Comparison of biodiversity between plantation and natural forests in Sabah using moths as indicators

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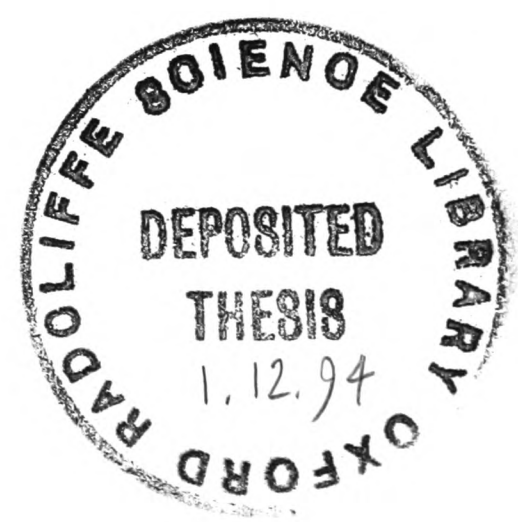

ABSTRACT

Comparison of biodiversity between plantation and natural forests in Sabah using moths as indicators.

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The Malaysian state of Sabah, in northern Borneo, started massive monoculture forest plantations of fast-growing introduced tree species in the mid-1970's to replace part of the harvested tropical rain forest. Many people, particularly conservationists in the West, are very much against this sort of reforestation as they fear it would spell a permanent loss to the Bornean rain forest biodiversity. This project was carried out at the more established forest plantations of Sabah Softwoods *Sdn. Bhd.* in Brumas from 1991 to 1993, where fast-growing exotics namely *Acacia mangium*, *Eucalyptus deglupta*, *Gmelina arborea*, *Paraserianthes* (=*Albizia*) *falcataria*, *Pinus caribaea*, were studied to assess their biodiversity and these plantations were compared with the natural regenerating logged-over secondary forest in Brumas, as well as the primary forest in Danum Valley, by using light-trapped macromoths as indicators. The method of light-trapping as a reliable means of capturing moths was supported by canopy knockdown in the form of mist-blowing.

Results obtained showed that for the year-long (January-December 1991) light-trap samples, the biodiversity values, as represented by Williams alpha (higher the value, higher the diversity), were unexpectedly high in the various plantation forests. Their alpha values ranged from the lowest in *Acacia mangium* with 208.14+-9.22, to the highest in *Eucalyptus deglupta* with 330.85+-16.37 which was even higher than the natural secondary forest with 314.53+-11.99, and certainly not inferior to the published values (300 to 350) from undisturbed Bornean forest of similar altitudes (below 500m). For the shorter month-long subsidiary samples (October/November 1992, January/February 1993), the alpha values of the samples from the lowland primary forest in Danum were not necessarily higher when compared with the similarly sampled disturbed forest habitats in Brumas, but despite its small samples, Danum produced some 33 species of macromoths which were never collected out of the 1680 species obtained from Brumas in the entire project.

The main reason behind the surprisingly good diversity measures (as indicated by moths) in these forest plantations was the presence of an understorey of varying diversity under the canopy. It would appear that with the fast-growing introduced trees acting as light-demanding pioneers, many plant species ranging from herbs, shrubs, to saplings of native tree species, managed to germinate and grow more or less efficiently in the understorey. *Eucalyptus deglupta* had a more diverse understorey both in terms of plant species and architecture, which in turn supported a more diverse moth fauna. These findings are encouraging in terms of biodiversity conservation, as plantation forestry seems to be the only way forward for many developing countries like Malaysia.

PREFACE & ACKNOWLEDGMENTS

The seeds of this project were sown in the autumn of 1990. At that time I was finishing my postgraduate diploma at Cardiff, which involved a pilot study on the moth fauna found in the plantation forests of Sabah. Dr Jeremy Holloway at the International Institute of Entomology told me the study showed promise, and that I could further it into a doctorate project at Oxford, working under Dr Martin Speight. So before I returned home that autumn, I went to see Dr Speight at Oxford, and was astounded by his support and friendliness. I knew then I wanted to do this project, even though I knew not where I could obtain funding.

Nonetheless back in Sabah I began my fieldwork in earnest. My employer Datuk Miller Munang, Director of Sabah Forestry Department, when told of my proposed research was most supportive, and gave me much encouragement. The Senior Research Officer at Sepilok Mr Lee Ying Fah also allowed me much freedom to pursue the project without encumbering me with the usual official duties. A few months later I finally obtained a scholarship jointly from the British High Commision in Kuala Lumpur and the Sabah State Government, my two sponsors to whom I am grateful.

From the beginning of the project until its completion many people have given me help and assistance in various ways. I am thankful to my entomology team back in Sepilok for helping me with my fieldwork at Brumas, in particular Mr Saikeh Lantoh and Mr Momin Binti. I also would like to thank Mr Patrick Cassels, Managing Director of Sabah Softwoods *Sdn. Bhd.*, for permitting me to conduct the research at Brumas, and to Mr Edward Chia the Research Manager I owe a special gratitude. He supplied me with much background information on my sampling sites, and always made me feel welcome whenever I called on him.

For the botanical survey I am grateful to Dr Wong Khoon Meng, Senior Botanist at Sepilok, for his useful suggestions on survey method. His herbarium staff in particular Mr Leopold Madani also helped me enormously in plant identifications. Another colleague of mine Mr Arthur Chung identified my ant specimens. To them and all my colleagues at Sepilok I am thankful.

Over here in England my work revolved round Oxford and London. The people in the Oxford Zoology Department especially those in the same laboratory as me have also helped me in one way or another. Dr Andy Bennett and Dr Andy Foggo often came to my aid when I faced difficulties in using the computer. Mr Steve Roberts and Mr Paul Embden allowed me to turn their office into a dark room for work on fluorescent particles, in this and many other ways they both have shown me their generosity. Also Mr Clive Hambler, Mr Martin Mbai, Mr Frederic Casella, Ms Ruth Levy, Dr Claire Ozanne, Dr Andy Richards, Ms Kate Wilson, Ms Jurie Intachat, and Mrs Rosie Fisher, they all have given me support and encouragement.

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My deepest gratitute goes to my two supervisors, Dr Martin Speight here in Oxford and Dr Jeremy Holloway in London. Dr Speight has shown me much kindness throughout the project, and has been a great source of inspiration and encouragement. Under his tutelage the project took on a different course from what I had envisaged in the beginning, and from him I have learnt the importance of independent thinking in scientific research, unfettered by half-truths and dogmas. To Dr Jeremy Holloway I owe a debt which cannot be repaid. He made available to me much of his material, and has constantly shown great interest in my work. I am most grateful to him for his immense support throughout the entire project, and most of all for inculcating in me a genuine love for my research work.

Chey Vun Khen,
autumn of 1994

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 Biodiversity in Bornean tropical rain forest

Borneo, the third largest island in the world, contains one of the oldest and richest tropical rain forest habitats. The term 'tropical rain forest' originated from *tropische Regenwald* which was coined by Schimper (1898), with the definition 'evergreen, hygrophilous in character, at least 30m high, rich in thick-stemmed lianes, and in woody as well as herbaceous epiphytes.' For many years, many Westerners had the inclination to imagine the forest in Borneo as wild and dangerous, a place only fit for inhabitation of head-hunters and such savagery. The prominent explorer naturalist Alfred Russel Wallace in his masterpiece 'The Malay Archipelago' (1869) further confirmed such conviction in the West, but at the same time fired the imagination of many others, amongst them dedicated naturalists who had to surmount overwhelming odds to travel to Borneo, seeking out new and unusual species of flora and fauna. For until the turn of the Twentieth Century the island of Borneo remained vastly unexplored, a treasure trove for those in search of natural history, as well as romance and adventure.

Globally, tropical rain forest covers only about 6% of the world's surface area, but houses half of the world's animal and plant species, including 70-75% of all known arthropods (Mabberley, 1983). It is of general consensus that Borneo is the centre of species diversity in tropical Asia, being exceptionally rich in endemics, and her geologically young terrain shows high edaphic heterogeneity which may represent a Pleistocene refugium (Ashton, 1989). For example, a plot size of just 2 hectares in the ridge forest of the Sepilok Forest Reserve

in the northern Bornean state of Sabah can contain up to 198 tree species, with 667 trees (diameter at breast height >= 10 cm) per hectare (Paijmans, 1976).

Over the past several years the word 'biodiversity' has been very much in vogue, and constantly affiliated with tropical rain forest. Biodiversity, being the amalgamation of biological diversity, may best be defined at the species level by 'species richness' and 'species evenness'. Species richness is the number of species present in a community, and species evenness incorporates the commonness and rarity of species (Begon *et al.*, 1990). Species diversity takes into account both species richness as well as the evenness with which individuals in the community are distributed among the species. Richness of food resources coupled with the relative constancy of environmental conditions all year round has given the tropical rain forest the greatest diversity of animal life of any biome (Cox *et al.*, 1976). The presence of an extremely rich insect fauna closely reflects the vast diversity of vegetation in the Bornean rain forest.

1.2 Insect diversity in relation to plant diversity

Southwood (1978a) listed the general components of insect diversity: a) metamorphosis which provides temporal separation important in both sympatric speciation and niche separation, b) possession of wings which increases the colonization rate (spread potential) with subsequent endemism (after allopatric speciation), c) their small size and trivial ranges enabling them to specialize for a particular local combination of resources, d) short generation times hence faster rates of adaptation, and e) an important component, the adaptation to living on and feeding on vegetation. Many insects are phytophagous, some are polyphagous with a wider niche breadth feeding on different species of plants e.g. colonizers characteristic of early succession, with some being family specific e.g. *Condica illecta* Walker on Compositae,

Mythimna spp. on Gramineae, while others are more host-plant specific with feeding preferences for a more narrow range of plant species. How the close links in coevolution arose between plant and insect can only be surmised. The first land plants are believed to have evolved in the Devonian, and the first phytophagous insects are known from the following Carboniferous period. Since then reciprocal adaptation and counteradaptation between plants and insect phytophages has been a vital mechanism giving rise to a steady increase in plant and insect diversity (Strong *et al.*, 1984). Out of the 1.4 million living species of organisms which have been described, about 750,000 are insects, and 250,000 are plants (Wilson, 1988).

The determinants of insect diversity in relation to plants are complex and varied. Apart from the species-area relationship which tries to explain why widespread species of plants are hosts for more insect species, the vegetation's structural diversity, with both spatial and architectural components, is recognized (Southwood *et al.*, 1979; Speight & Wainhouse, 1989). The Bornean rain forest, with a far greater pot-pourri of plant species than any other forest, has a more diverse vegetation structure favouring greater insect diversity. Many plants in Borneo evince strange biochemical characteristics, some are known to possess medicinal properties while many others still await discovery, and some possess chemical defences against herbivory, the insect herbivores in turn develop counter-measures, all of which play a part in bringing about an exceedingly rich and diverse insect fauna.

Hence a major reason for the diversity of insect life in the Bornean rain forest is the rich diversity of plant life. Through the millenia its community of plants and animals develops together in succession under the evolutionary process of speciation resulting in abundant and myriad species each with its ecological niche, and ultimately achieves a 'climax'- a state of equilibrium where no drastic changes occur.

1.3 Deforestation

In 1953 more than 86% of Sabah (then British North Borneo) was under forest cover (Collins, 1990) but by 1992, only about 45% (33,486 km2) remained covered by natural forest (Sabah Forest Department, 1992). Factors which have exacerbated the destruction of her rain forest are many, and may best be explained by economical, social and political pressures.

Upon independence from Britain in 1963, Sabah together with another Bornean state Sarawak joined Malaya to form Malaysia. Being newly independent, the state was in dire need of funds for her developments. The most readily available source of revenue obviously lay with her rich natural resources, mainly timber from her natural rain forest. Sabah in particular contained huge areas of accessible natural forest with many highly marketable timber species, especially those of the family Dipterocarpaceae. With the advent of modern and sophisticated deforestation machinery the raping of her virgin forest went into full swing, and many were still either ignorant or unconcerned of the ensuing impacts on her environment.

Burgess (1961) pointed out the importance of wildlife conservation in Borneo, which is by itself a continental island, completely cut off by sea to the mainland of Asia since the last glaciation, and hence has a fauna which is particularly vulnerable, for there is no possibility of natural recruitment from the mainland of Asia should any species become extinct through man's activities. Yet the prevailing drive to eradicate economic poverty was so immense that it more or less obliterated other considerations. For in Sabah many children especially those in the more remote villages were still suffering from malnutrition, hygiene was poor, and health care appallingly inadequate.

It was not until the recent past that the Malaysian Government came under intense criticisms from international 'green' bodies which have generated much public awareness in the West about the importance of biodiversity conservation in tropical rain forest. Many

conservationists feared for the permanent loss of plant and animal species producing an irreplaceable diminution in biodiversity as a consequence of logging activities in the rain forest. Collins (1980) found that the termite species diversity drops drastically with felling of dipterocarp forests at Sawai in Sarawak, with many of the Rhinotermitinae, Termitinae, and Nasutitermitinae disappearing. Driscoll (1978) showed that bird populations in Papua New Guinea have decreased where logging has been heavy. Statistics for the global survival of the rain forest with its biodiversity are on the whole depressing. Brown (1985) reported that less than 5% of the tropical rain forest are protected within parks and reserves, with 4% of the forest being protected in Africa, 2% in Latin America, 6% in Asia, but even these are subject to political and economic pressures. In 1981 FAO/UNEP reported that about 20 hectares of tropical forest were converted or destroyed every minute, and for every 4 hectares of forest lost in the tropics, less than 0.4 hectares is developed as plantation forest or reforested in any way (OTA, 1984). By 1989, more than half of the prehistoric cover of the world's tropical rain forests had disappeared, with about 8 million square kilometres remaining (Wilson, 1992), which were being destroyed at the suicidal speed of 142,000 square kilometres per year, equal to the area of a football field every second.

The importance of rain forest conservation and the adverse effects of timber extraction upon its ecosystem cannot be stressed often enough. Apart from offering timber and wood products, tropical rain forest can supply a host of raw materials such as resins, oils, fibres and fruits; in addition it provides an exceptional variety of genetic resources, which contribute to modern agriculture, medicine, industry and energy. And on top of all that, it gives significant environment benefits in protection of the soil and safeguards for watershed systems. But the exploitation process for its hardwood timber is usually so disruptive that all these outputs are severely reduced (Myers, 1988). Even sustained harvesting of timber by selective logging

operations from rain forest is difficult without causing adverse changes in the forest ecosystem (Lamb, 1980).

1.4 Reforestation

In Sabah, the Government has been aware of the fact that its timbers are not an inexhaustible resource, and steps have been taken to counteract deforestation with various measures among which is reforestation. With the more fertile land allocated for agriculture in the form of oil palm, cocoa, as well as rubber plantations, the more impoverished logged-over areas are given to plantation forestry in growing exotic tree species. Several reasons were propounded for the choice of exotic rather than native trees. These chosen exotic species such as *Acacia mangium, Paraserianthes falcataria, Gmelina arborea* are fast-growing trees which can thrive on relatively poor soils, with a rotation age of just 10 years or so. Native timber species such as dipterocarps require 50 years or more to reach harvestable age, and have never been successfully grown in massive plantation. While the fast-growing exotics are 'softwoods' mainly used for pulp and paper or chip, the dipterocarps are 'hardwoods' which have excellent end-user properties and are highly valued for building and construction purposes.

