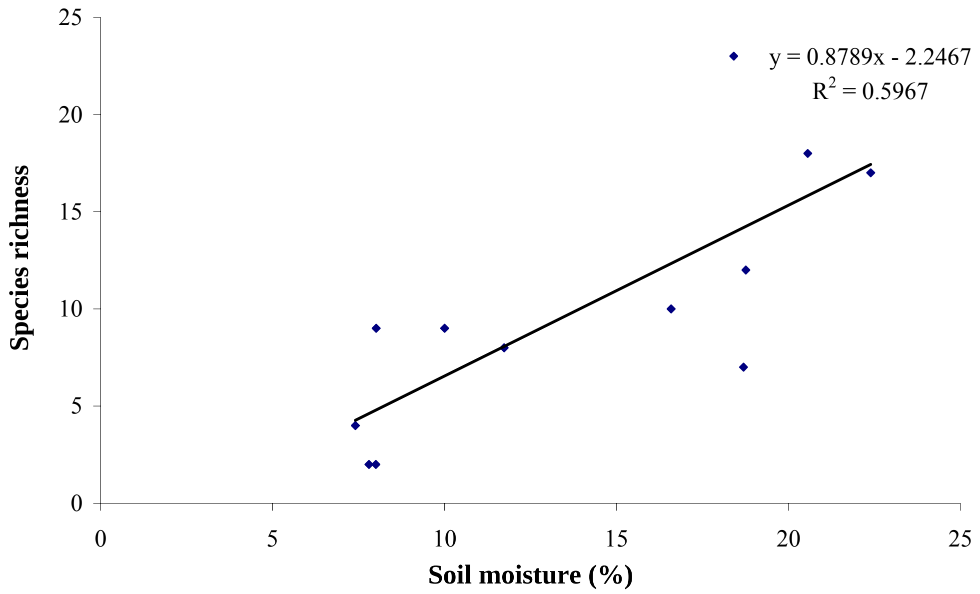


Figure 73 Relationship between soil moisture and number of pselaphine species in KARN.

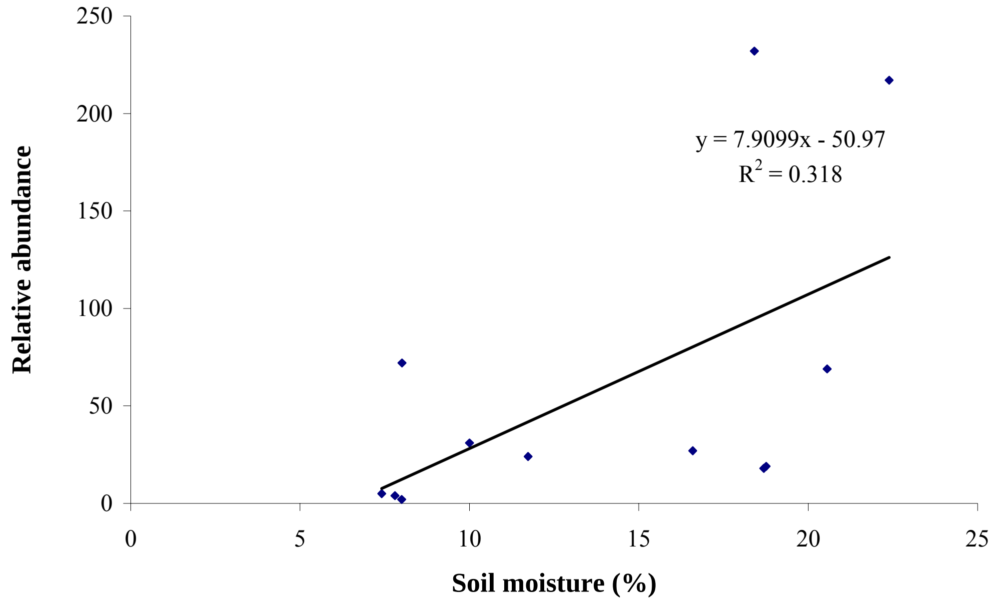


Figure 74 Relationship between soil moisture and relative abundance of pselaphine beetles in KARN.

The CCA emphasized the result of Pearson's correlation coefficient between species rich ness and abundance. However, there was a little difference on the result because of the data was summarized in different parameters and method. In Pearson's correlation, the analysis of the data was separately done by species and environmental variables and later abundance and environment variables. While species-abundance whole data set was used for analyzing together with all environmental variables. Therefore, in CCA the soil acidity (pH) was an important factor related to species-abundance of pselaphine assemblages.

Normally the environments in primary forests, degraded forest (SMDF), and monoculture plantation (TP) are qualitatively very different and thus potentially influence to pselaphine species richness, abundance and composition. In disturbed habitats, the trees are generally smaller with fewer species (Appendix Table 3) and less leaf litter falling. The land is more open, which decrease moisture and has less leaf litter. These important microclimatic factors caused the low diversity of soil dwelling animals. Primary forests (PMDF, MEF and HEF) provide a variety of microhabitats including a diversity of tree species, litter layers, moisture gradients, organic matter types and food to provide for the needs of living organisms. Ecosystem complexity is thus positively related to habitat diversity.

3.4 Diversity pattern between pselaphine beetles and soil dwelling ants

Species richness, abundance, and Shannon-Wiener's diversity index of ants and pselaphine beetles showed a significant response to habitat types. Both ant and pselaphine beetle diversity were significantly lower with increasing habitat disturbance as followed; MEF > PMDF > HEF > SMDF > TP.

The patterns of species richness and diversity of these two taxa drastically responded to habitat types as the data showed that primary forests (MEF, PMDF and HEF) hold the species numbers and Shannon-Wiener diversity index (*H*') higher than in SMDF and TP. Almost all parameters except Pielou's evenness index (*J*') showed strongly correlation in pooled data set (all seasons) and also found in separate data sets between dry and wet season.

Interestingly, there was habitat specific for pselaphine beetles as that found in evenness value which had higher index (*J*') in secondary forests and teak plantations than those in the primary forests. But in ants, there were no significant differences in evenness index among primary forests and degraded forests. This indicated that pselphine beetles are more spatially homogenous in degraded forests while ants seem to be more ubiquitous (Andersen, 2000).

Published studies on biodiversity indicators of different groups that covering a diverse spectrum of taxonomic groups across a similar land use gradient also reported a general trend of decreasing species richness with increasing habitat modification (Lawton *et al*., 1998; Schulze *et al*., 2004). However, there were no strongly pronounced relationships of the change in species richness among the eight different animal group surveys. This could be resulted from different taxa would respond to disturbance in different ways. Different groups such as birds, butterflies, dung beetles, ants, spider etc, they have different guilds and lives in spacious habitat, thus they would response to different degrees to habitat alteration. Though using different sampling methods they produced similar results.

On the other hand, in this study, there were positively significant correlation of most parameters between ants and pselaphine beetles (except Pielou's evenness index) and the Spearman's correlation coefficient (r) among parameters were high. These strong relationships between ants and pselaphine beetles in this study was due to the following reasons (1) both taxa have similar natural niches (factors necessary for species existence) (Molles, 2005) *i.e.* they have similar resource use (prey), similar habit (predator), and they live in similar microhabitat (soil and litter). (2) many pselaphine genera in several supertribes plus supertribe Clavigeritae are associated with social insects and ants (Chandler, 2001; Newton and Thayer, 1995), and (3) both insects were sampled with the same method and extraction was conducted the same technique.

Insects have been used as biodiversity indicator and monitoring of habitat change (Davis *et al*., 2001; Eggleton *et al*., 1997; Fermon, 2002; Halffter and Favila, 1993 and McGeoch *et al*., 2002) Among insects, ants and butterflies are the groups that have been used as biodiversity indicator. Andersen (1997) investigated the use of ant genera as predictor taxa, and proposed several large readily identifiable genera as biodiversity surrogates. For beetles, several subfamilies could have the potential to be a predictor taxa, though they tend to be occurring in only small abundances as this study. However, if they have specific habitat requirements, they could be used as indicator taxa, *i.e.* pselaphine beetles (Carlton, 1999), dung beetles, carabid beetles (Cole *et al*., 2005; McGeoch *et al*., 2002; Schulze *et al*., 2004).

3.5 General discussion

Significant differences in species richness, abundance and diversity of pselaphine beetles were found among forest habitats. Species richness, abundance and diversity value were found several times higher in primary forests (MEF, PMDF and HEF) than in disturbed forests or teak plantations. The indices estimated 138 species in all habitats of eastern forest complex of Thailand. In primary forests, estimated species were higher than those in degraded forests; for PMDF ranging from 56-99 (estimated) and 42 (observed) MEF: 79-112 (estimated) and 66 (observed), and HEF: 53-97 (estimated) and 42 (observed). While in degraded forests, the numbers of estimated species were lower; for SMDF ranging from 26-40 (estimated) and 23 (observed), and TP: 23-45 (estimated) and 21 (observed). This indicated that more pselaphine beetles live in the primary forest communities than those in degraded forest communities.

Many studies have shown that forest disturbance and fragmentation can cause decreasing or increasing of the abundance and diversity of arthropod species (Samways, 1994). The pattern of species decline in disturbed areas has been studied on several taxa (*i.e.* butterflies, ants, termites, beetles). A number of studies have examined the responses of butterfly communities to human disturbance (Ghazoul, 2002; Stork *et al*., 2003) Species richness generally declined with increasing disturbance, also appeared to other vertebrate and invertebrate faunas (Lawton *et al*., 1998), and soil fauna such as ants (Watt *et al*., 2002; Widodo *et al*., 2004), earthworm and termite. (Jones *et al*., 2003) This general trend of increasing disturbance resulted in decreasing arthropods fauna occur when forests are converted to other land uses (Jones *et al*., 2003).

Although some species were affected by disturbance, but there were others benefited from habitat alteration. For example, forest logging reduces biodiversity of certain insects, such as Collembola, ants and wasps, but it could increase diversity of other insects (Haneda, 2004), some find that butterfly diversity in intermediate disturbance is as high as undisturbed forests (Connell, 1978) and some find that arthropod diversity is higher in old forest plantation than semi-deciduous forest (Lachat *et al*., 2006). However, many authors reported that extreme disturbance usually cause a decrease in arthropod population (Abbot *et al*., 1999; Barbosa and Marquet, 2002; Jones *et al*., 2003; Stork *et al*., 2003). Effect of disturbance and fragmentation can be shown at the locality and species level (Tovar-Sanchez *et al*., 2003; Haneda, 2004).

Primary forests are the least disturbed habitats and they contain more varieties of microclimates for organisms. In this forest, the population of insects is equilibrium with the naturally abundant resources, and also supports higher diversity of vegetation in these forests with different structural characteristics of vegetations, Apart from the vegetation diversity, abundance and diversity of insects associated with a particular habitat are greatly influenced by the structural complexity in that particular habitat (Schulze *et al*., 2004; Lawton, 1983; Southwood, 1961).

Disturbance due to conversion of primary forests to secondary forest and plantation resulted in the environmental changes in the primary forests to deteriorated conditions, *i.e.* degraded forest (SMDF), and monoculture teak plantation (TP) which has qualitatively lower microenvironmental variables than primary forests. Thus could potentially influence on pselaphine species richness, abundance and composition. In disturbed forests, trees are generally smaller with fewer species and the mass of leaf litter is therefore less. The land is more open, which decreases moisture, less in leaf litter and more formation of crown gaps consequently allow more sunlight. These important microclimatic factors account for the lower diversity of soil dwelling animals in these perturbed habitats. Habitats (SMDF and TP) that have lower plant diversity, less leaf litter, low soil moisture and other microclimates could not provide enough niches for organisms to live and would effect the species richness, abundance and their composition.

Pselaphine beetle communities in the forest change with changes of their environment. These changes were evident in the forests at various types from primary forests to forest plantation. The composition of pselaphine beetles were found different between primary forest habitats and degraded forest habitats. Pselaphine beetles were different in their species richness, abundance, and composition. Factors affecting the changes of pselaphine beetles communities were forest structure, canopy cover, soil moisture and leaf litter. Soil moisture and leaf liter are the most important factors that showed significant relation to pselaphine beetle species richness and abundance among habitats.

Presence and absence of certain species in a habitat reflected the dynamics of those species and their reaction to the environment. The ability of insects respond to habitat disturbance depends on characteristics of species of a taxonomic group. Habitat disturbance has a greater effect on higher trophic levels, such as predators and parasitoids, than on their prey. Pselaphine beetles and soil dwelling ants have similar natural factors *i.e.* they have similar resource use (prey), have similar habit (predator), and live in similar microhabitat (litter). They response to change of habitats in the same manner and they proved to have strongly correlation response in similar to anthropogenic forest modification. Thus, both could be used as the tool to predict the changes in species richness and diversity pattern of each other.

Insects are like ants, dung beetles, termites and butterflies respond rapidly and drastically to changes in environmental conditions, make them potentially useful as bioindicators of forest habitat condition (Samways, 2005). In this study, pselaphine beetles appear to have certain habitat requirements. Many species were restricted to specific habitats, and their absence was strongly correlated with environmental differences. These traits make pselaphine beetles a suitable bioindicator taxon for assessing forest litter diversity and monitoring habitat change.

CONCLUSIONS

The first experiment on comparison of extraction devices for soil-litter macro-arthropods between Winkler and Tullgren methods suggested that Tullgren was a better device for qualitative extraction of soil samples, Tullgren extracted more species and specimens of all groups of soil arthropods including pselaphine beetles than those extracted with Winkler extraction. Thus, for a more complete species list inventory, ecological and taxonomic studies, Tullgren extraction method was considered to be the most effective one.

The study on the effect of storage times on the survival of soil organisms stored in cloth bags before extraction with Tullgren device indicated that the pselaphine samples stored for 3 hours gave more survival of macroarthropods including pselaphine beetles than those samples stored in longer periods (6, 12 and 24 hrs before extraction).

The third experiment provided more meaningful and gave a first overview of pselaphine beetle diversity study in the world and also provided the checklist of pselaphine genera and some species found in the eastern Thailand. Species richness, abundance, diversity index (*H*') and estimated indices were high in primary forests and low in secondary forest and teak plantation due to the low qualitative environmental variables which potentially influenced pselaphine beetle assemblages.

Species compositions were also different among forest types, and were grouped into three compositions; (1) primary forests which consisted of moist evergreen forest (MEF) and mixed deciduous forest (PMDF) tended to be similar to each other, (2) primary hill evergreen forest, and (3) degraded forests which consisted of secondary mixed deciduous forest (SMDF) and teak plantation (TP).

Microenvironmental variables apparently contributed to the changes in the beetle assemblages. The amount of leaf litter was correlated with the species richness, abundance and species composition of pselaphine beetle assemblages. Soil moisture, canopy cover and soil acidity (pH) were correlated with species richness and abundance.

Lastly, there were signs of ecological (habitat) diversity pattern among soil organisms as shown in data of pselaphine beetles and soil dwelling ants. The diversity pattern of one group could be used to predict the diversity of another group in the same habitat. Bearing in mind, the two organisms must be closely correlated, *i.e.* having similar resource use (preys), have similar habit (predator), and living in similar microhabitat (litter, canopy etc.).

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APPENDICES

Appendix A Unpublished identification guide on subfamilies Protopselaphinae and Pselaphinae of Asia (Staphylinidae:Protopselaphinae; Pselaphinae), Provided by Nomura (2006).

1. Elytra short; tarsi each 3- or 2-segmented; abdominal segments IV to VIII exposed; sternite VIII with diffence gland at basimedian part…………………..2

– Elytra long, covering abdominal segments IV to VIII; tarsi each 4- to 5-segmented; sternite VIII without diffence gland at basimedian part ……………… …………………………………………… not pselaphine nor protopselaphine.