In the mid-70's, plantation forestry started on a massive scale in Sabah, and by 1991, 64,165 hectares have been planted with mainly exotic fast-growing species, with 25,099 hectares in Brumas and Kalabakan under Sabah Softwoods *Sdn. Bhd.* (SSSB), 28,903 hectares mainly in Bengkoka under Sabah Forest Development Authority (SAFODA), and 10,163 hectares in Mendolong under Sabah Forest Industries (SFI) (Sabah Forest Department, 1992) (see Fig. 2.1). Many conservationists have their doubts over the contribution of this sort of reforestation towards conservation, and pessimistic forecasts by plantation-sceptics flourished. Prince Philip (1988) stated that massive plantations of exotic species are completely useless

to the native fauna, and the remaining native flora cannot survive in such plantations. Furthermore, exotic species may well have a different way of utilizing the available water, which may affect an area far greater than the plantation itself. Mabberley (1983) quoted the ill-fated Jari scheme in the Amazon in the 70's where establishment of exotic forest plantations for pulp such as *Gmelina, Eucalyptus* and pines failed, and the whole enormous project was eventually sold by the American businessman who set it up. Collins (1990) listed the various disadvantages of replacing natural rain forest with plantation: Firstly, the establishment of massive plantation is both expensive and difficult in terms of cost and labour, considering the extensive land clearance needed. Secondly, monoculture plantations are vulnerable to pests and diseases. And thirdly, some plantations in the humid tropics experienced soil nutrient limitation, which cannot be readily remedied by artificial fertilizers as in agicultural crops, and hence replacement of natural rain forest with plantations is a misguided policy from both conservation and economics point of view.

So far research on the effects on wildlife of replacing natural rain forest with exotic fast-growing tree plantations in Sabah concentrated solely on vertebrates. Davies (1981) surveyed the tree plantations of SSSB and reported the presence of a considerable abundance of some large mammals notably bearded pig (*Sus barbatus*) and barking deer (*Muntiacus muntjak*). Sheldon & Kennard (1982) found that in the *Paraserianthes* plantations of SSSB, some birds are extremely abundant and diverse, and may play an important role in limiting insect defoliation, but canopy bird species e.g. barbets, hornbills, pigeons, flycatchers are lacking (Sheldon, 1986). Duff *et al.* (1984) reported a shift in the mammalian composition in SSSB tree plantations from early colonizers such as rusa, barking deer, civets, leopard cats in the first two years after planting to later dominance by the bearded pig as the tree canopy closes, and that an island of logged-over natural forest within the plantations could serve as

a valuable refuge for wildlife, as it housed an abundance of other mammals including sunbear, clouded leopard and an exceptional density of gibbons. Stuebing & Gasis (1989) in their survey of small mammals within SSSB plantations found that *Maxomys whiteheadi* was most dominant in all plantation areas, followed by *Tupaia glis* and *T. tana*, but overall diversity and species biomass of small mammals are much lower in the plantations than in the logged forest. Most of these results on vertebrates seem to pinpoint the inferiority of plantations compared to natural forest. The scarcity of baseline information on the diversity of insect life in Sabah's exotic plantation forests makes it easy to embrace a plantation-sceptic viewpoint and dismiss offhand the conservation integrity of such reforestation. The aim of this project is to further investigate the impacts on her tropical ecosystem induced by such man-made forests, by using the diversity of moths as a detecting agent or indicator.

1.5 Moths as biological indicators

Moths and butterflies both belong to the same order Lepidoptera. They undergo complete metamorphosis with their larvae mostly phytophagous. Most butterflies and numerous moths are flower visitors, contributing towards pollination. Nielsen & Common (1991) defined adult Lepidoptera as haustellate, rarely mandibulate endopterygote Neoptera, without median ocellus, with two pairs of membranous wings, usually clothed on both surfaces with overlapping scales, their larvae eruciform, peripneustic or rarely holopneustic, their pupae rarely decticous, usually adecticous and obtect. The vast majority of moths are night-flying while butterflies are diurnal, and hence the major distinction between the two is behavioural rather than taxonomical. Moths are often grouped as either Macrolepidoptera (macromoths) which comprise mostly those of bigger size, or Microlepidoptera (micromoths) which are the smaller ones. All Macrolepidoptera belong to the suborder Ditrysia, members

of which possess a female genital opening (ostium) on sternum 8 separate from the ovipositor on sternum 9, and have dissimilar venation of fore- and hindwings (Holloway, 1986).

The common Macrolepidoptera superfamilies found in Borneo are Cossoidea (with common families Cossidae, Metarbelidae), Zygaenoidea (Zygaenidae, Limacodidae), Bombycoidea (Bombycidae, Lasiocampidae, Saturniidae, Sphingidae), Geometroidea (Geometridae, Drepanidae, Epiplemidae, Uraniidae), and Noctuoidea (Noctuidae, Arctiidae, Lymantriidae, Notodontidae). Most people get a general 'feel' of the various different groups after working on them for some time, as the more reliable characters separating them are not readily appreciable. For example, the Noctuoidea have the presence of the tympanal organ on the metathorax (Noctuidae having postspiracular counter-tympanal hood while Arctiidae prespiracular), while for Geometroidea the tympanal organ is found on the abdomen. These and other characters like wing venation (e.g. Noctuidae having FW M2 close to M3 at base as opposed to FW M2 not close to M3 at base in Notodontidae) are all too often masked by the dense scales and hairs present which render conventional identification keys user-unfriendly. Nonetheless the general shapes and external morphology of the members of Macrolepidoptera provide ample hints (e.g. the Sphingidae with their unmistakable robust hawk-like appearance), and make identification work enjoyable and less of a chore. Where external morphology (particularly markings on wings) fails to tell closely related members of species complex apart, then genitalia dissections are necessary. In particular the male genitalia of each species shows readily distinguishable characters in the form of sclerotized spines, cornuti, scobinate patches on its aedeagus (which penetrates into the female bursa copulatrix during copulation), and its valves are often unique in shape bearing an armature of sclerotized structures.

Robinson & Tuck (1993a) extrapolated 8628 species of moths in Borneo of which

3614 are Macrolepidoptera, while Holloway (1987a) estimated a total of about 4500 species of macromoths in Borneo. Their high species diversity, better known taxonomy (Barlow, 1982; Holloway, 1976, 1983a, 1985, 1986, 1987b, 1988, 1989, 1993), phytophagous feeding habit (either on living plants or plant material), relative ease in sampling (e.g. light-trapping), and their sensitivity (susceptibility) to environmental change (habitat preference) make them suitable biological indicators in the forests of Borneo. A biological indicator as defined by Spellerberg (1991a) is a species indicating the condition of the environment. Amongst the various faunal groups, vertebrates are less diverse and less readily observed or sampled. Morris (1978) commented on the low mammal populations in both logged and unlogged rain forests in Papua New Guinea, which makes the displacement of species difficult to quantify. Of the other insect groups Homoptera seem to fulfill most of the criteria as effective indicators but their relatively unknown state of taxonomy precludes their use (Holloway, 1983b).

It is of common conjecture that replacement of mixed natural rain forest with monoculture of exotic trees would result in a colossal loss of native insect species. Moreover, the removal of natural enemies in the process of replacement may leave some insects (which can utilize the new abundant food source) to multiply unchecked, escalating beyond the economic injury level to achieve pest status. In Sabah, *Xyleutes ceramica* Walker (Family : Cossidae) has been reported as a trunk borer of some concern in *Gmelina arborea* stands (Abe, 1983), and Chey (1987) compiled a list of lepidopteran and other insect defoliators on the fast-growing exotic trees. The high diversity in the natural rain forest in stabilizing communities is believed to be important for the absence of extensive insect pest outbreaks, and simplified communities such as monocultures may be more susceptible to such attacks (Speight & Wainhouse, 1989). This aspect also underlies the importance of determining the

diversity of insects in monoculture forests, with moths being the most suitable indicators.

Hitherto research on macromoth diversity in Borneo has been largely confined to natural forest habitats most notably that of Mount Kinabalu (Holloway, 1970, 1976), and Gunung Mulu (Holloway, 1984). Only pilot observations are available for the effects of conversion to plantation forestry on the macromoth communities (Holloway *et al.*, 1992). This project attempts to measure the diversity of macromoths in the various monoculture plantation forests and natural forest in Sabah, and in comparing their diversity indicate the impacts of such conversion on the forest ecosystem.

CHAPTER TWO

LIGHT-TRAPPING AND MOTH DIVERSITY

2.1 Introduction

2.1.1 Attraction of moths to light

The attraction of moths to light is a well known phenomenon and yet one which is not at present fully understood. Traps of various sorts all armed with a light source have been devised to capture moths. Moths are easily seduced by the potent charm of light, and they eagerly fly their way towards light and congregate around it as if spellbound.

Under natural conditions the moon in the night sky represents the only substantial source of light for the moths, which may exert its effect by bringing them upwards to a region where trees and other obstructions do not break up air currents, and the moths may take advantage of the unbroken flow of air currents for dispersal (Holloway, 1967). Seventy metres is considered as the critical height above which there is enough wind for migration (Muirhead-Thomson, 1991). The moon also acts as a major distractor in light-trapping, with the moonlight competing with the light coming from the moth trap, and a fuller moon generally produces a smaller catch. This may be attributed to the superior position of the moon, being higher up and has a far greater influence over the moths, and it lends support to the theory that moonlight facilitates dispersal. However it is interesting to note the possibility of a full moon shining bright at night may simulate to certain extent sunlight in the day, which might actually induce lethargy rather than activity in these nocturnal creatures. Williams *et al.* (1956) came up with the following theories while investigating the effects of moonlight on insects: a) moonlight has a depressant effect on the actual numbers of the population, b) reduction on

activity, c) on their flying habit in the sense that they might prefer flying in sheltered places, or they might fly higher. Janzen (1984) in his work on the bigger moths in Costa Rica found that some species of sphingids were foraging at flowers under a full moon, which led him to suspect that the lower catch using light-trap at full moon is more due to the moon obliterating the attraction effects of the artificial light rather than cessation of sphingid activity.

Another question of considerable intrigue is the reason behind the high male to female ratio of moths which have fallen victims to the light-traps. One would expect the ratio of male and female of most species to be about equal under natural breeding conditions, and the physical and structural make-up of their compound eyes and hence perception of light not to vary greatly. And yet it is the male gender which appears to be more frequently captured by light. Holloway (1967) suggested that the disparity in sex as shown in light captures could be due to the fact that the males of most species emerge earlier, and when mature will actively seek out females which are often mated as soon as they emerge. This reproductive drive coupled with a more active range of flight may subject the males more susceptible to light-traps, while many potentially trappable females would have been 'waylaid' before they get to the light, and thereafter have an overriding oviposition drive.

Another common observation is that moth sample size seems to increase on wet nights. Laithwaite (1960) observed in the European Vapourer Moth *Orgyia antiqua* that the male is responsive to the far infra-red wavelengths emitted by the female. The fact that as light passing through the suspended water droplets on wet nights also produces the desired far infra-red radiation may explain why moths flock to light in greater numbers on such occasions (Barlow, 1982). Also wet or overcast nights are correlated with a reduction in moonlight, and highest minimum nocturnal temperature, both of which may help to enhance catch size.

2.1.2 The use of light-traps in capturing moths

Light-traps are without doubt the single most widely used device for capturing moths. No other traps have proved to be more successful in capturing moths both quantitatively (large numbers of individuals) and qualitatively (great variety of species) (Muirhead-Thomson, 1991). Initially light from paraffin and acetylene lamps was used in such traps (Frost, 1952), later the tungsten filament electric light (e.g. Rothamsted trap), and after its development by Robinson & Robinson (1950) the ultra-violet light emitted by mercury vapour bulbs, which was found to be the most effective in sampling moths.

Apart from a small handful of day-flying moths e.g. Zygaenidae, a few species of Sphingidae (*Macroglossum* and *Cephonodes*), *Dysphania* species of Geometridae, *Nyctemera* species and some Syntominae of Arctiidae, and Agaristinae of Noctuidae (Holloway, 1984), the rest are nocturnal flyers and attracted to light. According to Southwood (1978b), the important factor influencing light-trap catches is the amount of contrast between the light source and surroundings. The greater the contrast, the greater the trap radius or catchment area. Various workers have drawn up elaborate experiments to determine the trap radius. McGeachie (1987) working on English moths by using 125W mercury vapour light traps, surrounded by concentric rings of water pan traps, concluded that with the elimination of wind effects, the effective radius usually exceeds 10m, but is less than 25m. In other words moths will ignore lights even if they could see them, unless they are within 25m of the radius. On the other hand, Bowden & Morris (1975) in their light-trap (125W mercury vapour) experiments in Uganda/Ghana found that the trap radius varies from 519m at new moon to 35m at full moon, with a ratio of 15:1, the main determinant of catch being the frequency with which insects cross the boundary of a region of influence whose size is determined by a radius of equal energy. Based on observations with night-sighted binoculars in Queensland,

Australia, the maximum range of influence of light for a Robinson's mercury vapour trap has been estimated to be about 100m (Holloway, 1984), but this may vary subject to local conditions. As mentioned earlier in 2.1.1, other climatic factors may also be involved such as rain. A rainy afternoon with a consequent wet night generally increases the catch. Minimum nocturnal temperature has also shown to affect catches, with increase in catch with temperature (Holloway, 1977; Hardwick, 1972). And also some intrinsic physiological characters within the moths themselves, different species may demonstrate different flight powers, difference in flight periodicity, and hence response to light.

Having discussed the various limitations caused by possible bias in light-traps, it is still felt that light-trap is the most suitable method in sampling moths. For apart from moonlight, the ambient parameters such as temperature are relatively stable in Borneo. Even the effects of physical variables in the environment will tend to get cancelled out when several samples are made in a given site and subsequently pooled (Holloway, 1984). Other methods (Barlow, 1982) such as sugaring (i.e. a mixture of molasses or black treacle and beer or rum painted onto tree trunks, and moths being subsequently intoxicated and captured) which was traditionally used in temperate climates before the advent of light-traps may not be compatible with climatic conditions in the tropics. Furthermore, baited traps with rotten fruits (bananas and pineapples), prawns, or pheromones may only appeal to limited number of species. At present no other method can replace light-trapping in terms of both qualitative and quantitative sampling of adult moths, which can broadly indicate their habitat preferences, and be conveniently utilized to monitor the dynamics of the tropical forest ecosystem.

2.2 Materials & Methods

2.2.1 Light-trap equipment

The light-trap used in this project was a 250W mercury-lithium (HgLi) bulb held right in front and on top of a vertical white sheet (1.8m x 1.8m square) (See Plate 2.1). The bulb was powered by a portable petrol generator. Macromoths which were attracted to the light and either dancing or resting on the illuminated white sheet were captured by shifts of collectors working all the time. They were placed in killing bottles charged with ethyl acetate. The chemical has a strong lethal effect which killed the moths instantly preventing any physical damage to their wings and bodies. Unlike carbon tetrachloride or chloroform, ethyl acetate is also less likely to induce discoloration of both green and blue pigments on the specimens. Moths thus killed were papered in the field and kept with naphthalene to inhibit fungal growth and to ward off predatory ants.

This particular form of light-trap, though labour intensive (one had to manually capture the moths into killing bottles) and at times a health hazard (the collector was vulnerable to nasty wasp stings, and his eyes could not avoid the strong glare of the light from time to time), was chosen mainly for the following reasons :

1. It ensured the efficiency in obtaining macromoths from all families. Barlow & Woiwod (1989) have pointed out the deficiency in the Rothamsted trap which might miss out on some larger moth species e.g. Sphingidae as the aperture of the trap may not be big enough. And traps primarily designed for use in temperate countries may also be too small to cope with the enormous catches so often encountered in the tropics (Barlow, 1982). The risk of a bias towards big and flashy specimens, to the detriment of smaller and less conspicuous ones, was minimised by employing the same team of collectors throughout the project, headed and supervised by the author.

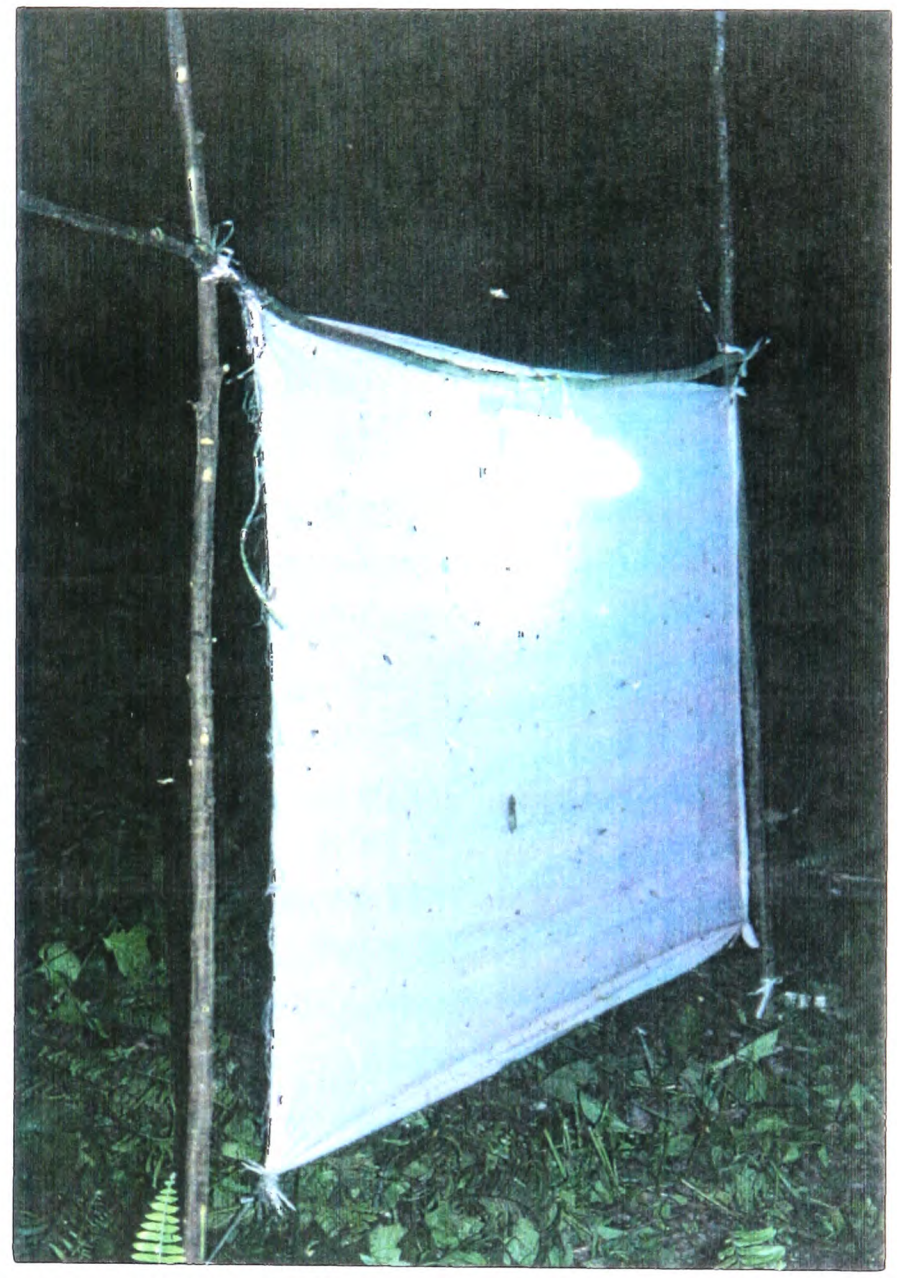


Plate 2.1 The light-trap. Basically a mercury-lithium bulb illuminating a vertical white sheet

2. One could execute discrimination against other unsolicited non-targeted insects and only collect those of interest. Whereas Robinson's as well as Rothamsted traps tend to collect other non-targeted insects indiscriminately and risk danger of physical damage to their targeted specimens. Non-targeted insects such as Coleoptera, Hymenoptera, Hemiptera, were able to redisperse into the forest when the light was turned off.

3. The trap is simple and easy to assemble in makeshift fashion using branches of saplings. This is an important requirement in the forests of Borneo, as simplicity is very much favoured in terms of logistics, and economics.

2.2.2 Sampling sites

The main concern of this project is plantation forestry, and Brumas being the most established plantation area in Sabah was chosen.

Brumas lies in the south-eastern part of Sabah along latitude 4^0 35'N and longitude 117^0 45'E. It is the main plantation block of Sabah Softwoods *Sendirian Berhad* (SSSB), which was formed in 1974 between a British timber company North Borneo Timbers and the major state government development agency Sabah Foundation, in order to reforest the logged-over lowland and hill dipterocarp forest sites in south-eastern part of Sabah. SSSB covers an area of 60,700ha which is divided into two blocks (see Fig. 2.1), Brumas (42,500ha) and Kalabakan (18,200ha) (Tan, 1987). By 1991, 25,099ha have been planted with mostly monocultures of fast-growing exotic trees such as *Acacia mangium*, *Paraserianthes falcataria*, and *Gmelina arborea* (Sabah Forest Department, 1992). One particular *P. falcataria* tree planted on 17 June 1974, which registered a growth of 10.74m in 13 months (about 28mm per day), even has the distinction of being the fastest-growing tree ever in the Guinness Book Of Records (Matthews, 1993).

SSSB plantation is part of the central upland of Sabah (Collenette, 1963), with the

Fig. 2.1 Map of Sabah showing areas of commercial forest plantations (hatched).

main part being residual landforms ranging from mountainous terrain, through steep to moderate hills, and depositional landforms of terraces, floodplains to tidal swamps. Altitudes vary from 120m to 500m above sea level. The parent materials of the soils are commonly mudstone/sandstone (major), sandstone/mudstone (major), and alluvium (minor), with some basic and intermediate and very rarely ultrabasic igneous rocks. Soil pH (4.5) and available phosphate are generally low. Main soil units under the FAO/UNESCO system of classification are Orthic Acrisols which consists mainly of Kumansi, Tanjong Lipat, Kapilit and Paliu soil families. The climate is hot and humid. The mean monthly temperature ranges from a maximum of 32+-2 ^{0}C to a minimum of 22+-2 ^{0}C. Relative humidity is approximately 86% in the morning to 68% in the afternoon. Rainfall has an annual mean of 2,200+-435mm (Tan, 1986, 1987).

To enable comparisons, the five major plantation species i.e. *Acacia mangium* Willd. (Leguminosae, origin: northeastern Australia, Papua New Guinea, the Moluccas and Irian Jaya), *Eucalyptus deglupta* Bl. (Myrtaceae, origin: Australia, the Moluccas, New Guinea, Sulawesi), *Gmelina arborea* Roxb. (Verbenaceae, origin: lower Himalayas to southern provinces of China), *Paraserianthes* (=*Albizia*) *falcataria* (L.) Nielsen (Leguminosae, origin: West Irian, Moluccas), *Pinus caribaea* Morelet var. *hondurensis* (Pinaceae, origin: Central America & West Indies) (Sabah Forest Department, 1983; Mabberley, 1987), as well as natural logged-over regenerating Secondary Forest (there being no sizable unlogged forest in Brumas) were selected. Details of each site are given in Table 2.1 (see map on Fig. 2.2) (Plates 2.2-2.7).

Ideally these monoculture plantation forests should have been of uniform age, size, elevation, etc. to minimize the variance in sampling but this was not entirely possible as the

Table 2.1 Details of the light-trapping sites chosen at Brumas in 1991.

Sampling Site	Area (ha)	Elevation (m)	Spacing (m)	Date Planted	DBH (cm)*	Est.Ht(m)	Understorey**	Remarks
Acacia mangium	43.76	183-244	1.82 x 1.82	Jan-88	11	30	Dense	
Eucalyptus deglupta	30.41	213-274	3.05 x 3.05	Mar-80	17	25	Very dense	
Gmelina arborea	40.46	183-213	3.05 x 3.05	Mar-88	10	25	Mostly fern	
Paraserianthes falcataria	56.74	183-274	3.05 x 3.05	Mar-Jul 87	17	30	Dense	
Pinus caribaea	30.03	280-335	1.83 x 1.83	Aug-76	19	25	Sparse	
Secondary Forest	>200	213-457						Last logged in 1984
I		244-274						Sampled in Jan,Feb,Jul,Aug
II		213-274						Sampled in Mar,Apr,Sep,Oct
III		274-457						Sampled in May,Jun, Nov,Dec

*Diameter at breast height. Measurement taken from average of 30 trees, in March 1991.

**See Chapter Five .

Plate 2.2 *Acacia mangium* plantation

Plate 2.3 *Gmelina arborea* plantation
Undergrowth predominantly *Nephrolepis biserrata* fern

Plate 2.4 *Eucalyptus deglupta* plantation
Note the varied and luxuriant understorey

Plate 2.5 *Paraserianthes* (=*Albizia*) *falcataria* plantation

Plate 2.6 *Pinus caribaea* plantation

Plate 2.7 Natural logged-over regenerating Secondary Forest

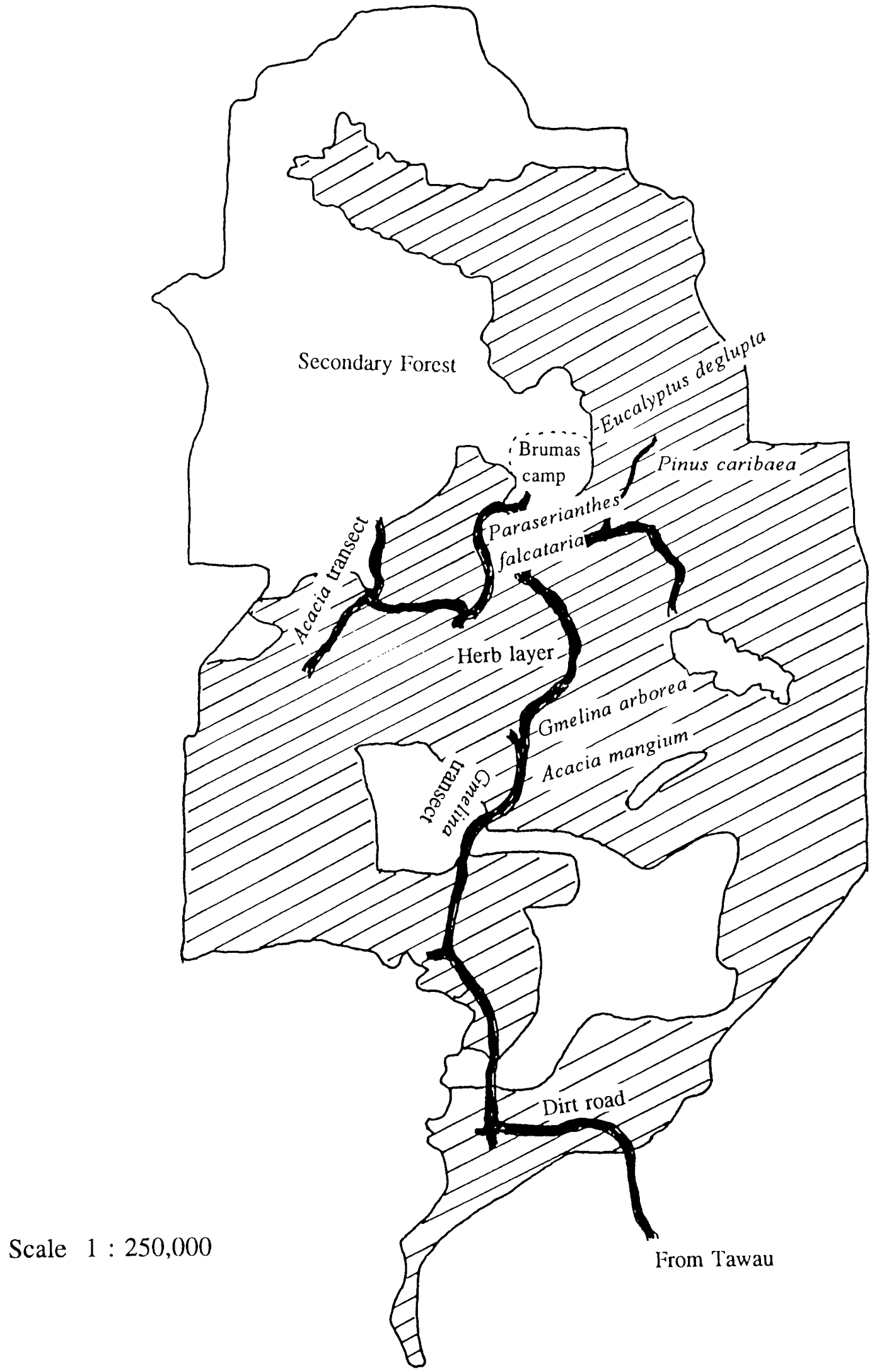


Fig. 2.2 Brumas map with locations of the various moth sampling sites. Hatched areas indicate plantations of fast growing introduced tree species, with some pockets of cocoa, coffee, oil palm and rubber.

area consisted of a mosaic of plantations grown over a period of almost twenty years subject to site suitability, material availability, as well as management policies.

The light-trap was set at a regular spot in each plantation which was felt to yield the maximum catch. And the spot chosen was a small clearing (experience has shown a clearing generally produces better catch due to better dissemination of light) along a dirt road with a minimum of 100m within the plantation (100m was assumed to be a reasonable radius of influence. See 2.1.2). In the Secondary Forest however, its floristic structure was far more complex, and being several times larger in size than each of the chosen plantation, three regular sampling spots were chosen to give a more comprehensive representation of the area. Each spot was, like the plantation, chosen for its potential for maximum catch, and located on a clearing by the roadside. The sampling regimen is detailed in Table 2.1.

2.2.3 Sampling periods

Light-trapping was conducted monthly from January through to December, 1991. Two continuous nights per month were light-trapped for macromoths at each of the six sites sequentially, each night lasting for four hours from 18:30hrs to 22:30hrs. To minimize trap bias, the sequence of sampling throughout the year was chosen randomly for the various sites giving each an equal chance of 'good' as well as 'bad' nights according to catch size, which as explained earlier in 2.1.2 could be influenced by various abiotic parameters such as moonlight intensity. The hours of sampling (18:30 i.e. sunset to 22:30 before midnight) were chosen as they represent the time of maximum activity for the moths (Williams, 1939-40; Robinson & Tuck, 1993a), the flight periodicity of which shows a steady decline in activity from around midnight towards daybreak, no less due to the increase in day light intensity.

2.2.4 Moth identifications/taxonomy

The papered and properly labelled moth specimens were subsequently brought back

to the laboratory in the Forest Research Centre (Sepilok), relaxed, and identified. Publications referred to were Barlow (1982), Holloway (1976, 1983a, 1985, 1986, 1987b, 1988, 1989, & 1993).

Unidentifiable specimens were pinned and later referred to the Bornean collection of J.D.Holloway as well as the main collection in the Natural History Museum in London.