2. Abdomen elongate and movable among segments, acuminate toward apex; elytron about twice as long as wide, without basal fovea; pretarsi each with symmetrical tarsal claws and a pair of parungeal setae …………………………..... ……..……. ***Protopselaphus*** **NEWTON & THAYER** (Subfam. Protopselaphinae)

– Abdomen elongate or shortened, never flexible among segments, rounded at apex in many cases; elytron less than twice as long as wide, with basal foveae in general; pretarsi with more or less reduced parungeal seta ... Subfam. Pselaphinae

A Simplified Key to Supertribes from Asia

Subfamily PSELAPHINAE

1. Tarsi each seemingly 2-segmented ………………...Supertribe Bythinoplectitae
– Tarsi each apparently 3-segmented …………………………………………..2
2. Mid and hind trochanters each elongate, thickened distally; mid and hind femora each distant from coxae at base ………………………. 3 (Division Macroscelia)
– Mid and hind trochanters each short; mid and hind femora each closed to coxae at base …………………………………………………4 (Division Brachyscelia)
3. Antennae normal in general, 11 –segmented; abdomen normal; tarsal segment II long ……………………………………….…………. Supertribe Pselaphitae
– Antennae each much thickened, reduced in number of segments from 6 to 2; abdomen with very large composite tergum formed by tergites III to VI; tarsal segment II short in many cases ……………………... Supertribe Clavigeritae
4. Tarsi each composed of short segments I and II, and large III; tarsal claws paired, symmetrical……………………………………….………… [Supertribe Faronitae]
– Tarsi each composed of short segment I, and large II and III, tarsal claw (s) asymmetrical or single ……………………….. 5
5. Hind coxae contiguous ………………………………... Supertribe Euplectitae
– Hind coxae clearly separated from each other…..…………………………….. 6
6. Antennal segment I subcylindrical, more or less projected at the external side of the apex, male genitalia with indistinct or atrophied parameres………………… ………………………………………………………Supertribe Batrisitae
– Antennal segment I without projection at the external side of the apex, male genitalia with a pair of complete parameres in general ..... Supertribe Goniaceritae

Supertribe BYTHINOPLECTITAE

1. Cranium with a pair of large palpal cavities in anterolateral parts; maxillary palpi contractive …………………………………………. (Tribe Bythinoplectini) 2
– Cranium without palpal cavity; maxillary palpi normal, uncontractive ………..3
2. Cranium with palpal cavities open anteriorly on the anterior side of head ………. ……………………………………………..………… Subtribe Pyxidicerina
– Cranium with palpal cavities open laterally on the anterolateral side of head……. ……………………………………………………… Subtribe Bythinoplectina
3. Body very small, less than 1 mm ; eyes absent; antennae with distinct club, segments II to VIII irregular in length ………………..………………………. …………………………………… *Mayetia* MULSANT et RAY (Tribe Mayetiini)
– Body small or large; eyes developed; antennae with or without distinct club, segments II to VIII normal ……………………………………… Tribe Dimerini

Tribe Bythinoplectini, Subtribe Pyxidicerina

1. Antennae each 7 –segmented ……….*Neopyxidicerus* COULON [Malay Peninsula]
– Antennae each 10-segmented or more ………………………………………….. 2
2. Antennae each 10 –segmented ……………………….…….*Pyxidicerinus* JEANNEL
– Antennae each 11-segmented; each elytron with three basal foveae, inner 2 foveae sometimes fused to each other…………………….…………..………. 3
3. Each elytron with nearly entire marginal carina ….*Pyxidicerus* MOTSCHULSKY
– Each elytron with reduced marginal carina in posterior part …………………… ………………………………...……… *Parapyxidicerus* K. SAWADA [Japan]

Tribe Bythinoplectini, Subtribe Bythinoplectina

1. Palpal segments III and IV each projected externally, with semispherical expansion at apex of the projection ……..……………………….……………. 2
– Palpal segment III not projected externally, without expansion, IV more or less constricted near the middle, with large and semispherical expansion demarcated

by carina on external side …………………………………………………….. 5

2. Antennae each 8 –segmented; head and pronotum coarsely punctate; each elytron with a short marginal carina in posterior part..*Euplectomorphus* MOTSCHULSKY

– Antennae each 10-segmented ………………………………………………… 3

3. Head not longitudinally striate on ventral side; male genitalia complicated …….. …………………………………...……… *Nipponozethus* COULON [Japan]

– Head longitudinally striate on ventral side; male genitalia various in shape …… 4

4. Body thick and broad; abdominal segments IV to VI each with a pair of long basimedian carinae almost reaching posterior margin ... *Pachyzethopsus* JEANNEL

– Body relatively narrow; abdominal tergites IV to VI each without or with very short basimedian carinae ……………………………… *Neozethopsus* JEANNEL

5. Antennae each 9–segmented, segment III strongly swollen in male ……………. ……………………………………………...……… *Bolbozethus* COULON

– Antennae each 10-segmented or more, segment III normal in male …………. 6

6. Antennae each 10–segmented; maxillary palpi short and compact …………… 7

– Antennae each 11-segmented, segments X and XI very thick and clearly separated from each other, forming distinct club; maxillary palpi very large and elongate, segment III elongate and nearly fusiform ……… *Proboscites* JEANNEL

7. Dorsal tentorial pits each located between base of frontal lobe and basal margin of palpal cavity …………………..………… *Rhinozethus* COULON [Myanmar]

– Dorsal tentorial pits located at base of frontal lobe, distant from basal margin of palpal cavity ………………………………..…..……… *Zethopsus* REITTER

Tribe Dimerini

1. Body short and thick, covered with coarse punctures in head and pronotum; antennae Short, thick, with distinct club formed by segments IX to XI; head with well projected antennal tubercle; frons with large, round median fovea ………… ……………………………………………...……… *Tub*eroplectus PARK

– Body very elongate and slender, covered with minute punctures in head and pronotum; antennae long and slender, with indistinct club; head with indistinct antennal tubercle ……………………………………………....……… 2

4. Head with a short median longitudinal sulcus from posterior end of frontal depression to middle of vertex ……………… (Gen. *Octomicrus* SCHAUFUSS) 3

– Head without median longitudinal sulcus ………………………………………. 4

5. Body convex; male genitalia thick, with broad basal sclerites …………………….
………………………………………………….. Subgen. *Octomicrus* s. str.

– Body narrow, flattened; male genitalia narrowed, with slender, pedonculate basal sclerites ……………………………………………… Subgen. Dimerus FIORI

6. Head with a large transverse sulcus just behind eyes on dorsal side and dorsally convex, laterally projected posterior lobe behind transverse sulcus ……...………
……………………………………………...……… *Octomicrites* JEANNEL

– Head without large transverse sulcus behind eyes; frons with or without an arcuate sulcus connecting dorsal tentorial pits ………………………………… 5

5. Body small (less than 1 mm in length); frons with an arcuate sulcus connecting dorsal tentorial pits; pronotum longer than wide, with a shallow transverse depression and a pair of median and a pair of lateral foveae at basal 1/3; elytra each with highly reduced outer basal fovea ………… *Microctomicrus* NOMURA

– Body large (more than 1 mm in length); frons without arcuate sulcus connecting dorsal tentorial pits; pronotum about as long as wide, with a longitudinal depression and a pair of lateral foveae; elytra each with normal outer basal fovea..
……………………………………………………….. *Octomicrus* JEANNEL

Supertribe EUPLECTITAE

1. Pronotum with (*Euplectus*) or without antebasal sulcus, often with a pair of lateral denticles behind antebasal foveae on lateral margins; elytra each with indistinct or very short discal stria; abdominal tergite IV longest in many cases (VII largest in *Euplectus*); male abdominal segment IX consisting of subequal paired sclerites …………………………………………………..……………. Tribe Euplectini
– Pronotum usually with antebasal sulcus, without lateral denticle behind antebasal foveae on lateral margins in general; elytra each with distinct and nearly complete discal stria; abdominal segments IV to VII subequal in length; male abdominal segment IX consisting of a large and ovoid median and a pair of small lateral sclerites ….………………………………………………. 2 (Tribe Trichonychini)
2. Pronotum without antebasal sulcus and median antebasal fovea; elytra each with 0-2 basal fovea(e) ……………………… Subtribe Bibloporina (=Bibloporellina)
– Pronotum with distinct antebasal sulcus and median antebasal fovea in general; if antebasal sulcus and median antebasal fovea of pronotum indistinct, elytra each with 3-4 basal foveae …………………………………………………………… 3
3. Antennal club formed by only segment XI ……..…………… Subtribe Trimiina
– Antennal club not formed only segment XI ……………………………………4
4. Mesocoxae separated from each other by posterior projection of mesosternum … …………………………… Subtribe Panaphantina (= Acetaliina, Bibloplectina)
– Mesocoxae not separated from each other by posterior projection of mesosternum ………………………………… [Subtribe Trichonychina, Neotropical Australian (= Pteracmini, Raffrayina, Chrestomerina, Trimiodytina)]

Position undeterminable:

Glastus RAFFRAY [Singapore]

Mirellus RAFFRAY [Singapore]

Sampsa RAFFRAY [Sumatra]

Microplectus RAFFRAY [Singapore; New Guinea]

Epiplectus RAFFRAY [Singapore, Burma]

Tribe Euplectini

1. Elytra each with 3 to 4 basal foveae, inner 2 foveae sometimes fused ………… 2
– Elytra each with 2 basal foveae ……………………………………………… 5
2. Frons with distinct transverse sulcus; vertex sometimes with postero-median fovea; labrum normal, without deep emargination on anterior margin………… 3
– Frons with distinct or indistinct transverse sulcus; vertex without posteromedian fovea; labrum with deep emargination on anterior margin…………………… 4
3. Body small (ca. 1 mm); antennae distinctly thickened distad; male genitalia with an elongate dorsal apophysis and basal strut like Batrisocenus group (Batrisitae) ……………………………………………*Forinus* KURBATOV [Far East Russia]
– Body small to large; antennae feebly thickened distad in general; male genitalia with an ovoid or subglobose basal bulb and complicated and apically broadened sclerite like other euplectine genera ……………….…………*Euplectus* LEACH
4. Labrum bilobed, with deep emargination on anterior margin; prosternum without median fovea; abdominal tergites IV and V without longitudinal carinae ………. …………………………*Leptoplectus* CASEY (= Grammoplectus) [Palearctic]
– Labrum trilobed, with a pair of deep arcuate emarginations on anterior margin; prosternum with a pair of median foveae just before fore coxae; abdominal tergite IV and V with a pair of longitudinal carinae ……………………….………………… ……………………………………………..*Labroplectus* KURBATOV [Kuril Isls.]
5. Abdominal tergite IV with a pair of longitudinal carinae, VII about as long as VI; antennal club about as wide as funicle ………. *Meliceria* RAFFRAY [Palearctic]
– Abdominal tergite IV without carina, VII usually longer than VI; antennal club thickened ………………………………….. *Plectophloeus* REITTER [Palearctic]

Tribe Trichonychini, Subtribe Panaphantina

1. Antennal segment XI predominantly large, conical in apical part, cylindrical in basal part, with a circle of spatulate setae between apical and basal parts, pronotum with 4 shallow depressions near base ……………………………… 2
– Antennal segment XI normal, without a circle of spatulate setae near the middle; pronotum usually with antebasal sulcus connecting a pair of lateral foveae and a basimedian fovea or depression ………………….……………………………. 3
2. Abdominal segment IV fused dorso-ventrally, with 2 to 3 pairs of basilateral carinae, without paratergite …………………………… *Acetalius* SHARP [Japan]
– Abdominal segment IV with a pair of narrow paratergites ………………………. …………………………………………………… *Philoscotus* K. SAWADA
3. Abdominal tergite IV distinctly longer than V; head narrower than pronotum, antennae short, pronotum without longitudinal sulcus ………………………. 4
– Abdominal tergite IV about as long as V ..…………………………….……….6
4. Pronotum with indistinct median sulcus or longitudinal depression ……………… ……………………………………………….………… *Philiopsis* RAFFRAY
– Pronotum with distinct median sulcus ..………………………….….……….5
5. Elytra each with 4 distinct basal fovea and 4 distinct longitudinal discal sulci ….. ………………………………………*Tiliactus* KURBATOV [Far East Russia]
– Elytra with 2 basal foveae and indistinct and short discal sulcus ………………… ……………………………………………….……… *Euplectodina* RAFFRAY
6. Abdominal tergite VII distinctly shorter than VI …………………………….. 7.
– Abdominal tergite VII about as long as VI …………………………………… 8.
7. Head distinctly transverse, strongly depressed dorso-laterad …………………… …………………………………………… *Euplectina* RAFFRAY [Singapore]
– Head as long as wide or slightly wider than long, normally convex on dorsal surface in many cases ………………………………….. *Pseudoplectus* REITTER
8. Antennal club formed by segments VII to XI .....*Methorius* RAFFRAY [Vietnam]
– Antennal club formed by segments IX to XI ………………………………….. 9
9. Pronotum without median longitudinal sulcus nor depression, uniformly convex in median part; abdominal segments IV to VI without depression nor carina ……

……………………………………… *Ramussia* KURBATOV [Far East Russia]

– Pronotum more or less depressed or sulcate in median part; abdominal segment IV to VI with or without depressions or carinae ……………………………… 10

10. Abdominal segment IV to VI each with a basimedian depression ……………… ……………………………… *Thesiastes* CASEY [Malay Peninsula, N-America]

– Abdominal segment IV to VI without basimedian depression ……………….. 11

11. Elytra broad, each with 4 basal foveae, but outer 2 and inner 2 each contiguous; pronotum with indistinct antebasal sulcus; abdominal segment IV with a pair of brushes at posterolateral corners …….. *Piptoncus* KURBATOV [Far East Russia]

– Elytra narrowed, slightly wider than head and pronotum, each with 3 to 4 basal foveae distant from each other; pronotum with distinct antebasal sulcus; abdominal segment IV normal ………………………… *Bibloplectus* REITTER

Tribe Trichonychini, Subtribe Bibloporina

1. Prosternum with a median carina, elytra each with 3 basal foveae; head narrower than pronotum, short, transverse and narrowed anteriorly, pronotum with three shallow longitudinal depressions ……………………………………………… 2

– Prosternum without median carina, elytra each with 2 basal foveae or without fovea; body elongate and nearly cylindrical, head not transverse in general; pronotum with or without depression or fovea ………………………………… 3

2. Body very small (less than 1 mm); elytra with 4 basal foveae, outer 2 and inner 2 foveae each contiguous; mid tibiae each with a spine near apex; male genitalia with large dorsal apophysis and a pair of asymmetrical parameres ……………… ……………………………………….… *Kuriporus* KURBATOV [Kuril Isls.]

– Body small to large (more than 1 mm in general); elytra with 3 basal foveae distant from each other; mid tibiae each with a large denticle on inner side near the middle; male genitalia with a pair of asymmetrical parameres and endophallus …………………………………….……………….. *Biblоporus* THOMSON

3. Pronotum with a pair of lateral and a median longitudinal sulci; elytra each with a humeral and 3 basal foveae …….. *Apoterus* RAFFRAY [Singapore; New Guinea]

– Pronotum without carina, sulci or depression; elytra without or with 2 basal foveae ……………………………..……………………………………… 4

4. Elytra strongly narrowed basad, without basal fovea; abdominal segment IV conspicuously larger than the rest segments conjoined …….……………………... …………………………………… *Aphilia* REITTER (= *Pseudozibus* JEANNEL)

– Elytra narrowed basally, each with 2 basal foveae; abdominal segment IV about as long as the rest segments conjoined …….. *Philotrimium* BLATTN_[Myanmar]

Tribe Trichonychini, Subtribe Trimiina

1. Antennae each 10-segmented, segment IX large, extending internally; body short and compact ……………………………………………. *Prophilus* RAFFRAY

– Antennae each 11-segmented; body elongate ……………………………….. 2

2. Abdominal segment IV apparently longer than V ………………………………. 3

– Abdominal segments IV and V subequal in length ………………………………4

3. Head broad and truncate anteriorly, more or less flattened on dorsal surface; antennal segment X distinctly larger than IX, asymmetrical …………………… …………………………………………………….……… [*Trimium* AUBÉ, Europe]

– Head narrowed anteriorly, convex on dorsal surface; antennal segment IX symmetrical or asymmetrical, pronotum with a pair of short, shallow and transverse depressions on antebasal part ………………… *Saulcyella* REITTER

4. Body elongate and cylindrical; pronotum with a pair of indistinct longitudinal depressions; elytra narrowed basally, with 2 basal foveae ………..………………. ……………………………………… *Trimiomorphus* RAFFRAY [Singapore]

– Body short, subparallel-sided; pronotum with a pair of lateral foveae; elytra expanded in humeri, each with 3 basal foveae ………..…………………….…… ……………………………………..…… *Amudrocerus* RAFFRAY [Singapore]

Supertribe BATRISITAE

1. Abdominal tergite IV not carinated on basilateral sides, with indistinct or rudimentary paratergites; body short, thick and stout, antennae short and thick, moniliform: palpal segment IV pedonculate in some cases ……………………..
…………………………………… Undescribed genus BA1 [Subtribe Stilipalpina]
– Abdominal segment IV more or less carinated on basilateral sides; body and antennae various in shape ……..…………………….…… 2 (Subtribe Batrisina)
2. Elytra each with two basal foveae; pronotum with a well demarcated transverse sulcus near basal 1/3; male genitalia asymmetrical, median lobe with articulated dorsal apophysis ………………………………….. Genus group of *Batrisocenus*
– Elytra each with three basal foveae in general; pronotum without well demarcated transverse sulcus; male genitalia symmetrical or asymmetrical …………… 3
3. Pronutum with a pair of denticles on both lateral sides in general; hind trochanters each with a short spine on posterior side in male in general; male genitalia asymmetrical, median lobe with an articulated dorsal apophysis ……………….
…………………………………………………… Genus group of *Tribasodes*
– Pronotum without lateral denticle; hind trochanters without spine in male; male genitalia symmetrical or asymmetrical, median lobe without articulated dorsal apophysis ………………………………………………………………… 4
4. Abdominal tergite IV with a pair of triangular paratergites each demarcated by narrow and oblique carina internally; male genitalia symmetrical or asymmetrical in part ……………………………………………….. Genus group of *Batrisus*
– Abdominal tergite IV with a pair of indistinct paratergites; male genitalia asymmetrical …………………………. Genus group of *Sathytes* (incertae sedis)

Tribe Batrisini, Subtribe Batrisina

The Genus Group of *Batrisus*

1. Antennal segment XI with a small denticle on ventral side near base in male; mid femora each with spine or denticle on posterior side in usual in male ………… 2
– Antennal segment XI without denticle near base in male; mid femora each with or …………………………… Genus group of *Sathytes* (incertae sedis)
without spine or denticle on posterior side in male ……………… …………… 6
2. Body very large and stout; head bulbous, vertex strongly convex; antennae thick, segments II to X each subspherical …………………………………………. 3
– Body not very large; head more or less flattened on dorsal side; antennae slender, segments II to X each longer than wide, ovoid or subcylindrical ……………… 4
3. Body very smooth and shiny, almost glabrous in head, pronotum and elytra ……. ………………………………………………… *Batristilbus* RAFFRAY [Japan]
– Body more or less punctuate, blunt on dorsal surface …………………………… …………………………………………………… Batrisus AUBẺ [Palearctic]
4. Head and pronotum densely covered with coarse punctures …………………… ……………………………… *Speobatrisodes* JEANNEL [Japan, cavernicolous]
– Head and pronotum moderately covered with punctures …………………….. 5
5. Tibiae stout; hind tibiae each with sexual patch of aeneous setae on inner side near apex in male ………………………………. *Kigatrodes* JEANNEL [Japan]
– Tibia slender; hind tibiae without sexual patch, but a group of aeneous setae on inner side near apex in both sexes ……………………… *Batrisodellus* JEANNEL
6. Frons with a pair of strongly projected antennal tubercle in male; antennal segment I with a large inner projection in apical part in male …………………… ……………………………………………… *Petaloscapus* JEANNEL [Japan]
– Frons with weakly expanded antennal tubercle or indistinct in male; antennal segment I without inner projection in many species ……………………………. 7
7. Frons with a well projected horn at middle of fronto-clypeal ridge and with a pair of pencils beneath antennal base in male; median lobe of male genitalia angulate, with large quadrangular basal foramen, apically broadened right and slender left

processes ………………………………… *Basitrodes* JEANNEL [Japan, Korea?]