Genitalia dissections were performed when considered necessary on closely related species whose external morphology failed to tell them apart. The abdomen was detached from the set specimen and immersed in a test-tube containing about 5 ml of 10% potash (KOH). The tube was brought to a boil in a Statim Thermobloc until the abdomen sank to the bottom. The macerated abdomen was then descaled and cleaned with a fine sable hair brush in a watch-glass containing 20% ethanol under a stereomicroscope. It was transferred to 80% ethanol, further cleaned, and the genitalia gently teased out from the caudal end. For the male genitalia care was taken not to lose its aedeagus which usually protruded from the anellus. For the female a cut was made between the 7th and 8th segments with care so as not to severe the ductus bursae. The bigger aedeagi were everted with a fine syringe (30G) to aid examination of their scobination. The cleaned genitalia as well as the abdomen were subsequently stained in Chlorazol Black for 2-3 minutes, dehydrated in 100% ethanol for another 10 minutes, put in Euparal Essence for 2 minutes and finally mounted in Euparal on microscopic slide. The prepared genitalia slide was labelled and compared with the slide collection of J.D.Holloway at the Natural History Museum for correct identification (see Appendix V).

There exists among several workers minor disagreements concerning the moth phylogeny, and hence the construction and grouping of the various families. Minet (1986, 1991) has placed Lasiocampidae under Lasiocampoidea based on their larvae retaining

unfused prothoracic coxae as opposed to Bombycoidea, Drepanidae under Drepanoidea instead of Geometroidea, and he considers Syntomidae a valid family rather than just a subfamily Syntominae under Arctiidae. A lot of discussion pertaining to macromoth classification is still going on (Nielsen & Common, 1991; Scoble, 1992), but in this project however, the classificatory scheme of the Bornean moths by Holloway (1986) has been followed with taxonomic relevance and convenience being the major considerations.

2.2.5 Data analyses

The species and individuals of macromoths captured in every sample were recorded for comparisons of species richness, abundance, and indices of diversity, both between habitats (sites), and also within habitats but between dates and times.

2.2.5.1 Diversity indices

Taylor (1978) gave a very clear account of the variety of diversity indices available for the use of lepidopterists, the complexities of which have baffled many a novice. His views are particularly suited for those working on light-trap samples of moths, and he endorses the use of Williams alpha for measurement of their diversity. He provided the following explanation for his choice. In a huge light-trap sample, one which purports to represent the entire moth population, one would obtain a full bell-shaped log-normal (normal distribution) curve when the number of species is plotted against the number of individuals per species. In a more common annual sample however, the curve is typically one-tailed and fits equally well to the log-series and the log-normal. But because of the movement inherent in all moth species, samples from impoverished sites (where the resident population is at relatively low density) may be flooded occasionally by singletons from many vagrant species bordering the impoverished zone. The resulting distribution thus has a high proportion of singletons and is strongly concave. These 'hollow' curves tend to project unrealistic values using the log-normal.

The log-series on the other hand is less subject to the vagaries of the non-resident species, and is more dependent on the mid-range species resident at the site and hence more representative. The log-series (Krebs, 1985) can be written as

$$\alpha X,\ \alpha X^2/2,\ \alpha X^3/3,...$$

where αX = number of species in the total catch represented by one individual

$\alpha X^2/2$ = number of species represented by two individuals, and so on

and $X = N/(N + \alpha)$, with N being the number of individuals

The sum of the terms in the series is equal to the total number of species in the catch. Their relationship can be represented by

$$S = \alpha \log_e(1 + N/\alpha)$$

where S = number of species in sample

N = number of individuals in sample

α = diversity index (or Williams alpha)

with higher values of α indicating higher diversity and vice versa.

With this equation, Fisher *et al.* (1943) reported that α is independent of sample size, and is proportional to the number of species of the group considered, at any chosen level of abundance. This is an important *sine qua non* for allowing comparisons between different samples. Wolda (1983) similarly in his tests found that α showed the greatest sample size independence of the measures he compared, pragmatically supporting the assertion of Fisher *et al.* (1943).

As for other indices (which are largely non-parametric), the Shannon-Weaver or more correctly known as Shannon-Wiener (Shannon & Weaver, 1949) information statistic, I, or commonly symbolized by H, and the inverse Simpson-Yule (Simpson, 1949; Yule, 1944) statistic, M, commonly symbolized by D, as well as the Berger-Parker (1970) dominance

index, d, are all adversely influenced by the vagaries of the commonest species, whereas α is not. None of the population statistics seem to approach α in discriminant ability between sites, and all these led Taylor (1978) to the conclusion that α in practise provides a completely efficient statistic for moth diversity in samples. Also, even though sample size of moths may vary through phases of the moon, α measure of the samples is not significantly affected, as indicated in a pilot study conducted in Indonesia by Bulansyarih (unpublished) (Holloway, pers. comm.). For the reasons mentioned above, the Williams alpha (α) was used in this project for measuring the moth diversity.

2.2.5.2 Similarity indices

Several indices are available for comparison of similarity/dissimilarity of either sites or species. The raw data collected in the project are set out in a matrix consisting of numbers of individuals (N), of species (S), among samples or sites. This matrix could be analysed either by R-mode to show pattern in species distributions among the sites, and hence species associations, or Q-mode where sites are classified according to the representation of species e.g. presence/absence or relative abundance (Holloway *et al.*, 1992). 'Coefficient of association' (henceforth referred to as 'Coefficient') is a R-mode measure of percentage dissimilarity between any two species for all the species found at the various sites. Suppose if the numbers of individuals of the species are arranged in a column for each particular site, and the numbers of individuals of the same species at the various sites are arranged in the same row, 'Coefficient' at first normalizes the data of the same site vertically producing a percentage in place of each number of individuals. It then normalizes the value with those of the same species at other sites (in the same row) horizontally producing a second percentage. The sum of the amount of overlap of these horizontally normalized percentages between any two species for the various sites gives rise to a similarity percentage which ranges from 1 to

100. The dissimilarity 'Coefficient' between the two species is therefore the result of 100 minus that particular value. Hence the lower the 'Coefficient' the more similar are the two species and *vice versa*. The method was first used by Holloway (1970) for his Mount Kinabalu moth samples, and also by Robinson (1975) on Fijian moths.

Another index is the Preston's coefficient of faunal resemblance (1962) based on the number of species present in each of any two sites (samples) and the number of shared species between them. This indicates the similarity between any pair of sites with a value which ranges from 0 at total similarity to 1 at total dissimilarity. Unlike 'Coefficient', this index does not take the abundance of species (numbers of individuals) into account, and is based solely on the presence or absence of species. While 'Coefficient' belongs to R-mode with emphasis on species associations and distributions (e.g. assemblage of high abundance of certain moths which could be legume feeders), Preston's index is of Q-mode which compares samples of species mixture regardless of associations (Holloway *et al.*, 1992). As moths are mobile, diversity measures obtained in samples could be due to a mixture of different ecological associations of moth species, for example associations of open ecosystem and mature forest ecosystem at a forest edge. R-mode which can identify associations of species is hence ecologically more useful than Q-mode which just lumps samples together. Robinson & Tuck (1993b) commented on the limitations of the Preston's coefficient, for being sample size- and diversity-dependent, and also having to assume exhaustive sampling of species, whereas modified versions of Morisita's index (Morisita, 1959), which though independent of such parameters, is highly sensitive to the abundance of the most abundant species (Magurran, 1988). In other words Morisita's index (based on relative abundance of species) suffers from dominance effects producing 'noise' which can obscure 'signal', meaning that the more abundant species getting more attention at the expense of the rarer species, but

rarer species may also be habitat specific and important in classifying samples, whereas Preston's coefficient at least gives rarer species equal weighting (Holloway, pers. comm.). Inspired by Wolda's (1981, 1983) technique for sampling at random computer-generated populations derived from the log-series, and based on their Microlepidoptera samples collected mostly at Kuala Belalong in Brunei, Robinson & Tuck (1993b) came up with the concept which seems to be both statistically valid and understandable by asking how many species are expected to be shared between samples and how many are actually observed to be shared. This simulation method however, has yet to be applied or tested widely. For the above reasons, the relatively uncomplicated R-mode 'Coefficient', which shows species distributions as well as associations, was in this project considered to be the most suitable similarity index.

With the 'Coefficient' values indicating the levels of similarity, dendrograms were drawn starting with the more similar species of lower values until all the species were connected by means of a single-link (nearest neighbour). Linkage diagrams were similarly produced with similar species being linked closer together away from less similar ones, and percentage dissimilarity was demarcated to better illustrate the clustering. Single-link cluster analysis and linkage diagrams were used to assess the strength of the clustering structure in preference to averaging or centroid methods. In the single-link, the smallest single dissimilarities are chosen to link species and clusters together, whereas in the averaging methods the smallest *averages* of dissimilarities are used instead. The disadvantage with average-link and centroid methods is that they may produce stronger clustering structure than is merited by the data (Holloway 1977, 1979).

2.2.5.3 TWINSPAN

TWINSPAN or Two-Way Indicator Species Analysis has been used quite commonly (more so in vegetation ecology than that of insect) to produce a hierarchical classification by

dividing data binomially into two groups, the division being repeated down the hierarchy until no further ecologically distinct groups can be obtained (Spellerberg, 1991a). It is basically a monothetic, divisive method as opposed to the polythetic, agglomerative method of cluster analysis, and produces a diagram resembling a family tree (Fig. 2.15). Whereas species are grouped together in the cluster analysis, in TWINSPAN sites are divided in a hierarchical classification. Cut-levels (e.g. defining the range of numbers of individuals) are predetermined, the left-hand and right-hand branches of each division are termed the negative and positive groups respectively (Innes & Whittaker, 1993). At each division certain indicator species will emerge which would tell us they are indicative of either the negative or positive group (each consisting of similar sites) at a certain cut-level. TWINSPAN is therefore a convenient way of classifying communities, and attempts were made to divide the Brumas moth samples using it.

2.3 Results & Discussion

2.3.1 Macromoths captured by light-trapping at Brumas

A complete checklist of moths collected by light-trapping at the various sites in Brumas in 1991 is given in Appendix I. Altogether a total of 34477 individuals was obtained consisting of some 1642 species. Host-plant records as well as habitat preferences are also included in the Appendix, and will be discussed together with the botanical survey in Chapter Five. The total numbers of individuals (N) and species (S) collected at each site are shown in Figure 2.3 with Secondary Forest scoring the highest number of both species (1048) and individuals (8490), and *Gmelina arborea* the lowest: 675 species, 4164 individuals. *Acacia mangium* was marked by a high number of individuals (6602) with relatively fewer species

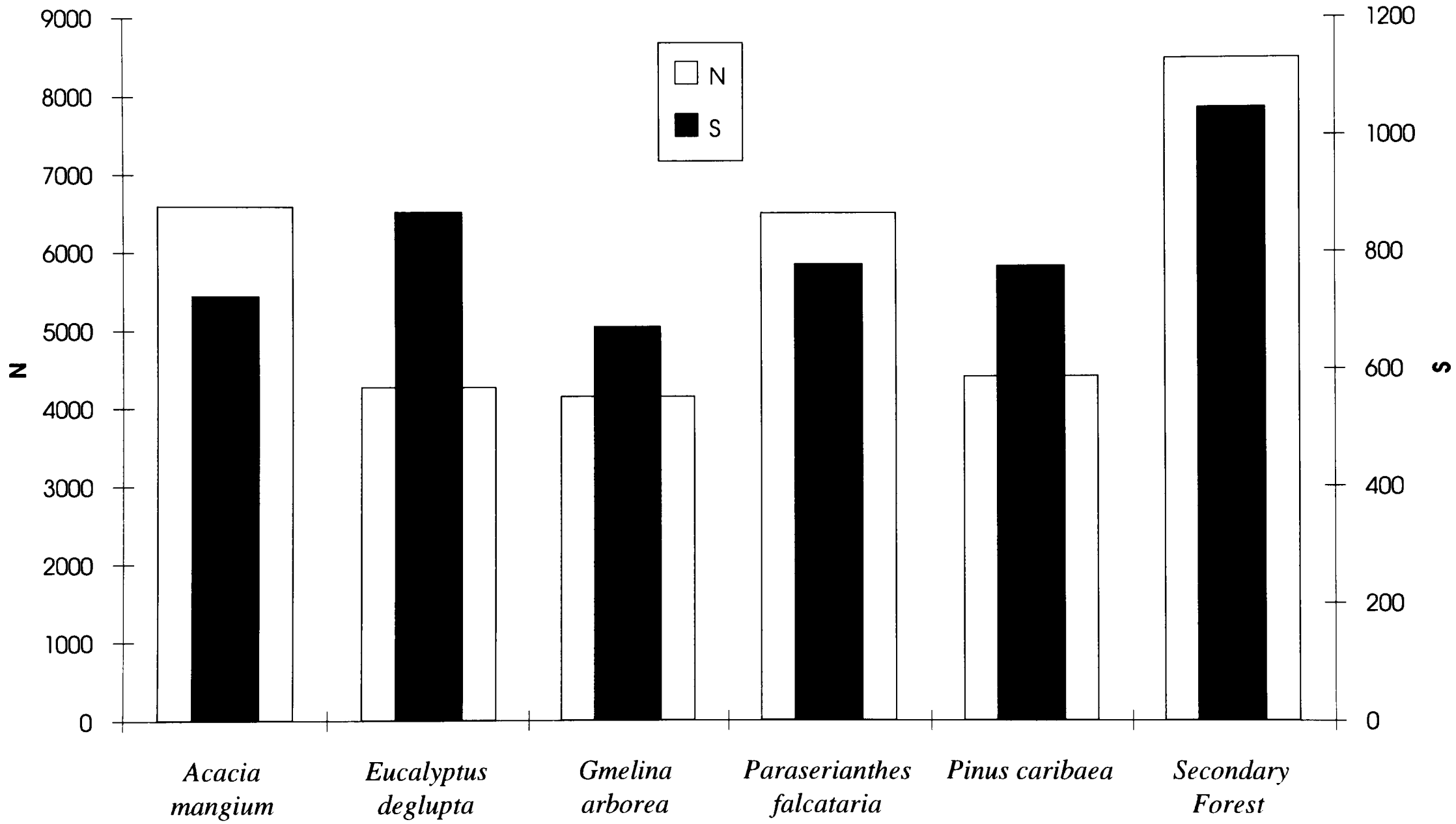


Fig. 2.3 Total numbers of individuals (N) & species (S) of macromoths collected at various sites, Brumas 1991

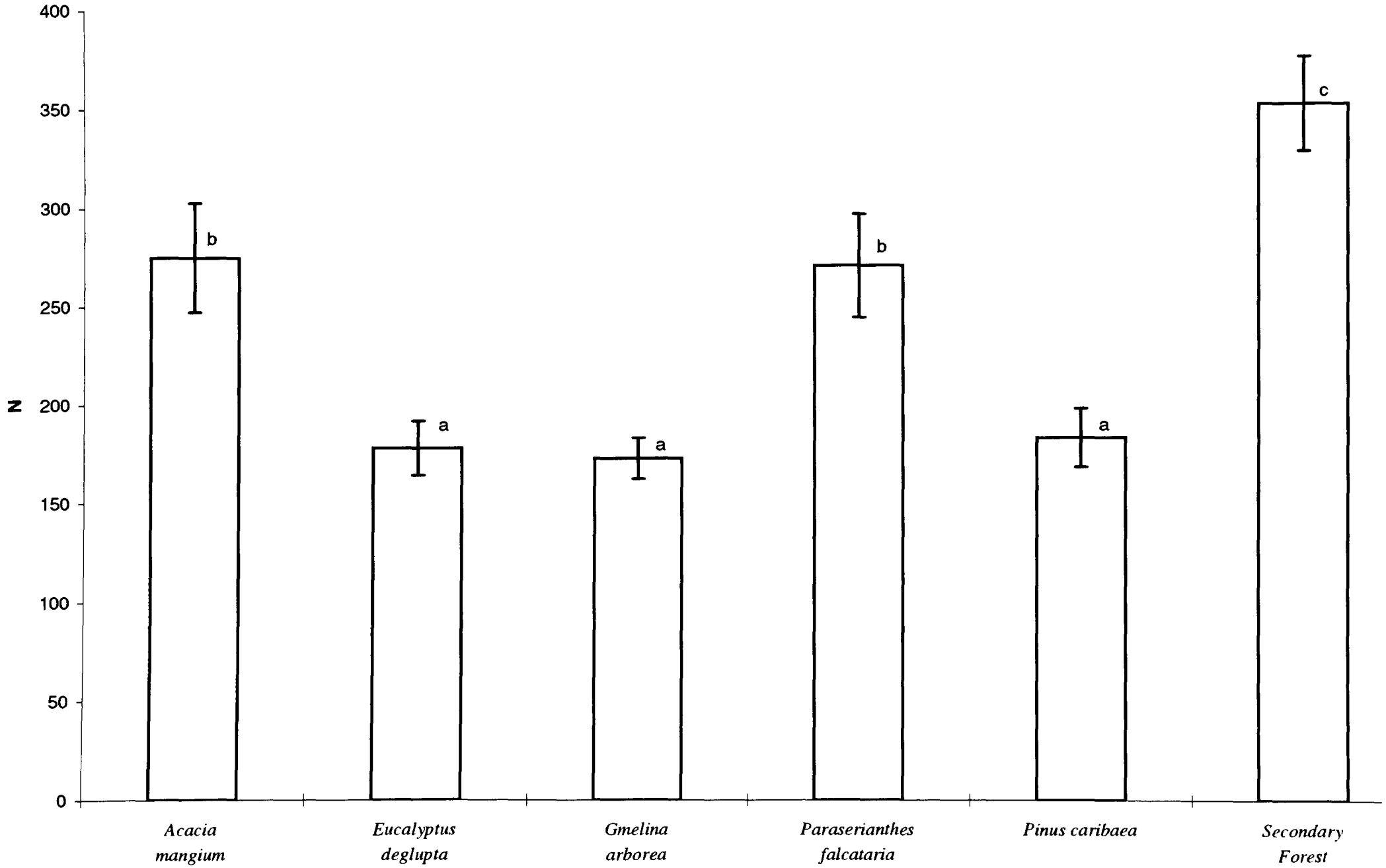


Fig. 2.4.1 Means & standard errors of numbers of individuals (N) captured per sampling night at various sites, Brumas 1991. Homogenous subsets (which are not significantly different, P < 0.05) are marked by same alphabet

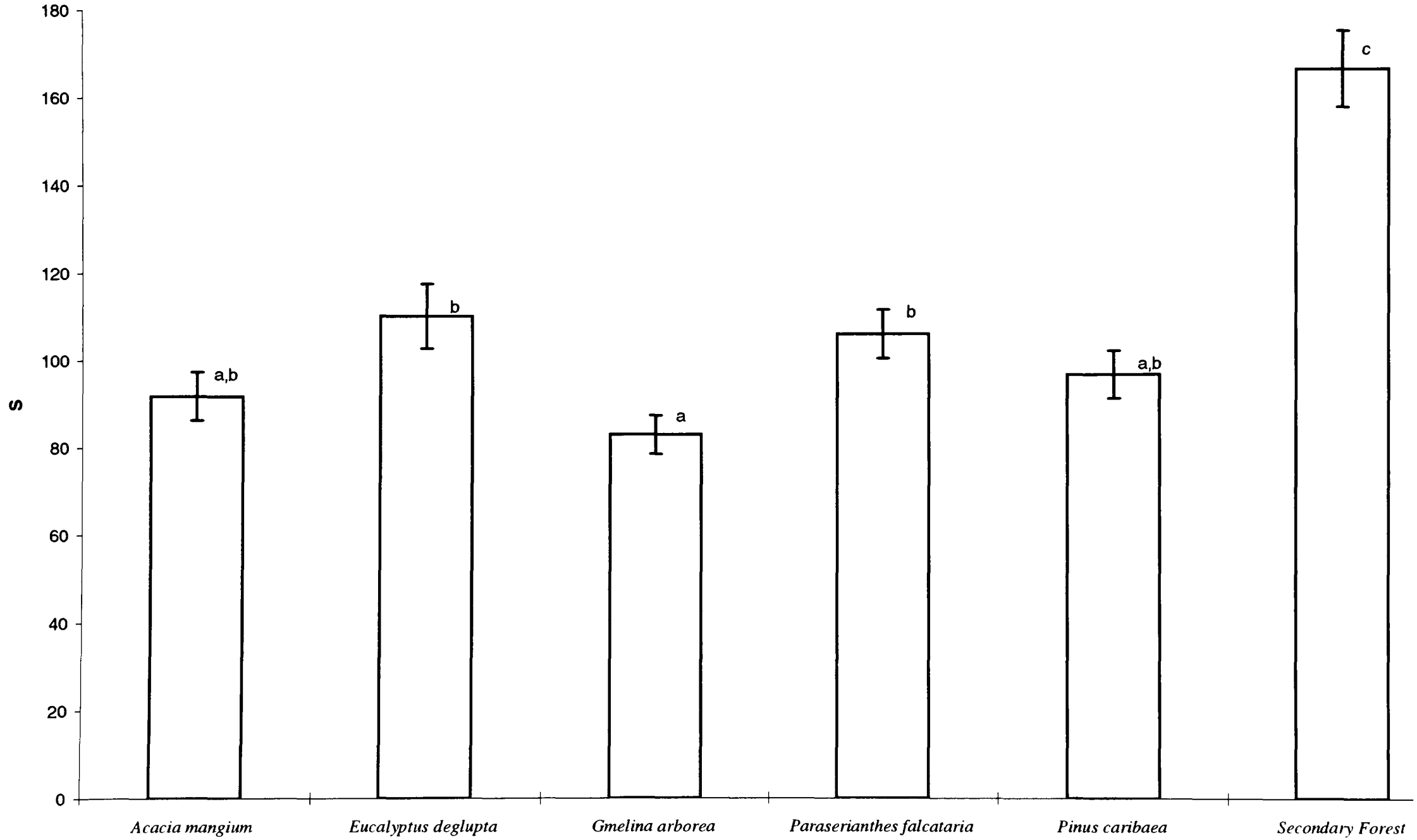


Fig. 2.4.2 Means & standard errors of numbers of species (S) captured per sampling night at various sites, Brumas 1991. Homogenous subsets (which are not significantly different, P < 0.05) are marked by same alphabet

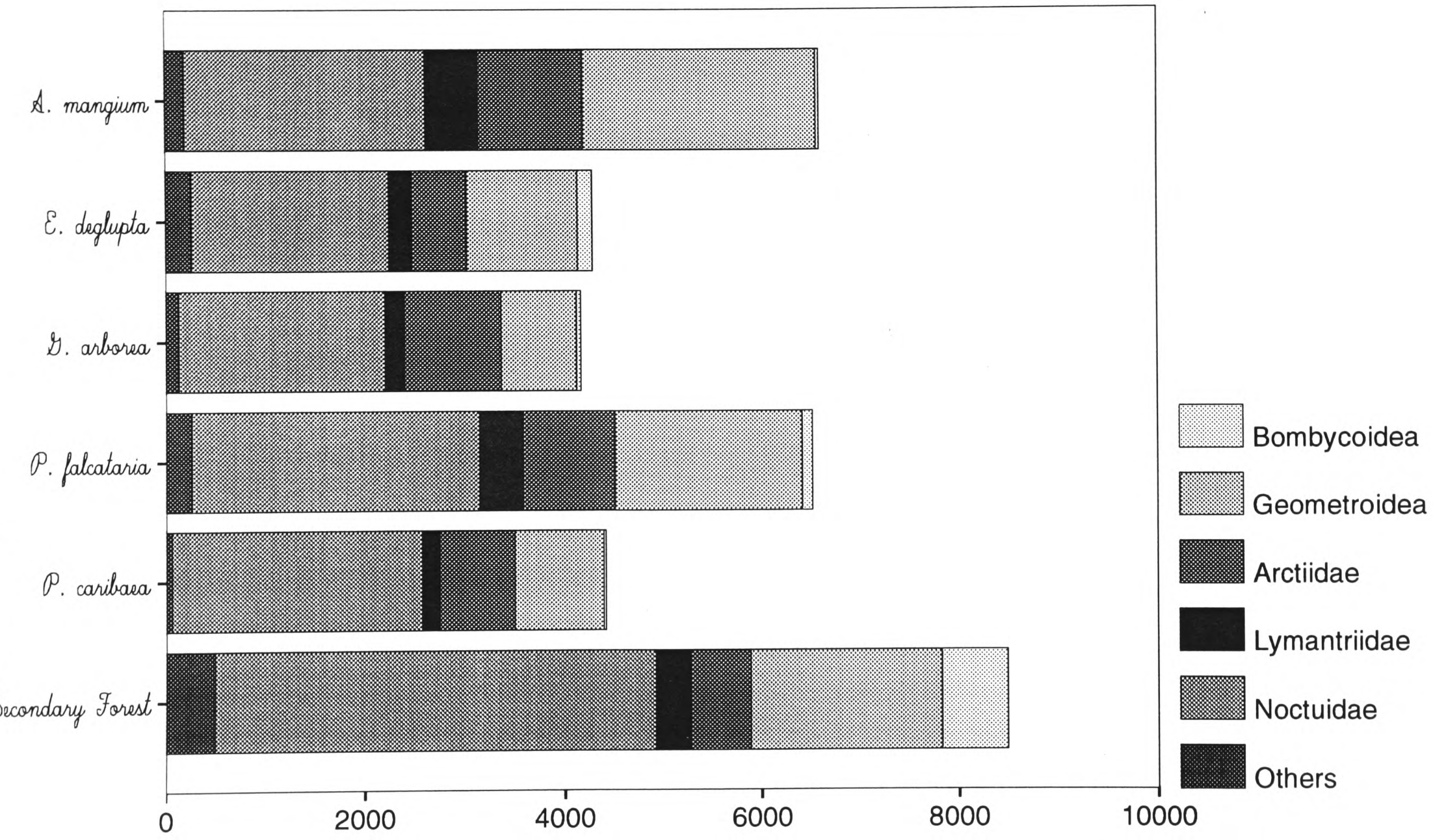


Fig. 2.5.1 Proportions of various groups by number of individuals

Brumas 1991

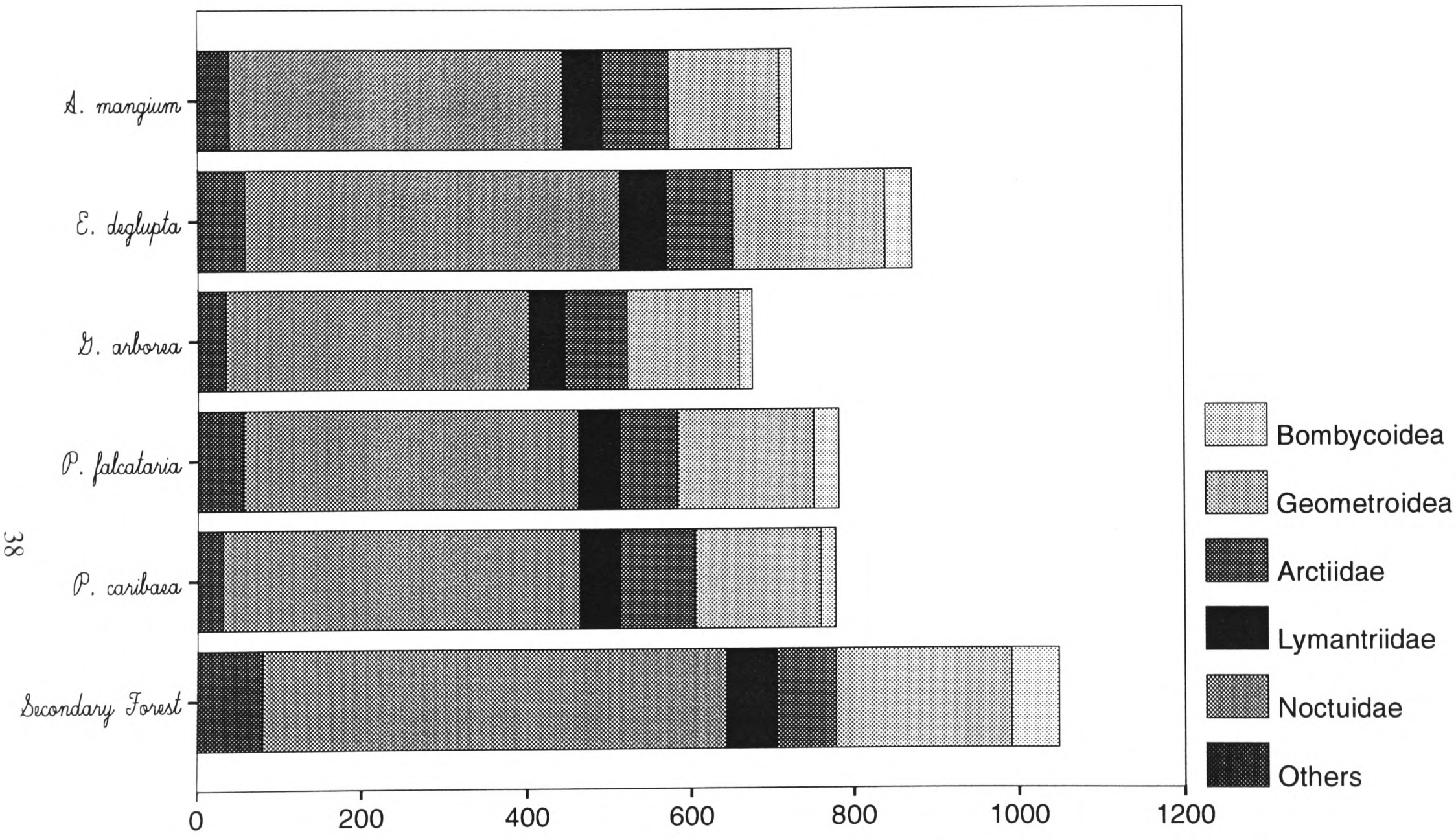


Fig. 2.5.2 Proportions of various groups by number of species

Brumas 1991

(726), the ennomine *Cleora decisaria* Walker with 1261 individuals captured at the site alone (19.1% of its total) was the single most abundant species captured at any site. The exceedingly high figure was rather alarming as it signified the vast potential of that particular moth to escalate into a major pest outbreak, the larva of which is a legume leaf-feeder (reared by the author on *Paraserianthes falcataria*). It was characteristic of a r-strategist defined as species with individuals favoured for their ability to reproduce rapidly (with a high r-value) (Begon *et al.*, 1990) enabling them to colonize effectively suitable disturbed habitat. This is in contrast with K-selected individuals which have lower growth potential but greater capabilities for utilizing and competing for scarce resources (Odum, 1989) to make a large proportional contribution to a population at its carrying capacity (K), e.g. more stable species within mature forest. *Eucalyptus deglupta*, on the other hand, showed comparatively high number of species (872) with only 4285 individuals. The means of the captures taken at each site for each sampling night (average of 24 sampling nights in 1991) are shown in Figures 2.4.1 (numbers of individuals) & 2.4.2 (numbers of species). Analysis of variance showed that Secondary Forest (marked by 'c' in the figures) had significantly higher numbers of individuals as well as species than the plantation sites.