– Frons with or without horn in male, without pencils beneath antennal base in male; male genitalia nearly symmetrical, sclerites of median lobe reduced to quadrangular frame and a middle horizontal bar ……… 8 (Batrisodes REITTER)

8. Hind tibiae without long spine at apex ……………. Subgenus *Batrisodes* s.str.

– Hind tibiae each with a long spine at apex …………………………………… 9

9. Antennal club swollen or modified in male ……………………………………10

– Antennal club without modification in male ………………………………….. 11

10. Frons with strongly projected antennal tubercles separated by a deep, smooth median depression ……………… Subgenus Batrisodinus JEANNEL [Palearctic]

– Frons with weakly expanded antennal tubercles, with sexual modification at Anteromedian part in male ………………. Subgenus *Excavodes* PARK [Japan]

11. Antennal segment X swollen, subspherical ……………………………………… ………………………………………….. Subgenus *Pubimodes* PARK [Japan]

– Antennal club with asymmetrical, denticulate segments in male ……………….. ………………………………….. Subgenus *Babnormodes* PARK [East America]

The Genus Group of *Batrisus*

1. Pronotum without spine angulate projection or distinct extension on lateral margins near the middle ……………..……………………………………… 2

– Pronotum with a pair of well projected spines, angulate projections or strong extensions on lateral margins near the middle …….…………………………… 6

2. Elytra without or each with a basal fovea ……………………………………… 3

– Elytra each with 3 basal foveae ……………………………………………… 5

3. Body very smooth, relatively small …………………………………………… 4

– Body very large, coarsely punctuate on dorsal surface; head with very large and deep excavation in male ……………………… *Megabatrus* LÖBL [SE-China]

4. Body large; elytra each with a basal fovea near suture …………………………… …………………………………… *Batristilbus concolor* group [Japan, China]

– Body relatively small; elytra without basal fovea ……………………………….

……………………………………………. Undescribed Genus BA2 [Japan]

5. Pronotum subspherical, with 5 to 6 deep longitudinal sulci; head narrowed in posterior part, flattened and sinuate on dorsal surface …………………………… …………………………………………. *Batrisodes*? *quinquesulcatus* group

– Pronotum constricted near the base, broadened in anterior part, with 4 to 5 longitudinal sulci; head normal ……………………… *Batriplica* RAFFRAY

6. Abdominal tergite IV with complete paratergites; each paratergite quadrangular, nearly parallel-sided ………………………………………………………….. 7

– Abdominal tergite IV without articulated paratergites, but with a pair of small triangular plates demarcated by oblique carinae in its lateral parts …………. 13

7. Body elongate and nearly parallel-sided, paratergites of abdominal tergite IV each Demarcated by narrow sulcus or membranous part on its mesal margin ………… ……………………………………………………… *Batrisoschema* REITTER

– Body broadened in posterior part ………………………………………………. 8

8. Pronotum with 5 longitudinal sulci; head transverse, postgenae rounded; palpal segment IV ovoid, acuminate toward apex ……………… *Batrisodema* RAFFRAY

– Pronotum with a sulcus or 2 or 3 longitudinal sulci …………………………… 9

9. Pronotum with 3 longitudinal sulci, with a very strong and acute lateral spines near the middle; frons convex, with a circle of sulcus and a median longitudinal sulcus just before dorsal tentorial pits ……………….. *Hypochraeus* RAFFRAY

– Pronotum with a sulcus or 2 longitudinal sulci ……………………………… 10

10. Pronotum with a longitudinal sulcus; head longer than wide, nearly triangular; body coarsely punctuate ……………………………….. *Batrisoplatus* RAFFRAY

– Pronotum with 2 longitudinal sulcus …………………….…………………… 11

11. Head slightly longer than wide, body very coarsely punctuate, covered with long and bold setae ………………………………………. *Triconomorphus* RAFFRAY

– Head distinctly transverse ………….………..………….……………………… 12

12. Postgenae strongly expanded postero-laterally, flattened on dorsal surface; pronotum bold setae …………………………………. *Triconomorphus* RAFFRAY with a pair of strong spines in basilateral parts ……………………….. ………………………………………….. *Ceroderma* RAFFRAY [Malaysia]

– Postgenae rounded; pronotum without spine, sparsely covered with coarse punctures in central part …………………………………….. *Diaugis* RAFFRAY

13. Abdominal tergites V to VII each with a pair of triangular plate on both laterals sides; body elongate, subparallel-sided ………………….. *Nenemeca* RAFFRAY

– Abdominal tergites V to VII without or with indistinctly demarcate lateral plates ……………………………………………………………………………… 14

14. Pronotum smooth on dorsal surface, with median longitudinal sulcus and a pair of lateral sulci or depressions at most …………………………………………… 15

– Pronotum rough on dorsal surface, with 5 to 6 longitudinal sulci and 1 or 2 pair(s) of spines or crochets ………………………………………………….………… 18

15. Pronotum strongly extended anterolaterad, distinctly wider than head; body large, distinctly flattened ………………………….. *Hingstoniella* JEANNEL [Tibet]

– Pronotum less extended anterolaterad; about as wide as head; body middle-sized, cylindrical ……………………………………………………………….. 16

16. Eyes very large; abdominal sternite IV rounded on both lateral sides, with a pair of narrow and well carinated triangular plates, a broad basimedian depression and a short median longitudinal carina ……………………… *Oxyomera* RAFFRAY

– Eyes small; abdominal sternite IV subparallel-sided, with a pair of very small triangular plates, smooth and weakly convex in median part … *Amana* RAFFRAY

17. Body robust and broad, inner 2 basal foveae of each elytron fused to form a large fovea ……………………………………………… *Coryphomodes* JEANNEL

– Body elongate and nearly parallel-sided in many cases, inner 2 basal foveae of each elytron completely separated …………………………………………… 17

18. Abdominal segment IV strongly concave near base; frons and antennae without sexual character in male ………………………………… *Tribasodes* JEANNEL

– Abdominal segment IV scarcely concave near base; frons or antennae with sexual character(s) in male ……………………………………… *Tribasodes* JEANNEL

Position undeterminable:

Batrisophyma RAFFRAY

The Genus Group of *Batrisocenus*

1. Fourth abdominal tergite with a pair of triangular plates in its lateral parts as in *Coryphomodes*, etc.; antennae usually with sexual modification in male ……… 2
– Fourth abdominal segment cylindrical, without triangular plate …………….. 10
2. Pronotum with longitudinal sulci or carina between median and lateral longitudinal sulci ………………………………………………………………… 3
– Pronotum without longitudinal sulcus nor carina between median and lateral longitudinal sulci, but sparsely covered with coarse punctures in this area; antennal segment VII strongly swollen in male …………….. *Trisinus* RAFFRAY
3. Pronotum with a pair of short and indistinct longitudinal carinae and coarse punctures between median and lateral longitudinal sulci ………………………… ………………………………………………………… *Batrisoplisus* RAFFRAY
– Pronotum with two pairs of longitudinal sulci between median and lateral longitudinal sulci …………………………. *Batrisocenus septemstriatus* group
4. Antennal segment I with a conical trichome formed by semihyaline setae at external apex ………………………………………………………………….. 5
– Antennal segment I without conical trichome ………………………………… 9
5. Abdominal tergite IV with sexual patch consisting of large concavity, fringe, filament, setiferous or acinous patches in male …………………………………… ……………………………… *Batrisiella* RAFFRAY (= *Arthromelus* JEANNEL?)
– Abdominal tergite IV without sexual patch in male; sexual patch present on abdominal segments V, IV, VII or hind femora …… 6 (*Batriscenellus* JEANNEL)
6. Hind femora each strongly thickened in distal part, with scaly setiferous setae on the thickened part in male ………………. Subgenus *Batriscenellinus* NOMURA
– Hind femora scarcely thickened in distal part in male, without setiferous seta; Abdominal tergite IV modified, with setiferous setae in male ………………….. 7
7. Abdominal tergite V without setiferous patch nor fringe on posterior margin …. ………………………………………… Subgenus *Nipponoscenellus* NOMURA
– Abdominal tergite V with setiferous patch or fringe on posterior margin ……… 8
8. Metasternum with a pair of small patches of bold setae in postero-median part; abdominal tergite V with setiferous patch …………………………………..

……………………………………………. Subgenus *Scaioscenellus* JEANNEL

– Metasternum without setiferous patch in postero-median part; abdominal tergite V with distinct fringe on postero-median margin.. Subgenus *Batriscenellus* s. str.

9. Antennal segment I strongly projected or expanded antero-laterad to be asymmetrical ………………………………………………………………….. 10

– Antennal segment I scarcely projected or expanded antero-laterad, symmetrically subcylindrical in apical part …………………………………………………. 12

10. Antennal segment I strongly projected antero-laterad ………………………. 11

– Antennal segment roundly expanded antero-laterad, with a very small pore at apex; body large, abdomen broadened and thick ……... Undescribed genus BA3

11. Antennal segment I with very small spine near apex of antero-lateral projection; body middle-sized; maxillary palpi short; hind femora each thickened near apex in male ……………………………………… *Babascenellus* NOMURA [Japan]

– Antennal segment I with very small pore at apex of antero-lateral projection; body large; maxillary palpi each very elongate and geniculate; hind femora equally thickened in both sexes ……………………………… *Cratna* RAFFRAY

12. Head and pronotum strongly narrowed; eyes very small; postgenae very large and rounded, densely covered with long and erect hairs … Undescribed genus BA4

– Head and pronotum normally narrowed; eyes developed; postgenae narrow, without long and erect hair …………………………………………………… 13

13. Male genitalia strongly transformed to bifurcate sclerite and internal sac (?) with at apex, without basal bulb; abdominal tergite IV with sexual patch in male crochet ………………………………………………… *Batriscenites* JEANNEL

– Male genitalia normal, median lobe with basal bulb …………………………. 14

14. Basal bulb of male genitalia constricted near the middle, hind tibiae thickened near apex, with sexual modification in male …………. *Batriscenodes* JEANNEL

– Basal bulb of male genitalia not constricted near the middle; hind tibiae slender and without sexual modification in male……………………………………… 15

15. Male genitalia eith more or less narrowed basal bulb of median lobe and elongate and simple dorsal apophysis ………………………………………………… 16

– Male genitalia with large and thickened basal bulb of median lobe and complicated or twisted dorsal apophysis ……………………………………… 19

16. Pronotum with indistinct or completely atrophied median longitudinal sulcus; apical 3 to 5 segments of antennae thickened in male .... *Trisiniotus* JEANNEL

– Pronotum with distinct median longitudinal sulcus; antennae normal in both sexes 17

17. Dorsal apophysis of male genitalia shorter than basal strut, weakly twisted but nearly straight; fore tibiae each with a pencil in male; abdominal tergite IV with large sexual patch in male .... *Batriscenaulax* JEANNEL

– Dorsal apophysis of male genitalia longer than basal strut in general, accurately curved internally 18

18. Hind femora thickened, with sexual modification in male; abdomen without sexual patch .... *Physomerinus* JEANNEL

– Hind femora slender, without sexual modification in male; abdomen usually with sexual patch in male .... *Batrisocenus* RAFFRAY

19. Clypeus broad, abdominal tergite VII with a median brush in both sexes .... *Batrisceniola* JEANNEL [Japan]

– Clypeus short, abdominal tergite VII without median brush .... *Arthromelodes* JEANNEL

Position undeterminable:
Eubatrisus RAFFRAY

The Genus Group of *Sathytes* (*incertae sedis*)

1. Body thick and subcylindrical, densely covered with reticulate sculptures like *Plagiophorus;* antennae elongate and thick, segments II to VIII each transverse and nearly cylindrical, IX to XI swollen and with sexual modification in male .... *Sathytes* WESTWOOD

– Body more or less flattened, normally punctuate or smooth; antennae slender .. 2

2. Antennal segment I elongate and subcylindrical, about as long as segments II to III or II to VI conjoined at least 3

– Antennal segment I short, shorter than segments II and III conjoined 5

3. Elytra without basal fovea, rounded on lateral sides; pronotum rounded laterally,

Smooth on dorsal surface, with a pair of short lateral longitudinal sulci; abdominal segment IV the largest, subcylindrical, without lateral ridge ………… ……………………………………………….. *Mnia* NEWTON & CHANDLER

– Elytra each with 2 or 3 basal foveae, more or less carinated along lateral margins; pronotum more or less punctuate on dorsal surface; abdominal segment IV the largest, with a pair of lateral ridges …………………………………………. 4

4. Body coarsely punctuate; elytra rounded laterally, strongly carinated along lateral margins; abdominal segment IV roundly expanded laterad, with a pair of strong lateral ridges ……………………………………… *Siteromina* LÖBL [Borneo]

– Body minutely punctuate; eyes large; elytra weakly broadened posteriorly, distinctly carinated laterad; abdominal segment IV subparallel-sided, with a pair of weak lateral ridges……………… Undescribed genus BA5 [Malay Peninsula]

5. Eyes very large and semispherical; antennae very long and slender, segments VIII to XI very long, forming antennal club; elytra rounded laterally, each with 3 basal foveae and a short discal carina between outer 2 foveae; abdominal segment IV the largest, constricted at base, with a pair of short basimedian carinae and a pair of short basilateral ridges ………………………………… *Batrictenistes* LÖBL

– Eyes very small; antennae very long and slender, segments IV to XI twisted and with sexual modification in male; elytra strongly narrowed basad, without basal fovea nor discal carina; abdominal segment IV short, never constricted at base ……………………………………… *Batrisopsis* RAFFRAY [Malay Peninsula]

Position undeterminable:
Batricrator JEANNEL
Borneana SCHAUFUSS

Supertribe GONIACERITAE

1. Abdominal segments III to VII fused to each other to form a large composite segment; antennae 7- to 11-segmented, with predominantly large last segment …………………………….. *Plagiophorus* MOTSCHULSKY (Tribe Cyathigerini)
– Abdominal segments III to VII normal; antennae 11-segmented in general, with not very large last segment …………………………………………………….. 2
2. Body large and thick, densely covered by long hairs; fore femora very thick and stout, with a crochet on inner side near apex; male genitalia large, bulbous and symmetrical with basal foramen in apical part ………………….. Tribe Arnyllini
– Body large or small, variously pubescent; fore femora simple; male genitalia usually with basal foramen in basal part ……………………………………… 3
3. Abdominal sternite III usually indistinctly separated from sternite IV, if distinct, far shorter than IV ……………………………………………………………… 4
– Abdominal sternite IV distinctly separated from sternite IV, about as long as IV ……………………………………………………………………………….. 7
4. Maxillary palpi large, each elongate and geniculate, palpal segment II long and slender, III short, IV largest, nearly ovoid to fusiform, expanded internally ……. …………………………………………………………….. Tribe Bythinini
– Maxillary palpi usually small, palpal segment II not very long ………………. 5
5. Elytra each with distinct subhumeral fovea and a nearly complete marginal carina running from subhumeral fovea to near apex …………………… Tribe Proterini
– Elytra each with indistinct subhumeral fovea and marginal carina; abdomen often strongly shortened, but tergite IV predominantly large ……. 6 (Tribe Iniocyphini)
6. Palpal segment IV broadly angulate on masal margin in basal half; pronotum with antebasal sulcus ……………………. *Sunorfa* RAFFRAY (subtribe Iniocyphina)
– Palpal segment IV shallowly convex on masal margin; pronotum without antebasal sulcus …………………………………………. Subtribe Natypleurina
7. Frons weakly convex and scarcely narrowed, without antennal tubercle; maxillary palpi usually very short, segment III bulbous ……………….. Tribe brachyglutini
– Frons more or less narrowed anteriorly and elevated to form an antennal tubercle, maxillary palpi large, segments III strongly constricted at apex and base,

triangular ………………………………………………………... Tribe Tychini

Tribe Proterini

1. Body subparallel-sided; abdominal tergites V to VII without well demarcated paratergite …………………………………………… *Pareuplectops* JEANNEL
– Body broadened laterally; abdominal tergites V to VII each with well demarcated paratergites ……………………………………………………………….. 2
2. Body stout and shiny, sparsely covered with minute punctures; antennal club indistinct ……………………………… *Proterus* RAFFRAY [Sumatra, Malaysia}
– Body small, not shiny, densely covered with coarse punctures; antennal club distinct ………………………………………………………………….……… 3
3. Antennal club formed by segments IX to XI, normal in proportion; pronotum with a pair of small denticles on lateral sides ………… *Mechanicus* SCHAUFUSS
– Antennal club very large, formed by segments IX to XI, longer than I to VIII conjoined, pronotum truncate on lateral sides ……………… *Imtempus* REITTER