Figures 2.5.1 & 2.5.2 give the proportions of the various moth groups (superfamilies or families) for each site by numbers of individuals and species respectively, and it can be seen that Noctuidae was the most dominant group in terms of numbers, followed by Geometroidea (mostly Geometridae). The Noctuidae, in particular, made up the majority (118 species) of the widespread species (250 in all), taken here as species found in all the sites. These species are either polyphagous, or possess high dispersive ability. Some illustrate a wide range of habitat preference: from primary forest to disturbed areas, lowland to montane. Worth pointing out also is the relatively high number of Bombycoidea (especially Sphingidae)

collected at the Secondary Forest compared to the plantation sites. Even though numerous members of Sphingidae are strong flyers and highly mobile, the availability of their food plants seemed in this case to be of more importance. A considerable number of sphingids feed on woody vines (Vitaceae), and the presence of these vines in the Secondary Forest (see Table 5.8) and their scarcity or absence in the plantations could be the telling factor behind the observed phenomenon.

2.3.2 Diversity measurements of moths sampled

2.3.2.1 Williams alpha diversity measure

Figure 2.6.1 shows the alpha values with 95% confidence range (c.r.) of the various sites sampled for moths at Brumas in 1991, which were calculated using a prewritten programme, Alpha Package by G.S.Robinson of the Natural History Museum in London. The order in decreasing diversity is *Eucalyptus deglupta* (α = 330.85, c.r.= 314.48 to 347.22), Secondary Forest (α = 314.53, c.r.= 302.54 to 326.52), *Pinus caribaea* (α = 273.99, c.r.= 260.38 to 287.6), *Paraserianthes falcataria* (α = 231.94, c.r.= 221.79 to 242.09), *Gmelina arborea* (α = 228.26, c.r. = 216.44 to 240.08), and *Acacia mangium* (α = 208.14, c.r. = 198.92 to 217.36). Since the catch at the Secondary Forest had always been consistently higher than the other sites both in terms of quantity (individuals) and quality (species), one would naturally assume it to show the highest diversity measure. The Williams alpha has instead accorded *Eucalyptus deglupta* with the highest diversity measure, a result which seemed rather misleading at first but its implication could be better understood when the site's relatively high number of species from a comparatively low number of individuals was taken into consideration. Likewise *Acacia mangium* though with the second highest number of individuals collected obtained the lowest alpha value as its species number was relatively low.

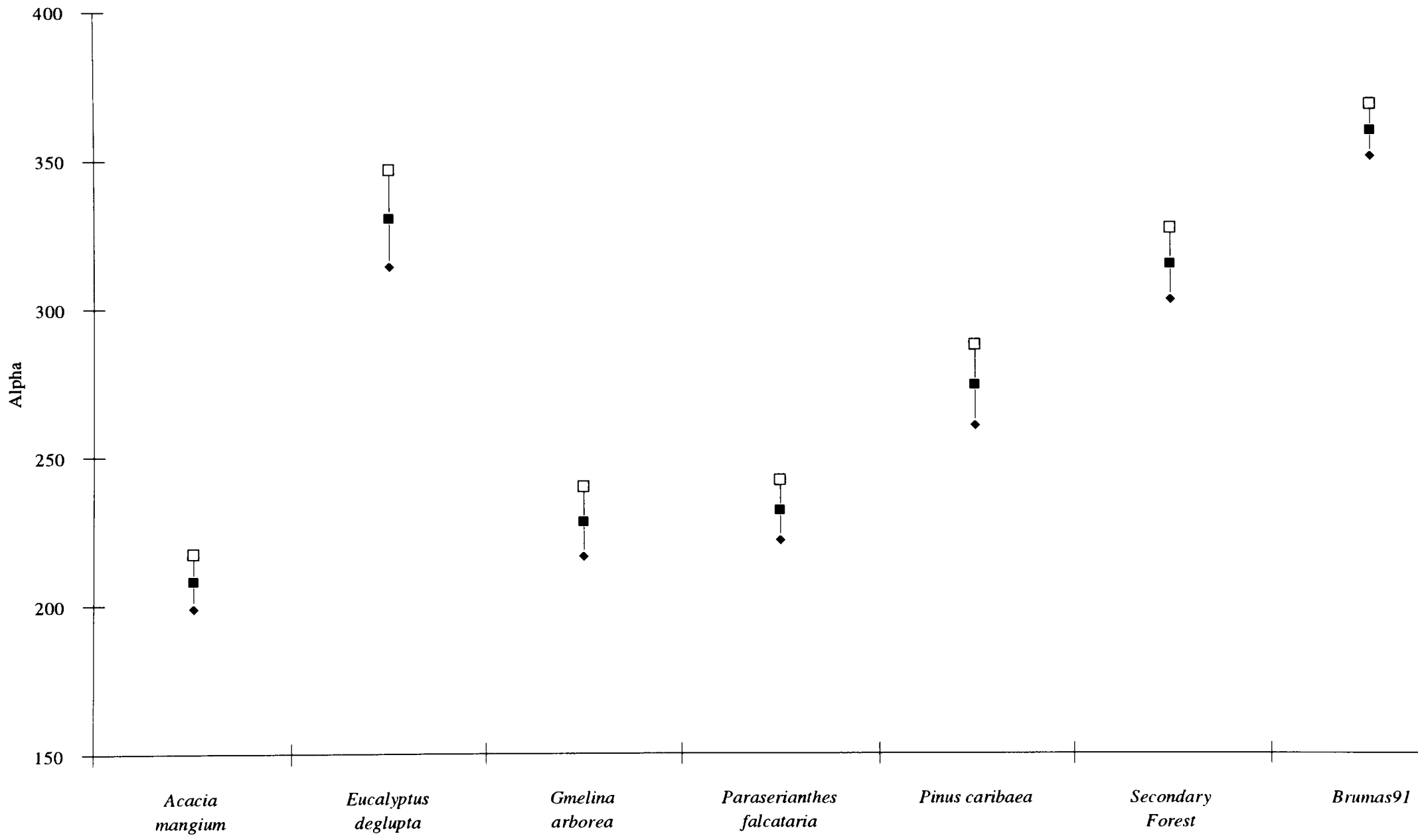


Fig. 2.6.1 Alpha values (95% confidence range) of the various moth-trapping sites at Brumas in 1991

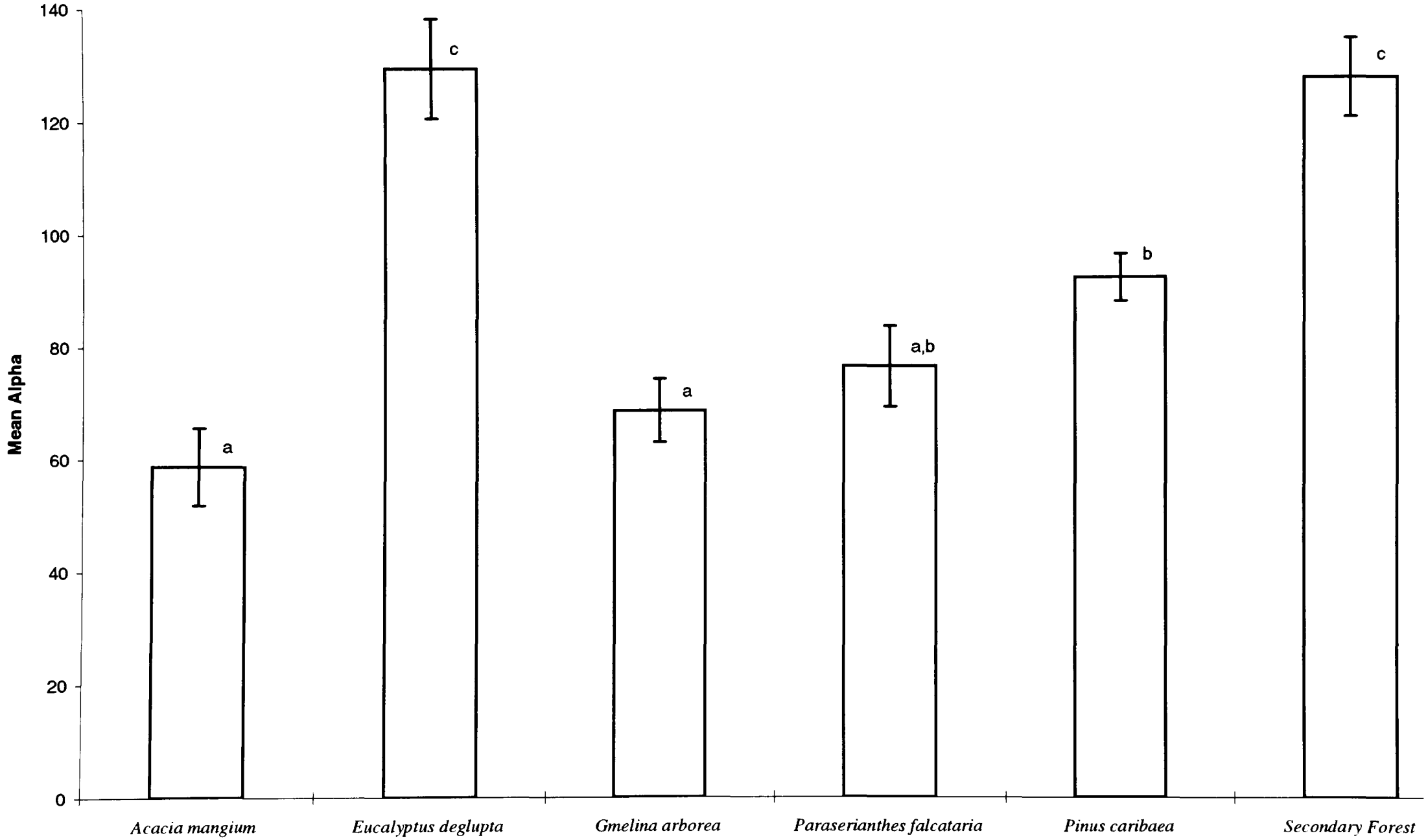


Fig. 2.6.2 Mean alpha values per sampling night at various sites, Brumas 1991. Homogenous subsets (which are not significantly different, P < 0.05) are marked by same alphabet

Analysis of variance of the alpha means of the 24 individual sampling nights at each site showed that *Eucalyptus deglupta* and Secondary Forest were not statistically different, and *Acacia mangium*, *Gmelina arborea*, *Paraserianthes falcataria* were statistically similar (Figure 2.6.2). An important factor contributing to the relatively rich moth species in *Eucalyptus deglupta* was its far denser and more diverse plantation understorey, with the plantation seemingly abandoned, in a state of neglect which lent the place an appearance approaching the disorderly galloping growth of a regenerating secondary forest (see Chapter Five).

When the data from the various sites are combined and considered as a single identity of Brumas 1991, with 34477 individuals and 1642 species, an alpha value of 358.87 (with a c.r. of 350.17 to 367.57) was obtained. This is by no means inferior to the values from undisturbed Bornean forest which Holloway & Barlow (1992) reported to be between 300 to 350 for similar altitudes to those of Brumas (below 500m), as well as Robinson & Tuck's (1993a) extrapolation of 310 for lowland forest in Borneo. Even *Acacia mangium* with the lowest value at 208.14 does not fare too badly, the situation being not as gloomy as some conservationists make it out to be.

2.3.2.2 Shannon-Wiener (-Weaver) function (H)

As a way of substantiating the results obtained above by Williams alpha, Shannon-Wiener function (H) values were also calculated. The function can be represented by the following equation:

$$H = -\sum_{i=1}^{st} P_i \log_e P_i$$

where Pi = proportion of individuals in the i th species

st = total number of species

The results represented in Figure 2.7 correlate well with the Williams alpha obtained earlier, which lend support to the trend in diversity measures for the various sites.

2.3.2.3 Species/Abundance curves

Species/Abundance curves have been used widely (Begon *et al.*, 1990; Holloway, 1984; Davis, 1993) to reflect the diversity of habitats. The log abundance is plotted against species rank (species ranked according to their numbers of individuals, 1 being most abundant and so on). The resulting curve indicates the degree of diversity, the shallower the curve the higher the diversity and *vice versa*. The 1991 Brumas moth samples when plotted (Fig. 2.8) produced curves indicating diversity levels which correspond quite well with Williams alpha. The plot also shows a high degree of overlap (up to a rank of around 200) particularly among the plantation sites, which suggests the plantation sites were of rather similar diversity (Williams alpha 200-300). *Eucalyptus deglupta*, however, has the shallowest of the plantation curves, and this also helps to support its high alpha value which with that of the Secondary Forest (with the uppermost curve) are the only two to exceed 300.

2.3.3 R-mode & Q-mode cluster analyses

2.3.3.1 R-mode analysis of species associations

The checklist in Appendix I has a huge number of moth species with numerous species having very low numbers of individuals. The low abundance of these species made them inadequate for and precluded them from cluster analysis. It is therefore essential to make selections out of the multitude of moths sampled.

Depending on the abundance of the various species in question, three selections were made from the checklist for cluster analysis using numerical methods, each with a manageable sum of 50-100 species. Based on the dissimilarity coefficients, numerical cluster analysis in the R-mode (which facilitates recognition of groups of species that are associated through a