Position undeterminable:
Phthartomicrus SCHAUFUSS [Sumatra]
Bythinoderes REITTER
Mimoplectus RAFFRAY [Laos]
Pseudoterus RAFFRAY

Tribe Bythinini

1. Antennae each with male sexual character in segment I, II or segments IX to XI; palpal segment IV elongate and quadrangular ….………… *Bryaxis* KUGELANN
– Antennae without male sexual character; segment I elongate and cylindrical; palpal segment II very elongate and slender, more or less granulate …………… 2
2. Body small; palpal segment IV short and ovoid ... *Tychobythinus* GANGLBAUER
– Body large; palpal segment IV fusiform, or elongate …………………………….. …………………………………………… *Bythoxenites* JEANNEL [Japan]

Tribe Iniocyphini, Subtribe Natypleurina

1. Body thick and bulbous; abdominal tergite IV the largest, but shorter than V to VIII combined in dorsal view ……………………………………………….. 2
– Body more or less flattened on dorsal side; abdominal tergite IV predominantly large, clearly larger than V to VIII combined in dorsal view ..………………….. 3
2. Body shiny, sparsely covered by minute punctures ……………………………… ……………………………………………. *Natypleurus* NEWTON & THAYER
– Body blunt, densely covered with coarse punctures …….. *Nedarassus* RAFFRAY
3. Body small; frons elevated in male …………………………………………….. 4
– Body large; frons more or less flattened ………..……………………………….5
4. Frons with subantennal cavity and small projection in middle part; antennal tubercle projected anteriorly …………………………………… *Morana* SHARP
– Frons without subantennal cavity, nor median projection; antennal tubercle normal ………………………..…………..…….. *Bythinophanax* REITTER
5. Antennal funicle very slender, each segment cylindrical or ovoid; frons with large median concavity in male in many species ………….. *Nipponobythus* JEANNEL
– Antennal funicle moniliform, each segment subspherical; frons with a pair of shallow depressions in male in many species ………………………………... 6
6. Frons with a pair of large concavities in male...*Machulkaia* LOBL [Korea, China]
– Frons without large concavity in male ………………………………………… 7
7. Frons projected anteriorly; pronotum distinctly narrowed near base; humeli flattened …………………………... *Bythiotes* NEWTON & CHANDLER [Japan]
– Frons weakly projected anteriorly; pronotum scarcely narrowed near base; humeli rounded ..…………………………………………….. *Takaorites* JEANNEL

Tribe Tychini

1. Elytra each with 3 basal foveae ………………………………………………… 2
– Elytra each with 2 basal foveae ………………………………………………… 3
2. Palpal segment III with an acute projection on its inner side, IV without apophysis ……………………….…………… *Atychodea* REITTER [Borneo]
– Palpal segment III with an obtuse angle or a round expansion on its inner side, IV with a small apophysis just inside palpal spine ………………………………….
………………………………………… *Tainochus* KURBATOV [Palearctic]
3. Postgena with a large ventromedian process; abdomen short, tergites VII to VIII each with a large sexual patch on posterior side in male ………..……………….
……………………………………… *Hyugatychus* NOMURA [Japan, China]
– Postgena flat or roundly expanded; abdomen normal, without sexual patch in cale ……………………………..………………….. *Tychus* LEECH [Holarctic]

Tribe Arnyllini

1. Head normal, about as long as wide …………. *Harmophorus* MOTSCHULSKY
– Head strongly prolonged behind eyes ……………………………….*Awas* LÖBL

Tribe Brachyglutini, Subtribe Brachyglutina

1. Frons without a median fovea ………………………………………………….. 2
– Fourth with a setose median fovea …………………………..…………..….. 14
2. Body more or less flattened, subparallel-sided; abdominal segment IV with a pair of complete paratergites ……………………………………………………… 3
– Body thick and bulbous; abdominal segment IV with a pair of reduced paratergites or short carinae only ……………………………………………… 7
3. Maxillary palpi short and simple ……………………………………………… 4
– Maxillary palpi large, distinctly modified ……………………………………… 6
4. Antennae with male sexual character ………………. *Prosthecarthron* RAFFRAY
– Antennae without male sexual character ……………………………………… 5

5. Elytra with subhumeral fovea and marginal carina …… *Physoplectus* REITTER
– Elytra without subhumeral fovea nor marginal carina ………………………….. …………………………………..……… *Pedisinops* NEWTON & CHANDLER)
6. Palpal segment IV the largest, longer than wide, twisted near the middle, III very short; abdominal segment IV normal in ventro-median part ……………..………. …………………………………… *Berlara* REITTER [Java, Singapore, manglobe]
– Palpal segment III the largest, strongly projected laterad, IV about as long as II, elongate; abdominal segment IV with very long and acute spine toward head on ventro-median part ………*Mangalobythus* TANOKUCHI [Singapore, manglobe]
7. Body generally large; tibiae each with swellings in middle and near apex ……. 8
– Body relatively small and compact; legs short, tibiae slender and nearly straight ……………………………………………………………………………………… 9
8. Body smooth, almost glabrous in dorsal surface; abdominal tergite IV with a pair of long basimedian carinae very close to each other … *Obricala* RAFFRAY [Java]
– Body smooth, almost glabrous or finely pubescent in dorsal surface; abdominal tergite IV with a pair of short basimedian carinae distant from each other …… …………………………………………………………… *Batraxis* REITTER
9. Body small and compact; legs short and slender; pronotum smooth in general..10
– Body middle sized; legs very long; pronotum coarsely punctuate in general .. 12
10. Body less thickened, punctuate and pubescent on dorsal surface; abdominal segment IV not very longer than V ……………. *Berlaraxis* JEANNEL [Vietnam]
– Body strongly thickened, smooth and almost glabrous in many species; abdominal segment IV far larger than V ……….. 11
11. Palpal segment IV strongly expanded basilaterad; frons with 3 tubercles ……….. …………………………………………………………… *Eupinidius* JEANNEL
– Palpal segment IV normally ovoid; frons moderately depressed ………………… ……………………………………………………… *Eupines* MOTSCHULSKY
12. Legs short and slender; antennal segment II swollen in male …………………… …………………………………………………….. *Noduliceps* JEANNEL [Japan]
– Legs long and slender; antennal segment II small in male …………………… 13
13. Head large, weakly angulate; eyes normal; palpal segment IV short and ovoid; antennae shorter than body; abdomen narrowed posteriorly, rounded at apex …..

……………………………………………………*Comatopselaphus* SCHAUFUSS

– Head small; eyes very large; palpal segment IV slightly expanded laterad; antennae very long, about as long as body; abdomen subconical in basal part and truncate at apex ………………………………………… *Atenisodus* RAFFRAY

14. Maxillary palpi large and elongate, segment IV symmetrically fusiform ……… …………………………………………………………… *Triomicrus* SHARP

– Maxillary palpi short and compact, segment IV ovoid ………………………. 15

15. Pronotum with a pair of transverse sulci each connecting lateral and median foveae ……………………………………………………… *Rybaxis* SAULCY

– Pronotum without transverse sulcus …………………………………………… 16

16. Elytron with 3 basal foveae ……………………………… *Trissemus* JEANNEL

– Elytron with 2 basal foveae ………………………………………………….. 17

17. Pronotum usually smooth or minutely punctuate on dorsal surface; parameres of male genitalia without seta ………………… *Reichenbachia* LEACH [Palearctic]

– Pronotum densely covered with coarse punctures on dorsal surface; parameres of male genitalia with setae ……………………………. *Reichenbachella* JEANNEL

Position undeterminable:

Ephymata RAFFRAY [Singapore]

Asanis NEWTON & CHANDLER

Anasidius JEANNEL [Java]

Supertribe PSELAPHITAE

1. Tarsi each with single claw ………………………………………………….. 2
– Tarsi each with 2 claws ………….……………………………..………..….. 3
2. Abdominal tergite IV predominantly large, much longer than the rest tergites ……………………………………………………………… Tribe Pselaphini
– Abdominal tergite IV not very long, about as long as V …………………………. ………………………………………… *Sabarhytus* LÖBL (Tribe Arhytodini)
3. Tarsal claws asymmetrical, hind claw distinctly smaller than fore one; body thick, often covered with scales …………………………………. Tribe Hybocephalini
– Tarsal claws symmetrical in size (asymmetrical in *Pseudophanias*); body thick or flattened, usually covered with normal pubescence or short and bold setae …… 4
4. Genae each with U-shaped setose groove between eye and antennal base ………. ………………………………………………………….. Tribe Tmesiphorini
– Genae each without or with short setose groove between eye and antennal base (Ctenistini, Odontalgini) …………………………………………………….. 5
5. Genae each with a short densely setose groove between eye and antennal base; postgenae densely setose; body covered with short, bold and recumbent setae, densely covered with scales or semihyaline microstructures between elytra and abdomen ……………………………………………………….. …………. 6
– Genae each with glabrous concavity between eye and antennal base; postgenae normally or densely setose; body covered with normal pubescence, sparsely or densely covered with scales between elytra and abdomen ……………………... 7
6. Clypeus with a pair of short processes or very large expansions in lateral parts; palpal segment II to IV each strongly thickened in apical part, with spine, pencil, tubercle or lateral projection …………………………………… Tribe Ctenistini
– Clypeus without lateral process; palpal segment II very long and slender, weakly thickened distad, III very short, IV elongate, very slender in basal part, weakly thickened and rounded near apex … *Odontalgus* RAFFRAY (Tribe Odontalgini)
7. Palpal segment II with 2 long spines on external side, III and IV each with a long spine ………………………………………… [Tribe Schistodactylini, Australia]
– Palpal segment II to IV usually without spine …………………. 8 (Tribe Tyrini)

8. Palpal segment III triangular, as long as wide, much smaller than IV; IV large and ovoid, with a longitudinal groove on mesal side …………………………………. …………………….. *Himepion* NOMURA & HLAVÁ_(Subtribe Somatipionina)
– Palpal segment III various in shape; IV also various in shape, without longitudinal groove on mesal side …………………………………………….. 9
9. Palpal segment III very large, elongate or ovoid, longer than wide; IV very small, triangular or subconical …………………………… Subtribe Centrophthalmina
– Palpal segment III smaller than IV or as large as IV; IV usually large and thick ……………... Subtribe Tyrina

Tribe Pselaphini

1. Tarsal claw scythe-shaped, basal part contracted into apical cavity of tarsal segment III; antennae long and slender, each segment subcylindrical; palpal segment IV ovoid, with a short spine ……………… *Hirashimanymus* NOMURA
– Tarsal claw normal, antennae elongate, each segment ovoid in general; palpal segment IV various in shape ………………………………………………….. 2
2. Maxillary palpi short and compact, segment IV ovoid to triangular …………… 3
– Maxillary palpi long, segment IV elongate ……………………………………. 4
3. Palpal segment IV about as long as wide, angulate internally, nearly triangular in dorsal view ………………………………………………… *Tyraphus* SHARP
– Palpal segment IV about twice as long as wide, ovoid or reniform ……………… ……………………………………………… *Curculionellus* WESTWOOD
3. Palpal segment IV fusiform, with 2 acute spines along external margin ………… ………………………………………………………… *Mentraphus* SHARP
– Palpal segment IV elongate without external spine …………………………… 4
4. Pronotum with an antebasal transverse sulcus ………………………………… 5
– Pronotum without antebasal transverse sulcus ………………………………… 6
5. Pronotum expanded laterally in anterior part, with 3 shallow longitudinal depression on dorsal surface ..…………… *Nabepselaphus* NOMURA [Yunnan]
– Pronotum rounded laterally, without longitudinal depression on dorsal surface …. …………………………………………………….. *Pselaphaulax* REITTER

6. Eyes small; postgenae usually glabrous, covered with scales in some species; elytra each with 2 basal foveae on both sides of discal carina ………………….. ……………………………………………………….. *Pselaphogenius* REITTER
– Eyes very large; elytra without basal foveae; postgenae covered with dense scales on lateral and ventral sides …………………………………………………… 7.
7. Palpal segment IV strongly swollen in apical half, covered with minute spines in the swollen area ..…………………………………………… *Pselaphus* HERBST
– Palpal segment IV thickened in apical part (apical 1/3 at most), with short groove and 2 setae at apex ………………………………….. *Pselaphidius* JEANNEL

Position undeterminable:
Acmaeonotusa BLATTN_[Myanmar]

Tribe Hybocephalini

1. Abdominal tergites IV to V without paratergite nor marginal carina ………… 2
– Abdominal tergites IV to V with paratergites or marginal carinae …………… 4
2. Body smooth on dorsal surface; abdominal tergite IV the largest, much longer than the other segment ..………………………… *Mestogaster* SCHMIDT-GÖBEL
– Body blunt, coarsely punctuate; abdominal tergite IV as long as V or slightly longer than V ……………………………………………………….….….. 3
3. Abdominal tergite IV slightly longer than V …… *Filigerinus* JEANNEL [Sumatra]
– Abdominal tergites IV to VI subequal in length …… *Hybocephalus* SCHAUFUSS
4. Antennal segment XI very large, with large excavation on ventral side in male … ..…………………………………………………….. *Apharinodes* RAFFRAY
– Antennal segment XI not very large, without excavation on ventral side in male ……………………………………………………….…………………….. 5
5. Antennal club formed by segments X and XI ……………… *Apharina* REITTER
– Antennal club formed by segments IX to XI ……………………………………6
6. Abdominal tergite VII very long ……… *Stipesa* SHARP (= *Filiger* SCHAUFUSS)
– Abdominal tergites IV to VIII subequal in length ………………………………. 7
7. Elytra without discal stria ………………… *Hybocephalodes* RAFFRAY [Borneo]

– Elytra each with a discal stria ………………………. *Pseudapharina* RAFFRAY

Tribe Ctenistini

1. Antennae thick, moniliform, without club; maxillary palpus short and thick, segments II to IV each thickened distally, with a pencil on external side ……. ..…………………………… *Centrotoma* HEIDEN [Palearctic, myrmecophilous]
– Antennae slender, segments II to XI each subcylindrical; maxillary palpus various in shape ..……………………………………………………………… 2
2. Antennae without distinct club; head transverse; palpal segments II to IV each pencilate ……………………………………………………… *Pilopius* CASEY
– Antennae with club formed by segments VIII to XI; head elongate or transverse; palpal segments various in shape ……………………………………………… 3
3. Body small (less than 2 mm); palpal segment II scarcely thickened distad, segment III and IV each distinctly transverse ………….. *Enoptostomus* SCHAUM
– Body small or large (more than 2 mm); palpal segment II more or less thickened distad, segment III and IV sometimes transverse ……………………………… 4
4. Head simple on ventral side; antennal club predominantly large, far longer than the rest segments; antennal segments II to VII each transverse or subspherical…5
– Head with a transverse carina and a pair of subconical projection beneath eyes; antennal club large, but not far longer than the rest segments; antennal segments II to VIII each ovoid, longer than wide ……………………………………... 6
5. Antennal club almost straight, segments VIII to X nearly subequal in length, segment X almost flat on inner side in male ………… *Ctenistes* REICHENBACH
– Antennal club weakly curved between segments IX and X, segment IX very short, about twice as long as wide at most, segment X larger than IX, weakly projected on inner side near base ………………………… *Ctenistidius* JEANNEL
6. Palpal segment IV acutely projected distad, with a short palpal spine at apex …. ……………………………………………………….. *Ctenisophus* RAFFRAY
– Palpal segment IV flattened or rounded distally, without palpal spine at apex ... 7
7. Body small, legs short; head transverse, with weakly projected antennal tubercle; palpal segment II with a pencil on external side …………… *Sognorus* REITTER

– Body large, legs long; head elongate, with strongly projected antennal tubercle; palpal segment II with or without pencil ………………………………………. 8