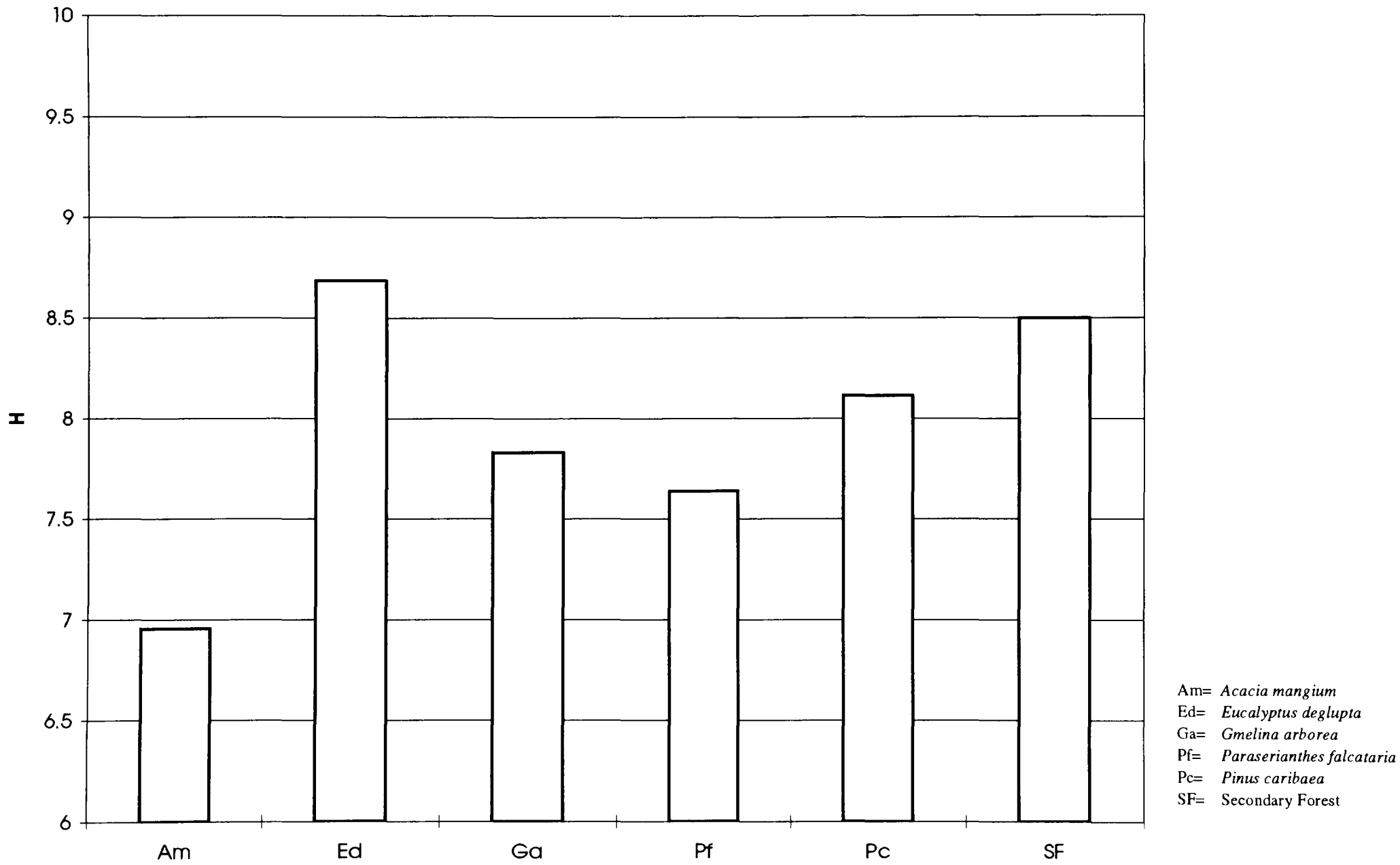


Fig. 2.7 Shannon-Wiener diversity index (H) - overall catches, Brumas 1991

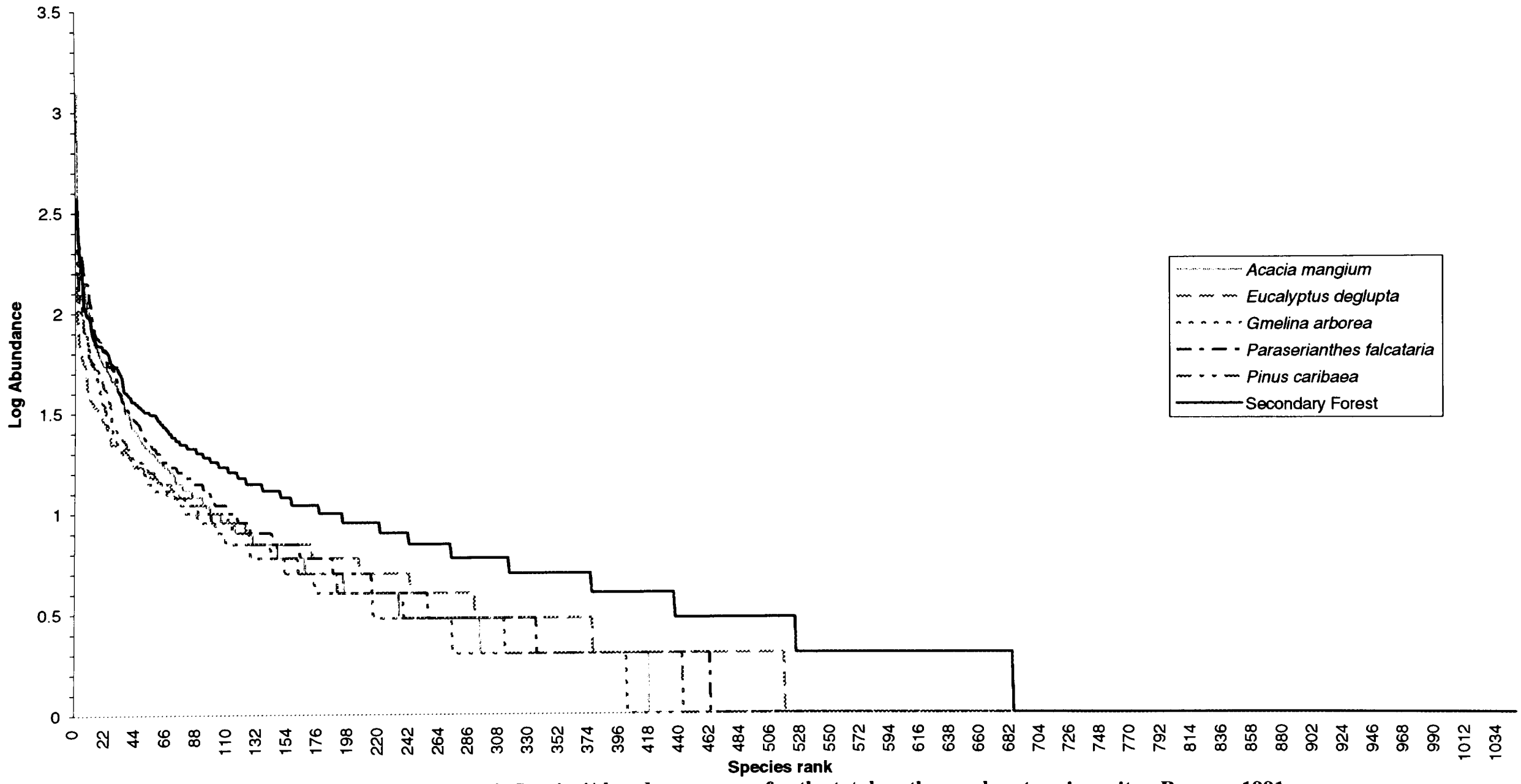


Fig. 2.8 Species/Abundance curves for the total moth samples at various sites, Brumas 1991

similar distribution of abundance over the samples) was performed. These associations of species themselves were represented in different proportions in each sample and therefore indicative of how the diversity in that sample was built up. The first analysis was based on the more abundant species from all families present with 100 individuals or more (Table 2.2). Obviously higher abundance of a particular species at a site means that the species is more likely to be resident rather than tourist. The second analysis consisted of species of Geometroidea with 25 individuals or more (Table 2.3). The geometroids have shown themselves to be sensitive to environmental change and hence good ecological indicators (Holloway, 1984). The third analysis was made for species of Noctuidae with 50 individuals or more (Table 2.4). The noctuids as seen in 2.3.1 have many widespread species and it would be interesting to compare this with the other two.

The results of the first analysis (species with 100 or more individuals) can be seen in Figures 2.9 & 2.10. Calculations of the percentage dissimilarity ('Coefficient') were performed using a programme written by G.S.Robinson. The pattern of the species clustering based on the percentage dissimilarity is clear with say for example the three comparatively more abundant species at *Acacia mangium* i.e. *Godonela ozararia* Walker (20), *Cleora decisaria* Walker (16), *Rhypotoses glebula* Swinhoe (40) being assembled together in the same cluster, and these three species can be considered as the *Acacia mangium* element, predominant at the site and hence representative. Two main clusters are evident as in Figure 2.10. The first has Secondary Forest sharing her more common species with *Eucalyptus deglupta* suggesting that the plantation with its luxuriant, dense and diverse understorey resembled the Secondary Forest both ecologically and structurally to a certain extent. The second cluster consists of species showing their greatest abundance in plantation systems other than *Eucalyptus*

Table 2.2 Checklist of macromoths with 100 individuals or more collected by light-trap at Brumas in 1991

			Am=	*Acacia mangium*					
			Ed=	*Eucalyptus deglupta*					
			Ga=	*Gmelina arborea*					
	MACROLEPIDOPTERA		Pf=	*Paraserianthes falcataria*					
	(sum >= 100)		Pc=	*Pinus caribaea*					
			SF=	Secondary Forest					
			Number of individuals						
No.	Species	Authority	Am	Ed	Ga	Pf	Pc	SF	sum
1	*Xyleutes ceramica*	Walker	8	18	15	9	2	68	120
2	*Cania bandura*	Moore	65	33	14	14	4	29	159
3	*Darna metaleuca*	Walker	26	7	14	72	2	2	123
4	*Setora cupreistriga*	Walker	12	31	16	28	4	36	127
5	*Setothosea asigna*	van Eecke	3	56	10	10	1	69	149
6	*Theretra rhesus*	Boisduval	1	55	6	36	1	191	290
7	*Tridrepana microcrocea*	Gaede	6	32	11	12	7	38	106
8	*Lyssa menoetius*	Hopffer	4	21	2	4		108	139
9	*Epiplema quadricaudata*	Walker	13	36	12	30	26	11	128
10	*Gelasma ?magnipuncta*	Prout	32	7	9	40	26	11	125
11	*Pingasa ruginaria*	Guenee	17	21	5	31	3	98	175
12	*Tanaorhinus rafflesii*	Moore	4	19	3	7	4	65	102
13	*Thalassodes ?griseifimbria*	Prout	6	17	11	13	5	69	121
14	*Scopula sp. no. 10765**		50	6	48	52	27	2	185
15	*Biston pustulata*	Warren	13	4	3	111	4	1	136
16	*Cleora decisaria*	Walker	1261	11	79	154	74	10	1589
17	*Cleora determinata*	Walker	75	16	16	54	18	40	219
18	*Curbia martiata*	Guenee	54	40	39	17	78	50	278
19	*Godonela ?translineata*	Walker	26	2	20	76	13		137
20	*Godonela ozararia*	Walker	115		2	2	1		120
21	*Godonela translineata*	Walker	100	40	47	374	77	12	650
22	*Heterostegane tritocampsis classeyi*	Holloway	59	3	5	72			139
23	*Hypochrosis binexata*	Walker	39	135	42	66	8	326	616
24	*Hypomecis transcissa*	Walker	52	10	3	73	9	18	165
25	*Hyposidra talaca*	Walker	31	8	18	140	15	27	239
26	*Iulotrichia decursaria*	Walker	62	11	4	33	10	7	127
27	*Asura ?nigripuncta*	Wileman	125	22	35	54	16	6	258
28	*Asura sp. no. 2713**		4	10	4		124	10	152
29	*Asura sp. no. 2740**		37	3	49	17	16	1	123
30	*Asura subcruciata*	Rothschild	170	34	164	236	13	3	620
31	*Eilema ?pulvereola*	Hampson	11	9	22	11	108	5	166
32	*Eugoa aequalis*	Walker	54	9	54	13	3	9	142
33	*Miltochrista roseororatus*	Butler	21	17	24	89	37	12	200
34	*Amata prepuncta*	Holloway	17	85	73	28	25	104	332
35	*Creatonotos transiens*	Walker	81	12	101	79	17	157	447
36	*Pareuchaetes pseudoinsulata*	Rego Barros	36	1	94	8		6	145
37	*Spilosoma griseabrunnea*	Holloway	31	14	21	52	16	29	163
38	*Euproctis eclipes*	Collenette	22	9	18	52	16	10	127
39	*Orgyia postica*	Walker	69	12	17	213	5	11	327
40	*Rhypotoses glebula*	Swinhoe	272	1	32	4	4	5	318
41	*Asota heliconia*	Linnaeus	16	21	6	35	3	75	156
42	*Bertula depressalis*	Snellen	68	35	61	141	28	9	342
43	Herminiinae 1		29	11	56	27	83	7	213
44	*Hipoepa biasalis*	Walker	149	67	109	184	109	34	652
45	*Hipoepa fractalis*	Guenee	143	28	80	158	160	7	576
46	*Mixomelia ?umbripars*	Hampson	39	4	12	19	26		100
47	*Nodaria cornicalis*	Fabricius	44	34	209	71	60	16	434
48	*Progonia sp. 1*		26	14	44	29	19	2	134
49	*Simplicia ?macrotheca*	Prout	31	59	20	33	35	54	232
50	*Simplicia circumscripta*	Walker	9	37	13	12	15	32	118
51	*Simplicia rufa occidentalis*	Holloway	17	65	10	18	44	263	417
52	*Ercheia cyllaria*	Cramer	14	15	6	30	10	92	167
53	*Bocula microscala*	Holloway	9	25	14	18	8	64	138
54	*Diascia hayesi*	Holloway	13	8	26	11	19	69	146
55	*Dinumma ?combusta*	Walker	20	5	18	93	3	8	147
56	*Episparis costistriga*	Walker	14	12	10	19	7	96	158
57	*Oxyodes scrobiculata*	Fabricius	145	50	11	75	1	185	467
58	*Tamba cosmoloma*	Prout	11	7	6	17	52	15	108
59	*Lophoptera acuda*	Swinhoe	57	28	54	20	55	79	293
60	*Lophoptera pallibasis*	Holloway	86	10	85	22	159	95	457
61	*Odontodes seranensis*	Prout	26	12	9	10	5	54	116
62	*Asinduma exscripta*	Walker	46	10	56	55	14	73	254
63	*Carea metaphaea*	Hampson	7	25	5	8	4	56	105
64	*Maceda mansueta*	Walker	49	22	20	20	55	35	201
65	*Athetis bipuncta*	Snellen	14	17	6	8	25	52	122
66	*Callopistria maillardi*	Guenee	55	20	41	114	53	62	345

			Number of individuals						
No.	Species	Authority	Am	Ed	Ga	Pf	Pc	SF	sum
67	*Condica illecta*	Walker	23	15	13	60	23	65	199
68	*Dipterygina dorsipallens*	Holloway	16		19	46	18	4	103
69	*Dipterygina vagivitta*	Walker	104	12	63	203	45	31	458
70	*Elusa ceneusalis*	Walker	44	10	11	18	12	28	123
71	*Tiracola plagiata*	Walker	3	5	4	21	8	70	111
		N	4411	1560	2259	3981	1977	3388	17576
		S	71	69	71	70	68	67	71
	* Refers to slide number in the Natural History Museum in London prepared by J.D.Holloway								

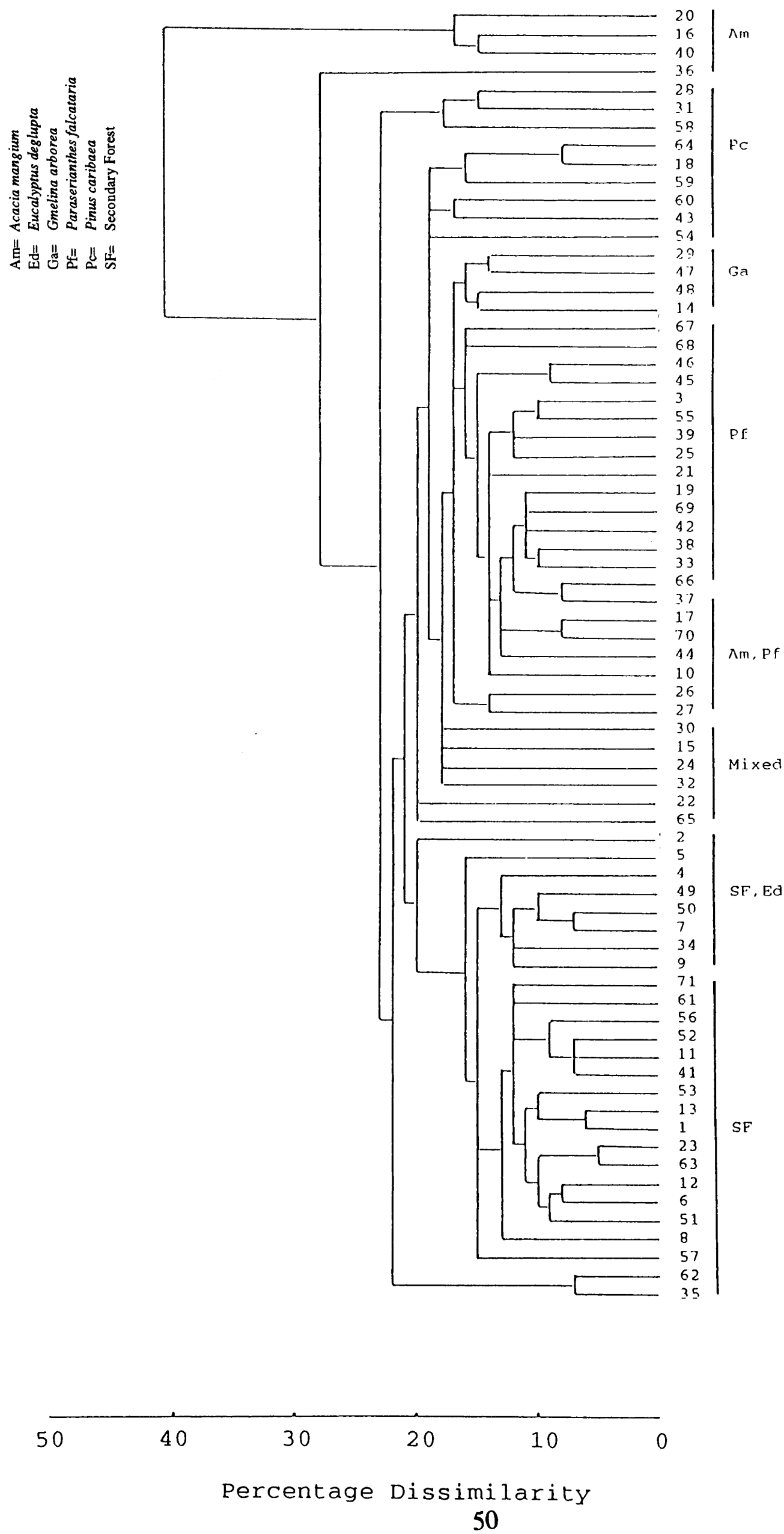


Fig. 2.9 Single-link dendrogram for moth species captured with 100 individuals or more.
Brumas 1991.
Numbers refer to species in Table 2.2.
Sites where species were most abundant are indicated at the bottom.