8. Palpal segment II with a pencil on external side ……….. *Poroderopsis* JEANNEL

– Palpal segment II without pencil ……………………………. *Poroderus* SHARP

Position undeterminable:
Metactenistes JEANNEL

Tribe Tmesiphorini

1. Maxillary palpus very short and simple; tarsal claws asymmetrical or symmetrical in size ………………………………………………………………………… 2

– Maxillary palpus large, simple or pencilate; tarsal claws symmetrical in size 3

2. Tarsal claws distinctly asymmetrical in size, seemingly single in some cases; body relatively small ………………………………… *Pseudophanias* RAFFRAY

– Tarsal claws nearly symmetrical in size; body relatively large ………………….
……………………………………………………… *Chandleriella* HLAVÁ_

3. Maxillary palpus large and simple, without pencil on segments II and III ……. 4

– Maxillary palpus large, segments II and III pencilate …………………………. 5

4. Palpal segment IV the largest and ovoid; antennae similar in both sexes; fore femora each with deep excavation on dorsal side near base in male ……………
………………………………………………………… *Saslisedes* KUBOTA

– Palpal segment IV about as large as III; antennae with sexual modification in male; fore femora without excavation in male ………. *Ancystrocerus* RAFFRAY
ovoid, longer than wide …………………………………………….... 6

5. Palpal segment IV without pencil on external side, roundly expanded laterad in some species ………………………………………………………………….. 6

– Palpal segment IV with a pencil on external side ……………………………… 7

6. Body elongate, covered with short and recumbent pubescence …………………..
……………………………………………………… *Tmesiphorus* LECONTE

– Body short and thick, covered with simple long pubescence ……………………
……………………………………………………… *Dacnotillus* RAFFRAY

7. Body covered with short pubescence, densely with coarse punctures in head and pronotum; abdominal tergite IV with a pair of distinct longitudinal carinae ……. ……………………………………………………………… *Raphitreus* SHARP
– Body covered with long pubescence, sparsely with punctures in head and pronotum; abdominal tergite IV with a pair of weak longitudinal carinae ………. ……………………………………... Raphitreodes NEWTON & CHANDLER

Tribe Tyrini, Subtribe Centrophthalmina

1. Palpal segment III large, more or less elongate and triangular, IV short and externally expanded and triangular ………………………. *Enantius* SCHAUFUSS
– Palpal segment III large, expanding externally, nearly ovoid to triangular, densely covered with short and thin hairs, IV very small, triangular, conical or fusiform ……………………………………………………………………2
2. Postgenae with spines or tubercles beneath eyes; antennal club distinct ………… ………………………………………… *Centrophthalmus* SCHMIDT-GÖBEL
– Postegenae simply rounded or flattened beneath eyes; antennal club indistinct … …………………………………………………… *Centrophthalmina* RAFFRAY

Tribe Tyrini, Subtribe Centrophthalmina

1. Pronotum with deep transverse sulcus near base ……………………………… 2
– Pronotum without transverse sulcus near base, or with a shallow antebasal sulcus connecting lateral and basimedian foveae …………………………………….. 6
2. Body large and broad; palpal segment III elongate, narrowed in basal part, swollen in apical part, IV swollen medially, nearly fusiform ………………… 3
– Body very large and broad; palpal segment III and IV various in shape ………. 4
3. Abdominal tergites IV to VII subequal in length, segment IV with a median longitudinal carina …………………………………………………... *Tyrus* AUBÉ
– Abdominal tergites IV and V subequal in length, each far longer than VI or VII, tergite IV without median longitudinal carina ……………….. *Tyrodes* RAFFRAY
4. Antennae very slender, segment I elongate, subcvlindrical, IX to XI forming a

club weakly thickened; palpal segment II to IV subequal in length, each elongate and very weakly thickened apicad ………………….. *Subulipalpus* SCHAUFUSS

– Antennae thick, segment I thick, angulately expanded postero-laterad, IX thick and ovoid, without distinct club; palpal segment II to IV thick ………………... 5

5. Palpal segment III short and subconical, IV very large and ovoid, with a longitudinal groove on mesal side ……………………………………………. ……………………………….. *Hamotopsis* RAFFRAY (=Horniella RAFFRAY?)

– Palpal segment III elongate, thickened distally, IV about as large as III, strongly narrowed near base, thickened in apical part .. *Megatyrus* HLAVÁ_ & NOMURA

6. Body medium-sized, flattened or thick; maxillary palpi relatively large and elongate, segments II to IV subequal in length, each swollen in apical part, strongly narrowed in basal part; legs simple, without spines or denticles …….. 7

– Body large-sized, thick; maxillary palpi relatively small; legs long and robust, with spines or denticles in some cases ……………………………………... 8

7. Body flattened, distinctly narrowed in head and pronotum; abdominal tergite IV the largest or as long as V, without basimedian carinae … *Tyrinasius* KURBATOV

– Body thick, weakly narrowed in head and pronotum; abdominal tergite IV predominantly large, with a pair of basimedian carinae ……….. *Durbos* SHARP

8. Elytra and abdominal segment IV with broad longitudinal carinae; palpal segment IV broadened, with a shallow and large depression on dorsal surface …. ……………………………………………………………… *Ctenotillus* RAFFRAY

– Elytra and abdominal tergite IV without longitudinal carina in general (elytra carinate in *Indophodes*); palpal segment IV without depression on dorsal surface …………………………..…………………………………………………... 9

9. Tarsal segment II broadly lobed beneath III extending nearly to tarsal claws .. 10

– Tarsal segment II simple, not lobed ……………………………………….. 11

10. Pronotum with antebasal sulcus connecting well developed median and lateral foveae; frons with a setose median fovea ……………. *Taiwanophodes* HLAVÁ_

– Pronotum without antebasal sulcus nor median and lateral fovea; frons without median fovea …………………………………………... *Nomuraius* HLAVÁ_

11. Palpal segment III almost symmetrical, neither expanded nor projected externally ……………………………………………………………………………….. 12

– Palpal segment III clearly asymmetrical, expanded or projected externally …... 13

12. Pronotum expanded anterolaterally, with a shallow antebasal sulcus connecting lateral and basimedian foveae; hind trochanters each with a small denticle ……… ……………………………………..…….... *Paralasinus* HLAVÁ_ & NOMURA

– Pronotum scarcely expanded anterolaterad, without antebasal sulcus; hind trochanters without denticle …………………………………... *Lasinus* SHARP

13. Head and pronotum uniformly covered with coarse punctures; frons with an indistinct median fovea; pronotum without median sulcus ……. *Linan* HLAVÁ_

– Head and pronotum irregularly covered with coarse punctures; frons with a well demarcated setose median fovea; pronotum with or without median sulcus …14

14. Pronotum with a deep median sulcus, a pair of ribs, a median and a pair of foveae; elytra each with a discal and a marginal carinae … *Indophodes* HLAVÁ_

– Pronotum with or without a median sulcus, a median and a pair of lateral foveae; elytra without longitudinal carinae …………………………………………… 15

15. Metasternum with a setose median fovea ………………….. *Labomimus* SHARP

– Metasternum without median fovea………………….. *Pselaphodes* WESTWOOD

Supertribe CLAVIGERITAE

1. Tarsal segment II long, far longer than I, slightly shorter than III …..……………. ……………………………………. *Colilodion* BESUCHET (Tribe Colilodionini)

– Tarsal segment II very short, as long as I, III very long ………. Tribe Clavigerini

Tribe Clavigerini

1. Head not constricted in posterior part, ovoid, retracted into anterior part of pronotum in posterior part; composite abdominal tergum (tergites III to VII) with very large, deep and glabrous excavation in posterior part ………………………. ……………………………………………………… *Pseudacerus* RAFFRAY

– Head more or less constricted in posterior part, subcylindrical in anterior part in general, scarcely retracted into anterior part of pronotum; composite abdominal tergum convex ……………………………………………………………….. 2

2. Antennae 2-segmented, segment I invisible in dorsal view …………………… 3
– Antennae 3-segmented or more …………………………………………………5
3. Abdomen very short, scarcely depressed at base; antennal segment II elongate, weakly thickened distad ……………………………… *Disarthricerus* RAFFRAY
– Abdomen large, strongly depressed at base; antennal segment various in shape...4
4. Antennae very short, shorter than head …………….. *Mastiger* MOTSCHULSKY
– Antennae longer than head, longer than wide, elongate …….. *Articerus* DALMAN
5. Antennae 3-segmented ……………………………………………………… 6
– Antennae 4-segmented or more ……………..……………………………………8
6. Antennal segment III large and elongate, thickened distally, rounded and covered with long erect setae at apex; pronotum and elytra densely covered with coarse reticulation; abdomen with a pair of large projections on both basilateral sides …………………………………………… *Cerylambus* NEWTON & CHANDLER
– Antennal segment III large and elongate, thickened distally, truncate at apex: pronotum and elytra without coarse reticulation; abdomen without basilateral projection ……………………………………………………………………….. 7
7. Elytra each with a conical or triangular trichome on posterolateral margin and linear microstructure on basal part ……………………….. *Triartiger* KUBOTA
– Elytra without trichome on posterior margin …………. [Fustiger LECONTE etc.]
8. Antennae 4-segmented ……………………………………………………… 9
– Antennae 5 segmented, segments II to V subequal in length, V longer than wide, subconical ……………………………………… *Archiclaviger* HELLER [Java]
9. Antennal segment IV asymmetrically modified on ventral part, rounded at apex; pronotum strongly constricted near the middle ..……… *Anaclasiger* RAFFRAY
– Antennal segment IV simply thickened distad, symmetrical, truncate at apex; pronotum not constricted near the middle ……………………………………… 10
10. Antennal segment I almost retracted into antennal tubercle, invisible in dorsal view, II and III subequal in length and width ………….. *Articerodes* RAFFRAY
– Antennal segments I and II subequal in length, each short, III and IV subequal in length, each large and elongate ………………………………………………. 11
11. Head ovoid, elytra strongly shortened ………………… *Micrelytriger* NOMURA
– Head elongate and cylindrical, elytra large …………………… *Diartiger* SHARP

Appendix B Tables

Appendix Table A Summary of recorded species and individuals of pselaphine beetles collected in 2006 in eastern forest complex of Thailand.

		Forest Habitat				
Supertribe	Species	PMDF	SDEF	MEF	HEF	TP
Batrisitae	*Amana* sp. 1				1	1
Batrisitae	*Batriscenaulax* sp. 1	16		21		1
Batrisitae	*Batrisiella* sp. 1			13		
Batrisitae	*Batrisodes* sp. 1				1	
Batrisitae	*Hypochareus* sp. 1	7	3	1		1
Batrisitae	*Hypochareus* sp. 2				2	
Batrisitae	*Hypochareus* sp. 3			1		
Batrisitae	*Mnia* sp. 1	1		210	25	
Batrisitae	*Physomerinus* sp. 1				1	
Batrisitae	*Sathytes* sp. 1			4		
Batrisitae	*Tribasodites* sp. 1	13		16		
Batrisitae	*Tribasodites* sp. 2	3				
Batrisitae	*Tribasodites* sp. 3	6		1		
Batrisitae	*Tribasodites* sp. 4	1		1		
Batrisitae	*Tribasodites* sp. 5		2	4		
Batrisitae	*Trisinus* sp. 1		2	1		
Batrisitae	Batrisina gen.undet. sp. 1	2				
Batrisitae	Batrisina gen.undet. sp. 2				1	
Bythiniplectitae	*Octomicrus longulus*	1				
Bythiniplectitae	*Parayxidicerus* sp. 1		1	2	1	11
Bythiniplectitae	*Tuberoplectus* sp. 1			8		
Bythiniplectitae	*Zethopsus opacus*		2		2	3
Bythiniplectitae	Bythinoplectina gen.undet. sp. 1	2		2		
Bythiniplectitae	Bythinoplectina gen.undet. sp. 2			5		
Bythiniplectitae	Bythinoplectina gen.undet. sp. 3	18		2		

Appendix Table A (Continued).

		Forest Habitat				
Supertribe	Species	PMDF	SDEF	MEF	HEF	TP
Bythiniplectitae	Bythinoplectina gen.undet. sp. 4					1
Bythiniplectitae	Pyxidicerina gen.undet. sp. 1	5	6	4	3	
Bythiniplectitae	Pyxidicerina gen.undet. sp. 2	3			5	3
Bythiniplectitae	Pyxidicerina gen.undet. sp. 3	2	1	3		1
Bythiniplectitae	Pyxidicerina gen.undet. sp. 4			1	3	
Bythiniplectitae	Pyxidicerina gen.undet. sp. 5	1				
Bythiniplectitae	Pyxidicerina gen.undet. sp. 6			1		
Bythiniplectitae	Pyxidicerina gen.undet. sp. 7			1		
Bythiniplectitae	Pyxidicerina gen.undet. sp. 8		1			
Bythiniplectitae	Pyxidicerina gen.undet. sp. 9				2	
Bythiniplectitae	Pyxidicerina gen.undet. sp. 10				2	
Clavigeritae	*Articerodes ohmomoi*	2				
Clavigeritae	*Articerodes thailandicus*		8			
Clavigeritae	*Articerodes jariyae*				3	
Clavigeritae	*Cerylambus reticulatus*			1	10	
Euplectitae	*Aphilia* sp. 1	35	4	46	1	1
Euplectitae	*Bibloporus* sp. 1			3		
Euplectitae	*Bibloporus* sp. 2			3		
Euplectitae	*Bibloporus* sp. 3	1		1		
Euplectitae	*Bibloporus* sp. 4	2				
Euplectitae	*Bibloporus* sp. 5			1		
Euplectitae	*Bibloporus* sp. 6				1	
Euplectitae	*Biblopectus* sp. 1			8		
Euplectitae	*Euplectus* sp. 1	1		11	1	
Euplectitae	*Euplectus* sp. 2		1	2		
Euplectitae	*Euplectodina* sp. 1	2		19	1	
Euplectitae	*Leptoplectus* sp. 1				17	1
Euplectitae	*Leptoplectus* sp. 2			1	5	

Appendix Table A (Continued).

		Forest Habitat				
Supertribe	Species	PMDF	SDEF	MEF	HEF	TP
Euplectitae	*Leptoplectus* sp. 3				5	
Euplectitae	*Leptoplectus* sp. 4				1	
Euplectitae	*Philiopsis* sp. 1	1		5	1	
Euplectitae	*Prophilus* sp. 1	1		20		
Euplectitae	*Prophilus* sp. 2				1	
Euplectitae	*Pseudoplectus* sp. 1	1				
Euplectitae	*Pseudoplectus* sp. 2		1			
Euplectitae	*Pseudoplectus* sp. 3			1		
Euplectitae	*Pseudoplectus* sp. 4	1		13		
Euplectitae	*Pseudoplectus* sp. 5					1
Euplectitae	*Pseudoplectus* sp. 6		1		1	
Euplectitae	*Saulcyella* sp. 1	1	1		1	
Euplectitae	*Saulcyella* sp. 2				1	
Euplectitae	*Saulcyella* sp. 3		1	26		
Euplectitae	*Saulcyella* sp. 4			1	1	
Euplectitae	Panaphantina gen.undet. sp. 1			1	1	
Goniaceritae	*Atenisodus* sp. 1	3	3	32		2
Goniaceritae	*Atenisodus* sp. 2			3	1	
Goniaceritae	*Atenisodus* sp. 3					2
Goniaceritae	*Atychodea* sp. 1				1	
Goniaceritae	*Batraxis brevis*			27		
Goniaceritae	*Batraxis doriae*	51		140		
Goniaceritae	*Batraxis* sp. 1			2		
Goniaceritae	*Batraxis* sp. 2	2				
Goniaceritae	*Comatopselaphus punticollis*			11		
Goniaceritae	*Eupines* sp. 1		2			1
Goniaceritae	*Eupines* sp. 2			1		

Appendix Table A (continued).

		Forest Habitat				
Supertribe	Species	PMDF	SDEF	MEF	HEF	TP
Goniaceritae	*Harmophorus gibbiodes*	3			4	
Goniaceritae	*Harmophorus* sp. 1	1		31	1	4
Goniaceritae	*Harmophorus* sp. 2	16				
Goniaceritae	*Harmophorus* sp. 3		4			
Goniaceritae	*Mechanicus* sp. 1				1	
Goniaceritae	*Morana* sp. 1			52		
Goniaceritae	*Natyplerus* sp. 1			8		
Goniaceritae	*Pareuplectops* sp. 1	1	3	1	1	2
Goniaceritae	*Pareuplectops* sp. 2					2
Goniaceritae	*Plagiophorus* sp. 1	359	1	26	45	
Goniaceritae	*Plagiophorus* sp. 2	6		20	9	
Goniaceritae	*Plagiophorus* sp. 3					1
Goniaceritae	*Rybaxis* sp. 1	1				
Goniaceritae	*Sunorfa* sp. 1	2		20		
Goniaceritae	*Trissemus* sp. 1		2	1		
Goniaceritae	*Trissemus* sp. 2			1		
Goniaceritae	*Trissemus* sp. 3			2		1
Goniaceritae	Natypleurina gen.undet. sp. 1				3	
Pselaphitae	*Ancystrocerus* sp. 1			8		
Pselaphitae	*Apharina conicicollis*			8		
Pselaphitae	*Apharina* sp. 1			1		
Pselaphitae	*Apharinodes* sp. 1				2	
Pselaphitae	*Centrophthalmus* sp. 1	65	24			
Pselaphitae	*Centrophthalmus* sp. 2					1
Pselaphitae	*Hamotopsis* sp. 1			4		
Pselaphitae	*Labomimus* sp. 1			8	3	
Pselaphitae	*Labomimus* sp. 2	1		4		

Appendix Table A (continued).

Supertribe	Species	Forest Habitat PMDF	SDEF	MEF	HEF	TP
Pselaphitae	*Labomimus* sp. 3					2
Pselaphitae	*Pselaphidius* sp. 1			1		
Pselaphitae	*Pselaphodes* sp. 1		1	1		
Pselaphitae	*Pseudophanias* sp. 1	4		26		
Pselaphitae	*Tmesiphorus* sp. 1	1		12		
Pselaphitae	*Tmesiphorus* sp. 2				15	
Pselaphitae	*Tyraphus pilosus*	1				
Number of individuals		646	75	916	187	43
Number of species		42	23	66	42	21

PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.

Appendix Table B Summary of recorded ant species in 2006 in eastern forest complex of Thailand.

		Forest habitat				
Subfamily	Species	PMDF	SMDF	MEF	HEF	TP
Aenictinae	*Aenictus artipus*				1	
Aenictinae	*Aenictus laeviceps*				23	
Aenictinae	*Aenictus* sp. 1	2				
Aenictinae	*Aenictus* sp. 2					2
Cerapachyinae	*Cerapachys* sp. 1	1	1			1
Cerapachyinae	*Cerapachys* sp. 2	3				
Cerapachyinae	*Cerapachys* sp. 3			8		
Cerapachyinae	*Cerapachys* sp. 4			4		
Cerapachyinae	*Cerapachys* sp. 5			3		
Cerapachyinae	*Cerapachys sulcinodis*				4	
Dolichoderinae	*Dolichoderus thoracicus*	88	262	135	66	45
Dolichoderinae	*Philidris* sp. 1	150		35		
Dolichoderinae	*Tapinoma melanocephalum*	18	121	10	1	39
Dolichoderinae	*Tapinoma* sp. 1					17
Dolichoderinae	*Technomyrmex kraepelini*	118	116	158	199	
Dolichoderinae	*Technomyrmex* sp. 1	153	55	273		298
Dolichoderinae	*Technomyrmex* sp. 2	39				
Dorylinae	*Dorylus vishuni*	44	1			
Formicinae	*Acropyga acutiventris*	20	5			
Formicinae	Acropygra sp.1			3		
Formicinae	*Camponotus camelinus*				1	
Formicinae	*Camponotus* sp. 1	1	11			
Formicinae	*Camponotus* sp. 2	1				2
Formicinae	*Myrmoteras* sp. 1			16	35	
Formicinae	*Oecophylla smaragdina*	1	2	3		

Appendix Table B (Continued).

		Forest habitat				
Subfamily	Species	PMDF	SMDF	MEF	HEF	TP
Formicinae	*Paratrechina* sp. 1	2071	454	1242	587	31
Formicinae	*Paratrechina* sp. 2	107	15	57	6	170
Formicinae	*Paratrechina* sp. 3					48
Formicinae	*Plagiolepis* sp. 1		38			318
Formicinae	*Polyrhachis armata*	1				
Formicinae	*Polyrhachis halidayi*				69	2
Formicinae	*Polyrhachis hippomanes*		8			6
Formicinae	*Polyrhachis proxima*		2		1	
Formicinae	*Pseudolasius* sp. 1				20	
Leptanillinae	*Leptanilla* sp.1			1		
Myrmicinae	*Anoplolepis gracilipes*		37			1
Myrmicinae	*Aphaenogaster* sp. 1				39	1
Myrmicinae	*Aphaenogaster* sp. 2			423		
Myrmicinae	*Calyptomyrmex* sp.1	50	41	914		37
Myrmicinae	*Cardiocondyla nuda*		1			
Myrmicinae	*Cardiocondyla wrongtonii*	1	11	1		
Myrmicinae	*Carebara castanea*		7			
Myrmicinae	*Cataulacus graenulatus*	1				
Myrmicinae	*Crematogaster* sp. 1		10			
Myrmicinae	*Crematogaster* sp. 2	107	1	101	15	2
Myrmicinae	*Crematogaster* sp. 2				4	
Myrmicinae	*Crematogaster coriaria*				26	
Myrmicinae	*Epitritus* sp. 1					1
Myrmicinae	*Lophomyrmex striatulus*		355	397		29
Myrmicinae	*Lordomyrma* sp.1			5		
Myrmicinae	Mayriella sp.1	240		856		75
Myrmicinae	*Monomorium chinensis*	23		20		

Appendix Table B (Continued).

Subfamily	Species	Forest habitat				
		PMDF	SMDF	MEF	HEF	TP
Myrmicinae	*Monomorium destructor*	95	8	45		86
Myrmicinae	*Monomorium floricola*	2	2	17	9	11
Myrmicinae	*Monomorium pharaonis*	886	328	772	654	611
Myrmicinae	*Monomorium sellense*		15	53		
Myrmicinae	*Monomorium* sp. 1	502	316	231	14	112
Myrmicinae	*Myrmecina* sp. 1	11		7	5	3
Myrmicinae	*Myrmecina* sp. 2	13				
Myrmicinae	*Oligomyrmex* sp.1	1387	640	2176	428	222
Myrmicinae	*Paratopula macta*					1
Myrmicinae	*Pheidole inornata*	853	72	493	151	142
Myrmicinae	*Pheidole longipes*			28		
Myrmicinae	*Pheidole pieli*	105	57	839	36	17
Myrmicinae	*Pheidole plagiaria*			143	25	
Myrmicinae	*Pheidole tandjongensis*	218	152	1988	8	8
Myrmicinae	*Pheidole* sp. 1	1544	70	334	225	71
Myrmicinae	*Pheidole* sp. 2				92	
Myrmicinae	*Pheidole* sp. 3	140		56	103	
Myrmicinae	*Pheidologeton affinis*	5	1	170	102	2
Myrmicinae	*Pheidologeton diversus*	271	67			211
Myrmicinae	*Pheidologeton tandjongensis*					5
Myrmicinae	*Pristomyrmex brevispinosus*			1		
Myrmicinae	*Pristomyrmex punctatus*			93		1
Myrmicinae	*Pristomyrmex* sp. 1	26			97	
Myrmicinae	*Proatta bulleli*	401	5	202		
Myrmicinae	*Recurvidris recurvipinosa*		1			20
Myrmicinae	*Smithistruma* sp. 1	164	11	46	26	26
Myrmicinae	*Smithistruma* sp. 2	6	2		5	58

Appendix Table B (Continued).

		Forest habitat				
Subfamily	Species	PMDF	SMDF	MEF	HEF	TP
Myrmicinae	*Smithistruma* sp. 3		9	38		26
Myrmicinae	*Smithistruma* sp. 4	29		185		8
Myrmicinae	*Smithistruma* sp. 5				102	
Myrmicinae	*Solenopsis geminata*				28	
Myrmicinae	*Solenopsis* sp. 1	67	1	42		
Myrmicinae	*Strumigenys* sp. 1	256	73	553	160	9
Myrmicinae	*Strumigenys* sp. 2	588	25	50	35	35
Myrmicinae	*Strumigenys* sp. 3			141	276	5
Myrmicinae	*Strumigenys* sp. 4	15		132		
Myrmicinae	*Strumigenys* sp. 5	42	20	50		
Myrmicinae	*Strumigenys* sp. 6	56	6	182	105	
Myrmicinae	*Tetramorium* sp. 1	716	276	871	36	31
Myrmicinae	*Tetramorium* sp. 2	138	57	37	2	
Myrmicinae	*Tetramorium* sp. 3	255				
Myrmicinae	*Tetramorium* sp. 4	105	1	67	46	
Myrmicinae	*Vollenhoria* sp. 1	69		332	40	
Ponerinae	*Amblyopone reclinata*		5			
Ponerinae	*Amblyopone* sp. 1			4		
Ponerinae	Amblyopone sp. 2		16	7		10
Ponerinae	*Anochetus graeffei*	102	25	183	1	
Ponerinae	*Anochetus* sp. 1	2	1			
Ponerinae	*Diacamma rugosum*		1			1
Ponerinae	*Diacamma vargans*		1	3		
Ponerinae	*Discothyrea* sp. 1	73	13	267	9	14
Ponerinae	*Discothyrea* sp. 2	1	15	38	5	1
Ponerinae	*Emeryopone buttelreepeni*	60	3			
Ponerinae	*Gnamptogenys bicolor*				1	

Appendix Table B (continued).

Subfamily	Species	Forest habitat				
		PMDF	SMDF	MEF	HEF	TP
Ponerinae	*Gnamptogenys binghami*	34	1	41	3	
Ponerinae	*Gnamptogenys* sp. 1	4				
Ponerinae	*Hypoponera* sp. 1	1046	353	626	67	226
Ponerinae	*Hypoponera* sp. 2	130		188		
Ponerinae	*Hypoponera* sp. 3	190				7
Ponerinae	*Hypoponera* sp. 4			346		
Ponerinae	*Leptogenys birmana*			1		
Ponerinae	*Leptogenys diminuta*		2	60	17	32
Ponerinae	*Leptogenys hysterica*	1	20	51		
Ponerinae	*Leptogenys kitteli*		5	12		
Ponerinae	*Leptogenys kraepelini*	30			2	73
Ponerinae	*Leptogenys* sp. 1	68		5		1
Ponerinae	*Leptogenys* sp. 2		1	1		
Ponerinae	*Myopopone castanea*			1		
Ponerinae	*Mystium* sp.1			1		
Ponerinae	*Odontomachus rixosus*	98	40	209		
Ponerinae	*Odontoponera denticulata*	15	11	8		7
Ponerinae	*Pachycondyla astuta*	3		3	27	
Ponerinae	*Pachycondyla chinensis*				68	
Ponerinae	*Pachycondyla leeuwenhoeki*	23	3	28	9	
Ponerinae	*Pachycondyla luteipes*	18	41	352	268	232
Ponerinae	*Pachycondyla rufipes*	1		11	5	
Ponerinae	*Pachycondyla* sp.1	26	2	24		
Ponerinae	*Pachycondyla* sp.2			26		
Ponerinae	*Platythyrea* sp. 1		1			
Ponerinae	*Ponera* sp. 1	10		107	38	
Ponerinae	*Ponera* sp. 2			32	66	

Appendix Table B (continued).

Subfamily	Species	Forest habitat PMDF	SMDF	MEF	HEF	TP
Ponerinae	*Ponera* sp. 3				8	
Ponerinae	*Ponera* sp. 4			13		
Ponerinae	*Probolomyrmex* sp. 1	1		18		2
Ponerinae	*Proceratium deelemane*				3	
Pseudomyrmecinae	*Tetraponera allaborans*				2	
Pseudomyrmecinae	*Tetraponera* sp. 1	1		1		
Number of individuals		14142	4329	17706	4506	3452
Number of species		76	68	85	61	56

PMDF, primary mixed deciduous forest; SMDF, secondary mixed deciduous forest; MEF, moist evergreen forest; HEF, hill evergreen forest; TP, teak plantation.

Appendix Table C

List of tree species and individuals in sampling areas

Appendix Table C1 List of tree species and individuals in sampling area ($10,000\ m^2$) in primary mixed deciduous forest (PMDF).

Family	Scientific name	Thai name	No.
Anacardiaceae	*Mangifera cochinchinensis*	มะม่วงไข่แลน	21
Annonaceae	*Cyathostemma micranthum*	น้ำเต้าน้อย	1
Annonaceae	*Meiogyne hainanensis*	ไสเดน	3
Annonaceae	*Miliusa lineata*	อีแรด	2
Annonaceae	*Platymitra siamensis*	หำช้าง	33
Annonaceae	*Polyaslhia cerasoides*	กระเจียน	7
Annonaceae	*Polyaslhia* sp.	สบันงาดง	9
Annonaceae	*Sageraea elliptica*	กะโมกเขา	4
Bignoniaceae	*Fernandoa adenophylla*	แคหางค่าง	5
Celastraceae	*Lophopetalum wightiana*	สองสลึง	1
Celastraceae	*Siphonodon celastrineus*	มะดูก	1
Combretaceae	*Terminalia citrina*	สมอดีงู	14
Combretaceae	*Terminalia triptera*	ขี้อ้าย	4
Crypteroniaceae	*Crypteronia paniculata*	กะอาม	1
Datiscaceae	*Tetrameles nudiflora*	สมพง	3
Dilleniaceae	*Dillenia obovata*	ส้านใหญ่	2
Dipterocarpaceae	*Anisoptera scaphula*	ช้าม่วง	2
Dipterocarpaceae	*Dipterocarpus turbinatus*	ยางแดง	12
Dipterocarpaceae	*Hopea odorata*	ตะเคียนทอง	1
Dipterocarpaceae	*Shorea henryana*	เคี่ยมคะนอง	1
Dipterocarpaceae	*Shorea thorelii*	เต็งตานี	4
Ebenaceae	*Diospyros apiculata*	มะพลับไข่นก	1
Ebenaceae	*Diospyros buxifolia*	สั่งทำ	3
Ebenaceae	*Diospyros montana*	ถ่านไฟผี	2

Appendix Table C1 (Continued).

Family	**Scientific name**	**Thai name**	**No.**
Ebenaceae	*Diospyros transitoria*	พลับทอง	35
Ebenaceae	*Diospyros undulata*	หม้าย	5
Euphorbiaceae	*Antidesma* sp.	เม่าเหล็ก	1
Euphorbiaceae	*Aporosa aurea*	กระดูกค่าง	1
Euphorbiaceae	*Aporosa planchoniana*	พริกไทยดง	12
Euphorbiaceae	*Aporosa serrata*	เหมือดหยักขน	7
Euphorbiaceae	*Baccaurea ramiflora*	มะไฟ	27
Euphorbiaceae	*Chaetocarpus castanocarpus*	สำเภา	33
Euphorbiaceae	*Cleistanthus helferi*	นกนอน	16
Euphorbiaceae	*Croton* sp. 1	เปล้าก้านยาว	16
Euphorbiaceae	*Drypetes harmandii*	หมักฟัก	2
Euphorbiaceae	*Macaranga siamensis*	เต้าหลวง	2
Euphorbiaceae	*Mallotus calocarpus*	อูนป่าฤาไน	1
Euphorbiaceae	*Suregada multiflorum*	ขันทองพยาบาท	1
Fagaceae	*Lithocarpus thomsonii*	ก่อหอมสัน	2
Gentianaceae	*Fagraea fragrans*	กันเกรา	1
Guttiferae	*Calophyllum sp.*	พะองใบเล็ก	1
Guttiferae	*Garcinia cowa*	ชะมวง	9
Guttiferae	*Garcinia speciosa*	พะวา	7
Guttiferae	*Mammea siamensis*	สารภีป่า	1
Irvingiaceae	*Irvingia oliveri*	กระบก	10
Lauraceae	*Beilschmiedia*	มะเขือขื่นขนแดง	3
Lauraceae	*Beilschmiedia*	มะเขือขื่นต้นนวล	28
Lauraceae	*Cryptocarya* sp. 1	ขนาน	1

Appendix Table C1 (continued).

Family	Scientific name	Thai name	No.
Lauraceae	*Cryptocarya* sp. 2	-	2
Lauraceae	*Cryptocarya* sp. 3	-	6
Lauraceae	*Cryptocarya* sp. 4	-	1
Lauraceae	*Dehaasia candolleana*	สิไหร	8
Lauraceae	*Neolitsea* sp.	พิกุลป่า	1
Lauraceae	*Phoebe lanceolata*	จวงหอม	9
Leguminosae-Papilionoideae	*Millettia atropurpurea*	แซะ	5
Leguminosae-Papilionoideae	*Lagerstroemia calyculata*	ตะแบกแดง	18
Leguminosae-Papilionoideae	*Lagerstroemia tomentosa*	เสลา	1
Melastomataceae	*Memecylon* sp. 1	พลอง	1
Melastomataceae	*Memecylon* sp. 2	พลองใบใหญ่	39
Melastomataceae	*Memecylon* sp. 3	พลองขี้ควาย	3
Meliaceae	*Aglaia grandis*	ตาเสือทอง	31
Meliaceae	*Aglaia silvestris*	จันทร์ชะมด	35
Meliaceae	*Aglaia* sp.	ตาเสือ	14
Meliaceae	*Chisocheton* sp.	ตาเสือใบบาง	1
Meliaceae	*Dysoxylum andamanicum*	ค้างคาวอีหลิด	24
Meliaceae	*Dysoxylum* sp.	ตาแมว	1
Meliaceae	*Walsura pinnata*	พญาไก่เถื่อน	55
Moraceae	*Artocarpus* sp.	มะหาด	1

Appendix Table C1 (Continued).

Family	Scientific name	Thai name	No.
Moraceae	*Artocarpus* sp.	ยางน่องฤาไน	1
Moraceae	*Ficus subcordata*	ไทร	2
Moraceae	*Ficus subcordata*	ไทรกร่าง	2
Moraceae	*Ficus hispida*	มะเดื่อปล้อง	2
Myristicaceae	*Horsfieldia glabra*	มะพร้าวนกกก	3
Myristicaceae	*Knema cinerea*	เลือดควาย	42
Myristicaceae	*Knema* sp.	เลือดกวาง	1
Myristicaceae	*Knema* sp. 1	เลือดควาย กัดลิ้น	1
Myrsinaceae	*Ardisia elliptica*	พิลังกาสา	1
Myrtaceae	*Syzygium grande*	เมา	2
Myrtaceae	*Syzygium ripicola*	แหว้	5
Myrtaceae	*Syzygium sp.*	แดงดง	18
Oleaceae	*Olea rosea*	อวบขน	1
Opiliaceae	*Champereia manillana*	ผักแหวน	1
Rhizophoraceae	*Carallia brachiata*	เฉียงพร้านางแอ	1
Rubiaceae	*Neonauclea pallida*	ก้านเหลือง	21
Rubiaceae	*Prismatomeris fragrans*	อวบขาว	61
Rubiaceae	*Prismatomeris* sp.	เขี้ยวกระจง	3
Rubiaceae	*Rothmannia sootepensis*	สะแล่งหอมไก๋	9
Rutaceae	*Acronychia pedunculata*	กะอวม	1
Sapindaceae	*Harpullia cupanoides*	กะโปกม้า	4
Sapindaceae	*Litchi chinensis*	ลิ้นจี่ป่า	22
Sapindaceae	*Nephelium hypoleucum*	คอแลน	4
Sapindaceae	*Xerospermum noronhianum*	คอเหี้ย	201

Appendix Table C1 (Continued).

Family	**Scientific name**	**Thai name**	**No.**
Sapotaceae	*Palaquium obovatum*	ขนุนนก	1
Simaroubaceae	*Ailanthus triphysa*	ยมป่า	1
Sterculiaceae	*Heritiera javanica*	ชุมแพรก	24
Sterculiaceae	*Pterocymbium javanicum*	ปออีเก้ง	10
Sterculiaceae	*Pterospermum cinnamomeum*	ตองเต่า	25
Sterculiaceae	*Pterygota alata*	หัวกา	1
Sterculiaceae	*Scaphium macropodum*	สำรอง	30
Sterculiaceae	*Sterculia balanghas*	ปอขนุน	8
Symplocaceae	*Symplocos* sp.	เหมือดก้านม่วง	2
Theaceae	*Ternstroemia wallichiana*	ตำเสา	4
Thymelaeaceae	*Aquilaria crassna*	กฤษณา	1
Tiliaceae	*Microcos paniculata*	ลาย	1
Tiliaceae	*Microcos tomentosa*	พลับพลา	2
Tiliaceae	*Pentace burmanica*	สีเสียดเปลือก	2
Xanthophyllaceae	*Xanthophyllum sp.*	ชุมแสง	1
Total	108 species	Total	1137

Appendix Table C2 List of tree species and individuals in sampling area ($10,000\ m^2$) in moist evergreen forest (MEF).

Family	Scientific name	Thai name	No.
Anacardiaceae	*Buchanania sessifolia*	จิกรัก	3
Anacardiaceae	*Dracontomelon dao*	พระเจ้าห้าพระองค์	3
Anacardiaceae	*Mangifera cf. cochinchinensis*	มะม่วงไข่เลน	5
Anacardiaceae	*Semecarpus albescens*	รักขาว	7
Anacardiaceae	*Spondias pinnata*	มะกูก	1
Annonaceae	*Alphonsea boniana*	กล้วยค่าง	21
Annonaceae	*Cyathocalyx martabanicus*	สบันงวง	22
Annonaceae	*Enicosanthum membranaceum*	ยางเหลือง	3
Annonaceae	*Meiogyne hainanensis*	พริกหาง	2
Annonaceae	*Miliusa lineata*	อีแรด	8
Annonaceae	*Mitrephora thorelii*	มะป่วน	6
Annonaceae	*Orophea polycarpa*	จันเหลือง	2
Annonaceae	*Platymitra macrocarpa*	หำช้าง	10
Annonaceae	*Polyaslhia jucunda*	มะป่วนใบยาว	1
Annonaceae	*Pseuduvaria rugosa*	เหลืองกระจูก	3
Annonaceae	*Sageraea elliptica*	กะโมกเขา	5
Apocynaceae	*Alstonia scholaris*	ตีนเป็ด	1
Apocynaceae	*Hunteria zeylanica*	ตับเหลือง	4
Aquifoliaceae	aff. *Ilex* sp. 1	-	2
Bignoniaceae	*Markhamia pierrei*	แคป่า	9
Bignoniaceae	*Radermachera hainanensis*	ปีบทอง	6
Celastraceae	*cf. Siphonodon celastrineus*	มะดูกเปลือกเรียบ	1
Celastraceae	*Glyptopetalum sclerocarpum*	ช้องนาง	3
Celastraceae	*Lophopetalum cf. javanicum*	พวมพร้าว	1

Appendix Table C2 (Continued).

Family	Scientific name	Thai name	No.
Combretaceae	*Terminalia cf. citrina*	กล้วยขน	1
Datiscaceae	*Tetrameles nudiflora*	สมพง	5
Dilleniaceae	*Dillenia pentagyna*	ส้านช้าง	1
Dipterocarpaceae	*Dipterocarpus alatus*	ยางนา	2
Dipterocarpaceae	*Dipterocarpus turbinatus*	ยางแดง	2
Dipterocarpaceae	*Shorea guiso*	เต็งตานี	2
Ebenaceae	*Diospyros buxifolia*	สั่งทำ	3
Ebenaceae	*Diospyros rubra*	มะเกลือกา	39
Ebenaceae	*Diospyros transitoria*	มะพลับทอง	54
Ebenaceae	*Diospyros variegata*	พญารากดำ	6
Elaeocarpaceae	*Elaeocarpus lanceifolius*	ผีพ่าย	2
Euphorbiaceae	*Alchornea rugosa*	มะกีบ	21
Euphorbiaceae	*Antidesma bunius*	เม่าช้างแคบ	1
Euphorbiaceae	*Antidesma puncticulatum*	เม่าพั้ง	1
Euphorbiaceae	*Bischofia javensis*	เติม	1
Euphorbiaceae	*Chaetocarpus castanocarpus*	ดังข้าว	4
Euphorbiaceae	*Claoxylon indicum*	ขางน้ำเชื่อม	3
Euphorbiaceae	*Cleidion spiciflorum*	ดีหมี	12
Euphorbiaceae	*Excoecaria oppositifolia*	ตังตาบอด	14
Euphorbiaceae	*Glochidion assamicum*	ไคร้ป้อม	1
Euphorbiaceae	*Macaranga siamensis*	เต้าหลวง	1
Euphorbiaceae	*Mallotus peltatus*	สลัด	85
Euphorbiaceae	*Mallotus philippensis*	มะกายคัด	5
Euphorbiaceae	*Mallotus resinosus*	พูสลัก	7

Appendix Table C2 (Continued).

Family	Scientific name	Thai name	No.
Euphorbiaceae	*Suregada multiflorum*	ขันทองพยาบาท	2
Euphorbiaceae	*Trigonostemon albiflorus*	มะหมี่	18
Fagaceae	*Quercus* sp.	ก่อหยักขน	1
Flacourtiaceae	*aff. Hydnocarpus* sp.	กระเบากิ่งเหลือง	3
Flacourtiaceae	*Casearia flavovirens*	ขันเงิน	6
Flacourtiaceae	*Casearia grewiifolia*	กรวยกระ	7
Flacourtiaceae	*Flacourtia jangomas*	ตะขบใบเล็ก	1
Guttiferae	*Garcinia cowa*	ชะมวง	3
Guttiferae	*Garcinia rostrata*	นวล	2
Guttiferae	*Garcinia vilersiana*	มะพูด	1
Icacinaceae	*Gonocaryum lobbianum*	ดันหมี	4
Irvingiaceae	*Irvingia malayana*	กระบก	1
Labiatae	*Gmelina arborea*	ซ้อ	7
Labiatae	*Vitex gamosepala*	อีแปะ	5
Lauraceae	*Beilschmiedia brevipes*	หมีพี่เอิร์น	20
Lauraceae	*Beilschmiedia gammieana*	มะเขือขื่นหูแคบ	2
Lauraceae	*Cinnamomum iners*	เชียด	1
Lauraceae	*Cryptocarya pustulata*	หมากขี้อ้าย	2
Lauraceae	*Dehaasia kurzii*	สิไหรใบเล็ก	1
Lauraceae	*Dehaasia suborbicularis*	สิไหรใบใหญ่	1
Lauraceae	*Litsea umbellata*	สีฟัน	4
Lauraceae	*Phoebe paniculata*	สะทิบ	4
Leguminosae-Caesalpinioideae	*Saraca declinata*	โสกเขา	63
Leguminosae-Mimosoideae	*Adenanthera pavonina*	มะกล่ำต้น	1

Appendix Table C2 (Continued).

Family	Scientific name	Thai name	No.
Leguminosae-Mimosoideae	*Albizia lucidior*	ปันแถ	12
Leguminosae-Papilionoideae	*Dalbergia oliveri*	ชิงชัน	2
Leguminosae-Papilionoideae	*Erythrina subumbrans*	ทองหลางป่า	2
Leguminosae-Papilionoideae	*Millettia erythrocatyx*	ขะเจ๊าะ	7
Magnoliaceae	*Magnolia liliifera*	ยี่หุบปลี	1
Melastomataceae	*Memecylon aff. merguicum*	พลองแขนง	2
Melastomataceae	*Memecylon ovatum*	พลองกินลูก	2
Meliaceae	*Aglaia cf. eximia*	สังเครียด	3
Meliaceae	*Aglaia edulis*	เสือล่อน	22
Meliaceae	*Aglaia elaeagnoidea*	กระดูกเขียด	6
Meliaceae	*Aglaia silvestris*	จันทน์ชะมด	10
Meliaceae	*Chisocheton ceramicus*	ยมมะกอก	1
Meliaceae	*Chukrasia tabularis*	ยมหิน	4
Meliaceae	*Dysoxylum alliaceum*	ค้างคาว	15
Meliaceae	*Dysoxylum cauliflorum*	ตาเสือ	11
Meliaceae	*Dysoxylum* sp.	ยมปลายคี่	1
Meliaceae	*Sandoricum koetjape*	กระท้อนป่า	3
Meliaceae	*Walsura pinnata*	กัดลิ้นใบใหญ่	13
Meliaceae	*Walsura robusta*	กัดลิ้นใบเล็ก	6
Moraceae	*Artocarpus gomezianus*	มะหาดเล็ก	7
Moraceae	*Artocarpus lacucha*	มะหาดเล็กมีขน	2
Moraceae	*Artocarpus nitidus*	ไทรเบี้ยว	3
Moraceae	*Artocarpus rigidus*	มะหาดสาก	3
Moraceae	*Ficus capillipes*	มะเดื่อไฟ	3

Appendix C2 (Continued).

Family	**Scientific name**	**Thai name**	**No.**
Moraceae	*Ficus fistulosa*	ชิ้ง	1
Moraceae	*Ficus hispida*	มะเดื่อปล้อง	3
Moraceae	*Ficus Kurzii*	ไทรย้อยแกนแบน	1
Myristicaceae	*Horsfieldia glabra*	มะพร้าวนกกก	2
Myristicaceae	*Knema elegans*	เลือดควาย	15
Myrtaceae	*Syzygium grande*	หว้าใบจุด	1
Myrtaceae	*Syzygium siamense*	ชมพู่น้ำ	3
Oleaceae	*Chionanthus mala - elengi*	อวบดำ	1
Rhizophoraceae	*Carallia brachiata*	เฉียงพร้านางแอ	2
Rosaceae	*Prunus cf. arborea*	นู้ดต้น	10
Rubiaceae	*Anthocephalus chinensis*	กระทุ่มน้ำ	2
Rubiaceae	*Pavetta graciliflora*	ตองแตก	1
Rubiaceae	*Rothmannia cf. sootepensis*	ค่างเต้นหลีบ	5
Rubiaceae	*Tarenna hoaensis*	เข็มเหนี่ย	1
Rubiaceae	*Tarennoidea wallichii*	คอไก่	1
Rutaceae	*Acronychia pedunculata*	กะอวม	1
Rutaceae	*Atalantia monophylla*	ส้มข่อย	3
Rutaceae	*Clausena excavata*	สันโสก	1
Rutaceae	*Glycosmis* sp.	เขยใหญ่	1
Sapindaceae	*Dimocarpus longan*	ลำไยป่า	7
Sapindaceae	*Harpullia cupanioides*	หงอนไก่แดง	8
Sapindaceae	*Litchi chinensis*	สีรามัน	2
Sapindaceae	*Xerospermum noronhianum*	คอเหี้ย	27
Sapindaceae	*Palaguium obovatum*	ขนุนนก	1

Appendix C2 (Continued).

Family	**Scientific name**	**Thai name**	**No.**
Simaroubaceae	*Picrasma javanica*	กอมขม	22
Staphyleaceae	*Turpinia pomifera*	มะกอกพราน	7
Sterculiaceae	*cf. Sterculia*	หงอนก่วม	3
Sterculiaceae	*Pterocymbium tinctorium*	ปออีเก้ง	17
Sterculiaceae	*Pterospermum diversifolium*	ลำป้าง	13
Sterculiaceae	*Pterospermum littorale*	ขนาน	1
Sterculiaceae	*Pterygota alata*	หัวกา	24
Sterculiaceae	*Scaphium scaphigerum*	สำรอง	43
Sterculiaceae	*Sterculia parviflora*	ปอแดงเกลี้ยง	2
Thymelaceae	*Aquilaria crassna*	กฤษณา	11
Ulmaceae	*Aphananthe cuspidata*	กรวยแหลม	4
Ulmaceae	*Celtis timorensis*	แก้งขี้พระร่วง	5
Ulmaceae	*Holoptelea integrifolia*	กระเชา	1
Ulmaceae	*Ulmus lancaefolia*	ลูบลีบ	2
Urticaceae	*Dendrocnide stimulans*	แว่น	11
Total	135 species	Total	969

Appendix Table C3 List of tree species and individuals in sampling area ($10,000\ m^2$) in hill evergreen forest (HEF).

Family	Scientific name	Thai name	No.
Anacardiaceae	*Mangifera cf. cochinchinensis*	ซางช้อน	4
Anacardiaceae	*Bouea oppositifolia*	มะปริง	5
Annonaceae	*Sageraea elliptica*	กะโมกเขา	2
Annonaceae	*Polyaslhia jucunda*	มะป่วนใบยาว	2
Annonaceae	*Cyathocalyx martabanicus*	สบันงวง	1
Annonaceae	*Pseuduvaria rugosa*	เหลืองกระจุก	3
Annonaceae	*Miliusa lineata*	อีแรด	1
Apocynaceae	*Hunteria zeylanica*	ตับเหลือง	13
Caprifoliaceae	*Viburnum sambucinum*	เข็มสามเส้น	3
Celastraceae	*Lophopetalum duperreanum*	ชมพู่กิ่งเหลี่ยม	1
Celastraceae	*cf. Euonymus* sp.	ชะมวงกวาง	1
Combretaceae	*Terminalia bellirica*	สมอพิเภก	1
Dipterocarpaceae	*Anisoptera costata*	กระบากพลวง	4
Dipterocarpaceae	*Hopea odorata*	ตะเคียนเบี้ยว	2
Dipterocarpaceae	*Shorea thorelii*	เต็งตานี	15
Dipterocarpaceae	*Hopea helferi*	ทะลอก	1
Dipterocarpaceae	*Shorea hypochra*	พนอง	14
Dipterocarpaceae	*Vatica harmandiana*	พันจำ	4
Dipterocarpaceae	*Dipterocarpus turbinatus*	ยางแดง	1
Dipterocarpaceae	*Dipterocarpus costatus*	ยางปาย	4
Ebenaceae	*Diospyros variegata*	พญาใบบาง	1
Ebenaceae	*Diospyros pendula*	มะพลับขาง	12
Ebenaceae	*Diospyros sp.*	ลูกอินทร์ป่า	48
Elaeocarpaceae	*Elaeocarpus lanceifolius*	ผีพ่าย	3

Appendix Table C3 (Continued).

Family	Scientific name	Thai name	No.
Elaeocarpaceae	*Elaeocarpus petiolatus*	มุ่นคมสัน	7
Elaeocarpaceae	*Elaeocarpus sphaericus*	มุ่นโซฟี	1
Elaeocarpaceae	*Elaeocarpus robustus*	สะท้อนรอกเกลี้ยง	2
Euphobiaceae	*Glochidion hypoleucum*	เก็ดขาว	1
Euphobiaceae	*Suregada multiflorum*	ขันทองพยาบาท	2
Euphobiaceae	*Chaetocarpus castanocarpus*	ดังข้าว	8
Euphobiaceae	*Cleistanthus myrianthus*	ทุเรียนนก	1
Euphobiaceae	*Croton kongkandanus*	ปริก	1
Euphobiaceae	*Balakata baccata*	โพบาย	2
Euphobiaceae	*Bridelia insulana*	มะกาต้น	1
Euphobiaceae	*Baccaurea ramiflora*	มะไฟพลวง	1
Euphobiaceae	*Baccaurea parviflora*	มะไฟรี	2
Euphobiaceae	*Antidesma cuspidatum*	เม่าปิด	20
Euphobiaceae	*Mallotus paniculatus*	สอยดาว	7
Euphobiaceae	*Drypetes cambodica*	หมักขะแม	3
Euphobiaceae	*Microdesmis Caseariifolia*	หมักฟักหยัก	25
Euphobiaceae	*Antidesma montanum*	หอกปิด	4
Fagaceae	*Castanopsis piriformis*	ก่อเบี้ยว	19
Flacourtiaceae	*Casearia grewiifolia*	กรวยกระ	1
Flacourtiaceae	*Hydnocarpus aslhelminthicus*	กระเบาเบี้ยว	2
Flacourtiaceae	*Casearia flavovirens*	ขันเงิน	4
Flacourtiaceae	*Scolopia spinosa.*	ตะขบพลวง	1
Flacourtiaceae	*Ryparosa cf. javanica*	ปอท้องขาว	10
Guttiferae	*Garcinia nigrolineata*	ชะมวงก้านยาว	2

Appendix Table C3 (Continued).

Family	Scientific name	Thai name	No.
Guttiferae	*Calophyllum polyanthum*	ตังหนใบแคบ	5
Guttiferae	*Garcinia rostrata*	นวล	12
Guttiferae	*Garcinia vilersiana*	มะพูด	4
Guttiferae	*Garcinia hanburyi*	รง	12
Icacinaceae	*Gonocaryum lobbianum*	ดันหมี	81
Lauraceae	*Actinodaphne cf. angustifolia*	ตองลาด	3
Lauraceae	*Actinodaphne sesquipedalis*	ตองลาดใบใหญ่	2
Lauraceae	*Litsea myristicaefolia*	ท้องขาว	9
Lauraceae	*Phoebe paniculata*	สะทิบ	2
Lauraceae	*Dehaasia Kurzii*	สิไหร	5
Lauraceae	*cf. Endiandra macrophylla*	หมีขาง	1
Lauraceae	*cf. Cryptocarya albiramea*	หมีพลู	2
Lauraceae	*Beilschmiedia brevipes*	หมีพี่เอิร์น	6
Lauraceae	*Cinnamomum* sp.	อบแข็ง	2
Lecythidaceae	*Barringtonia racemosa*	จิกน้ำ	13
Lecythidaceae	*Barringtonia angusta*	จิกใหญ่	18
Leguminosae-Caesalpinioideae	*Saraca declinata*	โสกเขา	13
Leguminosae-Mimosoideae	*Adenanthera pavonina*	มะกล่ำต้น	3
Leguminosae-Mimosoideae	*Parkia sumatrana*	สะตอพลวง	1
Leguminosae-Mimosoideae	*Archidendron quocense*	หย่อง	170
Magnoliaceae	*Michelia baillonii*	จำปีป่า	1

Appendix Table C3 (Continued).

Family	Scientific name	Thai name	No.
Magnoliaceae	*Magnolia liliifera*	ยี่หุบปรี	14
Melastomataceae	*Memecylon ovatum*	พลองกินลูก	27
Meliaceae	*Aglaia elaeagnoidea*	กระดูกเขียด	3
Meliaceae	*Walsura pinnata*	กัดลิ้นใบใหญ่	12
Meliaceae	*Dysoxylum alliaceum*	ค้างคาว	7
Meliaceae	*Dysoxylum cauliflorum*	ตาเสือ	3
Meliaceae	*Dysoxylum* sp.	ยมปลายคี่	2
Meliaceae	*Chisocheton patens*	ยมมะกอก	1
Meliaceae	*Aglaia cf. eximia*	สังเครียด	7
Meliaceae	*Aglaia silvestris*	สังเครียดก้านแดง	2
Meliaceae	*Aglaia edulis*	เสือล่อน	7
Moraceae	*Artocarpus rigidus*	ขนุนปาน	12
Moraceae	*Ficus fistulosa*	ชิ้งเหลือบ	2
Moraceae	*Artocarpus nitidus*	ไทรเบี้ยว	10
Moraceae	*Ficus vasculosa*	ไทรยอดม่วง	1
Moraceae	*Artocarpus lacucha*	มะหาดเล็กมีขน	2
Myristicaceae	*Myristica iners*	จันทน์แดง	1
Myristicaceae	*Horsfieldia glabra*	มะพร้าวนกกก	28
Myristicaceae	*Knema latericia*	เลือดควายใบเล็ก	85
Myristicaceae	*Knema cf. andamanica*	เลือดควายใบใหญ่	27
Myrsinaceae	*Ardisia colorata*	ตาสี	2
Myrsinaceae	*Ardisia helferiana*	มะเขือขน	1
Myrtaceae	*Syzygium* sp.	ชมพู่นก	3
Myrtaceae	*Syzygium pseudoformosum*	ชมพู่น้ำ	10

Appendix Table C3 (Continued).

Family	Scientific name	Thai name	No.
Myrtaceae	*Syzygium syzygioides*	เสม็ดแดง	7
Myrtaceae	*Syzygium cf. polyanthum*	หว้าเขียวเข้ม	4
Myrtaceae	*Cleistocalyx nervosum*	หว้าเน่าใน	6
Myrtaceae	*Syzygium lineatum*	หว้าพลอง	1
Myrtaceae	*Syzygium grande*	หว้าหิน	2
Myrtaceae	*Syzygium attenuatum*	หว้าอ่างกา	11
Oleaceae	*cf. Chionanthus* sp.	อวบก้านเหลือง	3
Podocarpaceae	*Nageia wallichiana*	ขุนไม้	5
Proteaceae	*Heliciopsis terminalis*	เหมือดคนดง	1
Rosaceae	*Prunus arborea*	นู้ดขน	2
Rosaceae	*Prunus javanica*	นู้ดบ่อง	2
Rubiaceae	*Neonauclea pallida*	กระทุ่มเขา	8
Rubiaceae	*Ixora nigricans*	เข็มปิด	5
Rubiaceae	*Aidia parviflora*	เข็มหอก	1
Rubiaceae	*Metadina trichotoma*	แข้งพลวง	2
Rubiaceae	*Canthium glabrum*	ค่างเต้นขน	1
Rubiaceae	*Pavetta graciliflora*	ตองแตก	1
Rubiaceae	*Rothmannia cf. sootepensis*	แสล่งหอมไก๋	5
Rutaceae	*Glycosmis pierriei*	เขยคาว	2
Sapindaceae	*Nephelium cf. melliferum*	คอลำไย	7
Sapindaceae	*Xerospermum noronhianum*	คอเหี้ย	19
Sapindaceae	*Litchi chinensis*	สีรามัน	3
Sapotaceae	*Palaguium obovatum*	ขนุนนก	31
Sapotaceae	*Madhuca cf. floribunda*	พิกุลโล้	1

Appendix Table C3 (Continued).

Family	Scientific name	Thai name	No.
Sapotaceae	*Sarcosperma arboreum*	มะยาง	1
Simaroubaceae	*Eurycoma longifolia*	ปลาไหลเผือก	8
Sterculiaceae	*Heritiera sumatrana*	ชุมแพรก	14
Sterculiaceae	*Sterculia balanghas*	ปอขนุน	9
Sterculiaceae	*Sterculia parviflora*	ปอแดงเกลี้ยง	5
Sterculiaceae	*Pterocymbium tinctorium*	ปออีเก้ง	1
Sterculiaceae	*Scaphium scaphigerum*	สำรอง	182
Sterculiaceae	*Pterygota alata*	หัวกา	1
Symplocaceae	*Symplocos cochinchinensis*	เหมือดหลวง	3
Theaceae	*Schima wallichii*	ทะโล้	3
Theaceae	*Ternstroemia wallichiana*	ลำพอง	7
Thymelaeaceae	*Aquilaria crassna pierre*	กฤษณา	5
Tiliaceae	*Microcos paniculata*	พลับพลาแฉก	17
Ulmaceae	*Gironniera subequalis*	ขี้หนอนควาย	21
Xanthophyllaceae	*Xanthophyllum flavescens*	ไม้นกค่อ	12
Total	132 species	Total	1326

Appendix Table C4 List of tree species and individuals in sampling area ($10{,}000\ m^2$) in secondary mixed deciduous forest (SMDF).

Family	Scientific Name	Thai name	No.
Annonaceae	*Anomianthus dulcis*	นมวัว	5
Annonaceae	*Uvaria dac*	กล้วยอีเห็น	8
Bignoniaceae	*Stereospermum fimbriatum*	แคทราย	7
Celastraceae	*Siphonodon celastrineus*	มะดูก	2
Combretaceae	*Terminalia triptera*	ขี้อ้าย	1
Dipterocarpaceae	*Dipterocarpus turbinatus*	ยางแดง	11
Ebenaceae	*Diospyros bejaudii*	พลับดง	9
Ebenaceae	*Diospyros hasseltii*	ตะโก (กระทุ่มบก)	1
Euphorbiaceae	*Antidesma* sp.	มะเม่า	5
Euphorbiaceae	*Aporusa plannchoniana*	พริกไทยดง	1
Euphorbiaceae	*Aporusa serrata*	เหมือดหยักขน	1
Euphorbiaceae	*Baccaurea* sp.	มะไฟป่า	3
Euphorbiaceae	*Bridelia tomentosa*	มะแก	1
Euphorbiaceae	*Mallotus subpeltatus*	แร้ว	3
Euphorbiaceae	*Suregada multiflorum*	ขันทองพยาบาท	24
Flacourtiaceae	*Hydnocarpus ilicifolia*	กระเบากลัก	3
Guttiferae	*Calophyllum inophyllum*	กระทิงป่า	1
Guttiferae	*Cratoxylum maingayi*	แต้ว	1
Guttiferae	*Garcinia speciosa*	พะวา	2
Irvingiaceae	*Irvingia oliveri*	กระบก	1
Labiatae	*Tectona grandis*	สัก	8
Labiatae	*Vitex pinnata*	สมอหิน	1
Lauraceae	*Litsea glutinosa*	หมีเหม็น	1
Lauraceae	*Phoebe paniculata*	สะทิบ	5

Appendix TableC4 (Continued).

Family	**Scientific Name**	**Thai name**	**No.**
Leguminosae	*Peltophorum pterocarpum*	นนทรี	8
Leguminosae	*Pterocarpus macrocarpus*	ประดู่	18
Leguminosae-Mimosoideae	*Samanea saman*	ก้ามปู	1
Leguminosae-Papilionoideae	*Dalbergia cochinchinensis*	พะยูง	2
Loganiaceae	*Mitrasacme thorelii*	ลำดวนป่า	8
Lythraceae	*Lagerstroemia cuspidata*	ตะแบก	20
Lythraceae	*Lagerstroemia venusta*	ติ้ว	69
Melastomataceae	*Memecylon cyaneum*	พลองใบใหญ่	4
Melastomataceae	*Memecylon geddesianum*	พลองใบเล็ก	1
Meliaceae	*Chukrasia tabularis*	ยมหิน	2
Meliaceae	*Melia azedarach .*	เลี่ยน	2
Moraceae	*Ficus callosa*	มะเดื่อต้น	2
Moraceae	*Ficus hispida*	มะเดื่อปล้อง	13
Moraceae	*Streblus ilicolius*	ข่อยหนาม	3
Myrtaceae	*Syzygium cumini*	หว้า	1
Myrtaceae	*Syzygium hemsleyanum*	หว้าใบเล็ก	23
Myrtaceae	*Syzygium pergamentaceum*	หว้าใบใหญ่	8
Orchidaceae	*Dendrobium pensile*	หวาย	3
Palmae	*Licuala spinosa*	กะพ้อ	1
Rhamnaceae	*Ziziphus oenoplia*	หนามเล็บแมว	1
Rhizophoraceae	*Carallia brachiata*	เฉียงพร้านางแอ	5
Rubiaceae	*Hymenodictyon orixense*	ส้มกบ	1
Rubiaceae	*Ixora cibdela*	เข็มป่า	3

Appendix Table C4 (Continued).

Family	**Scientific Name**	**Thai name**	**No.**
Rubiaceae	*Neonauclea calycina*	ลิ้นกวาง	5
Rutaceae	*Micromelum minutum*	หัสคุณ	5
Sapindaceae	*Lepisanthes rubiginosa*	มะหวด	9
Sapindaceae	*Nephelium melliferum*	คอแลน	9
Simaroubaceae	*Ailanthus triphysa*	ยมป่า	24
Sterculiaceae	*Pterospermum littorale*	ขนาน	75
Tilaceae	*Microcos tomentosa*	ม้าลาย (พลับพลา)	28
Zingiberaceae	*Zingiber zerumbet*	กระทือ	1
Total	55 species	Total	460

Appendix Table C5 List of tree species and individuals in sampling area (10,000 m^2) in teak plantation (TP).

Family	**Scientific name**	**Thai name**	**No.**
Anacardiaceae	*Spondias bipinnata*	มะกอกป่า	1
Anacardiaceae	*Spondias pinnata*	มะกอก	1
Bignoniaceae	*Dolichandrone serrulata*	แคขาว	1
Labiatae	*Tectona grandis* L.	สัก	36
Lauraceae	*Litsea glutinosa*	หมีเหม็น	5
Leguminosae-Caesalpinioideae	*Bauhinia bassacensis*	เถาบันไดลิง	2
Leguminosae-Caesalpinioideae	*Senna garrettiana*	แสมสาร	10
Leguminosae-Mimosoideae	*Acacia catechu*	สีเสียดแก่น	1
Leguminosae-Mimosoideae	*Albizia procera*	ถ่อน	4
Leguminosae-Mimosoideae	*Leucaena leucocephala*	กระถิน	2
Leguminosae-Mimosoideae	*Parkia sumatrana*	มะขามเฒ่า	11
Leguminosae-Mimosoideae	*Xylia xylocarpa*	แดง	4
Leguminosae-Papilionoideae	*Dalbergia nigrescens*	ฉนวน	16
Leguminosae-Papilionoideae	*Pterocarpus macrocarpus*	ประดู่	22
Leguminosae-Papilionoideae	*Tadehagi triquetrum*	ข้าวเม่า	7
Lythraceae	*Lagerstroemia calyculata*	ตะแบกแดง	1
Lythraceae	*Lagerstroemia cuspidata*	ตะแบก	3
Lythraceae	*Lagerstroemia macrocarpa*	อินทนิลบก	1
Lythraceae	*Lagerstroemia venusta*	ติ้ว	3
Moraceae	*Ficus callosa*	มะเดื่อต้น	4
Moraceae	*Ficus hispida*	มะเดื่อปล้อง	2
Moraceae	*Streblus asper*	ข่อย	41
Opiliaceae	*Champereia manillana*	ผักหวานป่า	1

Appendix Table C5 (Continued).

Family	Scientific name	Thai name	No.
Opiliaceae	*Melientha suavis*	ผักหวาน	4
Rhamnaceae	*Ziziphus oenoplia*	หนามเล็บเหยี่ยว	1
Sapindaceae	*Lepisanthes rubiginosa*	มะหวด	115
Simaroubaceae	*Harrisonia perforata*	หนามคนทา	10
Sterculiaceae	*Reevesia pubescens*	โมลี	1
Total	28 species	Total	310

Appendix Table D Two-way ANOVA of microenvironmental variables in different forest habitats in eastern Thailand.

Soil moisture

Source	**df**	**Sum of square**	**Mean square**	***F-ratio***	***P.***
Habitat	4	2047.493	511.873	16.976	0.001
Season	1	2420.290	2420.290	80.266	0.001
Habitat X season	4	357.058	89.265	2.960	0.04
Error	20	603.067	30.153		
Total	30	19775.940			

pH

Source	**df**	**Sum of square**	**Mean square**	***F-ratio***	***P.***
Habitat	4	2.549	0.637	15.166	0.001
Season	1	0.010	0.010	0.249	0.623
Habitat X season	4	0.270	0.068	1.609	0.211
Error	20	0.840	0.042		
Total	30	1225.823			

Appendix Table D (Continued).

Canopy cover

Source	**df**	**Sum of square**	**Mean square**	***F-ratio***	***P.***
Habitat	4	3845.650	961.413	7.671	0.001
Season	1	84.202	84.202	0.672	0.422
Habitat X season	4	464.063	116.016	0.926	0.469
Error	20	2506.531	125.327		
Total	30	228405.646			

Litter weight

Source	**df**	**Sum of square**	**Mean square**	***F-ratio***	***P.***
Habitat	4	6.330	1.582	8.335	0.001
Season	1	0.106	0.106	0.556	0.464
Habitat X season	4	0.806	0.201	1.061	0.402
Error	20	3.797	0.190		
Total	30	80.838			

CIRRICULUM VITAE

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