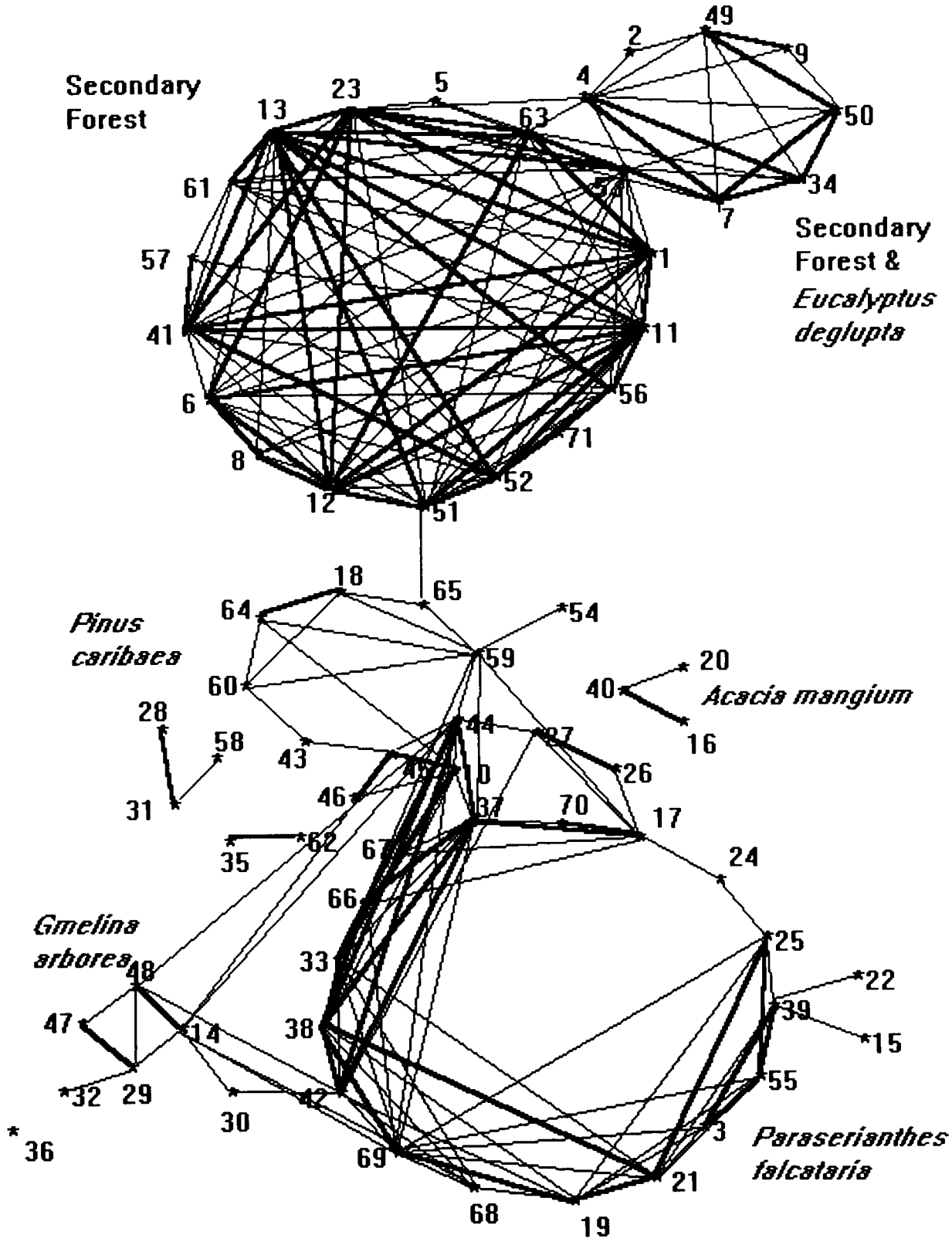


Fig. 2.10

Linkage diagram for moth species captured with 100 individuals or more, based on dissimilarity coefficient (percentage). Brumas 1991.

——— Percentage dissimilarity 15 or below

——— Percentage dissimilarity 16 -> 21

Table 2.3 Checklist of Geometroidea with 25 individuals or more collected by light-trap at Brumas in 1991

			Am=	*Acacia mangium*					
			Ed=	*Eucalyptus deglupta*					
			Ga=	*Gmelina arborea*					
	GEOMETROIDEA		Pf=	*Paraserianthes falcataria*					
	(sum >= 25)		Pc=	*Pinus caribaea*					
			SF=	Secondary Forest					
				Number of individuals					
No.	Species	Authority	Am	Ed	Ga	Pf	Pc	SF	sum
1	*Teldenia specca*	Wilkinson	1	10	2	4	3	12	32
2	*Tridrepana microcrocea*	Gaede	6	32	11	12	7	38	106
3	*Lyssa menoetius*	Hopffer	4	21	2	4		108	139
4	*Epiplema conflictaria*	Walker	2	4	2	2	15	3	28
5	*Epiplema instabilata*	Walker	7	1	57	2	2		69
6	*Epiplema quadricaudata*	Walker	13	36	12	30	26	11	128
7	*Phazaca erosioides*	Walker	5	5	4	7	35	6	62
8	*Celerena signata*	Warren	6	12	1	14		65	98
9	*Ozola ?basisparsata*	Walker	8	5	8	24	22	11	78
10	*Ozola ?minor*	Moore	3	2	20	3	4	1	33
11	*Berta annulifera*	Warren		9	6	4	3	4	26
12	*Comibaena attenuata*	Warren	9	10	5	15	9	7	55
13	*Gelasma ?magnipuncta*	Prout	32	7	9	40	26	11	125
14	*Idiochlora ?subtusumbrata*	Fuchs	3	6	1	3	11	1	25
15	*Ornithospila submonstrans*	Walker	11	14	5	13	11	14	68
16	*Ornithospila succincta*	Prout	9	10	1	7	5	20	52
17	*Pingasa ruginaria*	Guenee	17	21	5	31	3	98	175
18	*Prasinocyma floresaria*	Walker	3	27	9	18	12	15	84
19	*Tanaorhinus rafflesii*	Moore	4	19	3	7	4	65	102
20	*Thalassodes ?griseifimbria*	Prout	6	17	11	13	5	69	121
21	*Uliocnemis biplagiata*	Moore	10	8	9	6	4	5	42
22	*Antitrygodes divisaria*	Walker	3	9	4	6	6	16	44
23	*Gnamptoloma aventiaria*	Guenee	13	2	6	54	10	1	86
24	*Scopula sp. no. 10765**		50	6	48	52	27	2	185
25	*Scopula tenuispersata*	Fuchs	4	6	6	7	21	9	53
26	*Scopula vacuata*	Guenee	7	22	2	7	18	19	75
27	Sterrhinae 1		17		10	36	2		65
28	*Zythos obliterata*	Warren	1	11		3		34	49
29	*Zythos strigata*	Warren	3	14	1	9	7	32	66
30	*Zythos turbata*	Walker	4	8	2	3	2	16	35
31	*Pomasia vernacularia*	Guenee	3	5	5	10	12	7	42
32	*Achrosis fulvifusa*	Warren	1	32	4	2	2	13	54
33	*Biston pustulata*	Warren	13	4	3	111	4	1	136
34	*Borbacha altipardaria*	Holloway	2	3	3	6	4	8	26
35	*Bracca maculosa*	Walker	3	11	4	8	5	18	49
36	*Bulonga schistacearia*	Walker	1	2	3	8	3	9	26
37	*Cleora decisaria*	Walker	1261	11	79	154	74	10	1589
38	*Cleora determinata*	Walker	75	16	16	54	18	40	219
39	*Cleora repetita*	Butler	16	4	9	1	3	2	35
40	*Curbia martiata*	Guenee	54	40	39	17	78	50	278
41	*Ectropidia fimbripedata*	Warren	4	14	8	4	11	23	64
42	*Ectropis bhurmitra*	Walker	7	1	7	13	1		29
43	*Godonela ?translineata*	Walker	26	2	20	76	13		137
44	*Godonela avitusaria*	Walker	2	7		4	4	22	39
45	*Godonela nora*	Walker	2	7	3	22	3	21	58
46	*Godonela ozararia*	Walker	115		2	2	1		120
47	*Godonela translineata*	Walker	100	40	47	374	77	12	650
48	*Heterolocha pyreniata*	Walker		29	4	1	1	6	41
49	*Heterostegane tritocampsis classeyi*	Holloway	59	3	5	72			139
50	*Hypochrosis binexata*	Walker	39	135	42	66	8	326	616
51	*Hypochrosis pyrrhophaeata*	Walker	5	8	4	10		30	57
52	*Hypomecis costaria*	Guenee	3	14	2	8	3	13	43
53	*Hypomecis separata*	Walker	3	10	3	3	9	19	47
54	*Hypomecis transcissa*	Walker	52	10	3	73	9	18	165
55	*Hyposidra talaca*	Walker	31	8	18	140	15	27	239
56	*Iulotrichia decursaria*	Walker	62	11	4	33	10	7	127
57	*Luxiaria submonstrata*	Walker	6	8	4	8	2	10	38
58	*Nigriblephara semiparata*	Walker	2	8	10	9	5	21	55
59	*Parasynegia lineata*	Warren	5	2	6	11	4	3	31
60	*Parasynegia sundastriaria*	Holloway	4	4	2	4	4	16	34
61	*Peratophyga venetia*	Swinhoe	7	6	2	1	15	4	35
62	*Petelia medardaria*	Herrich-Schaffer	7	5	4	5	4	4	29
63	*Plutodes cyclaria*	Guenee	5	22	7	1	12	14	61
64	*Zamarada denticulata*	Fletcher	1	3	3	2	14	8	31
		N	2237	839	637	1749	728	1455	7645
		S	62	62	62	64	59	58	64

* Refers to slide number in the Natural History Museum in London prepared by J.D.Holloway

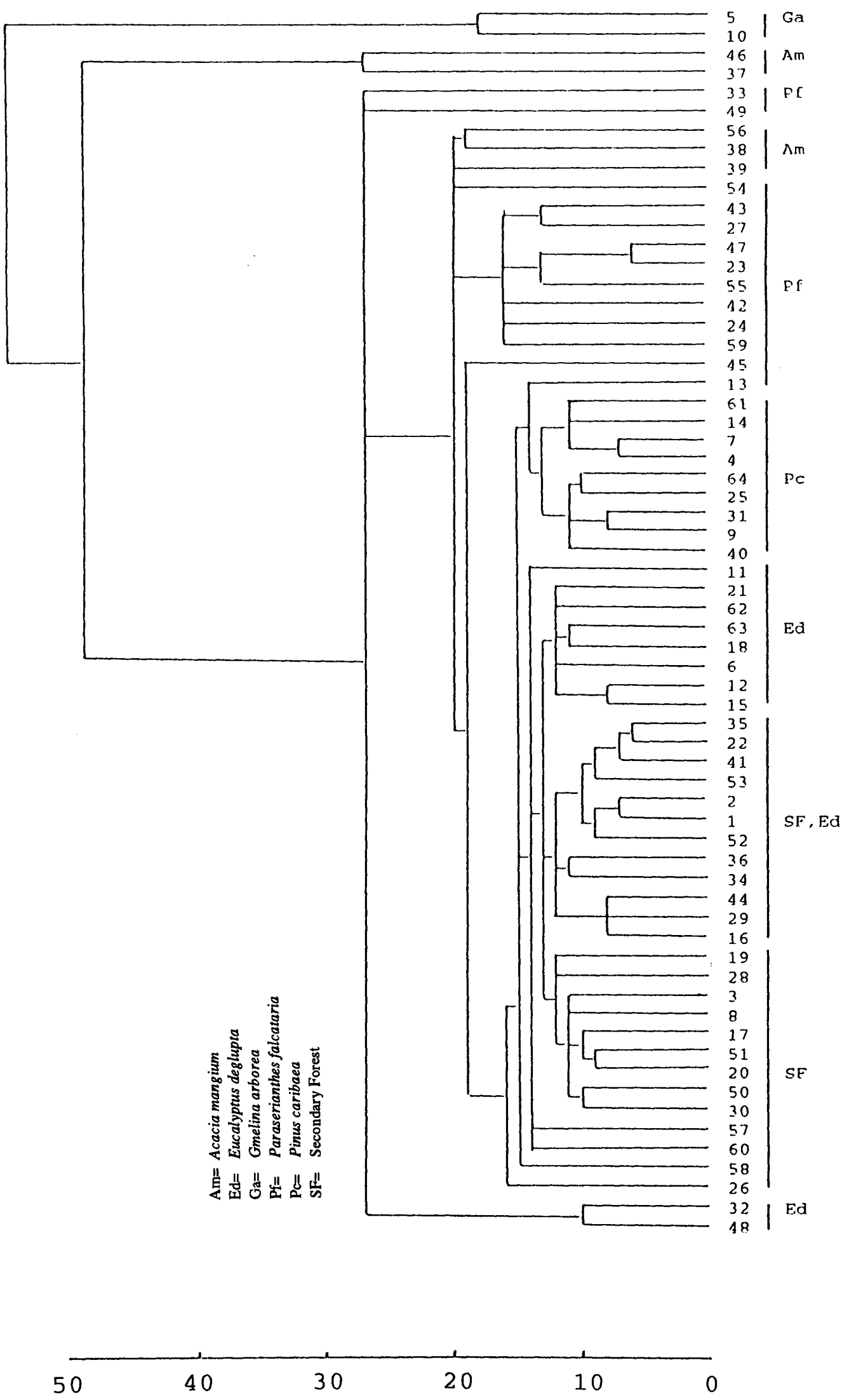


Fig. 2.11 Single-link dendrogram for species of Geometroidea captured with 25 individuals or more. Brumas 1991.
Numbers refer to species in Table 2.3.
Sites where species were most abundant are indicated at the bottom.

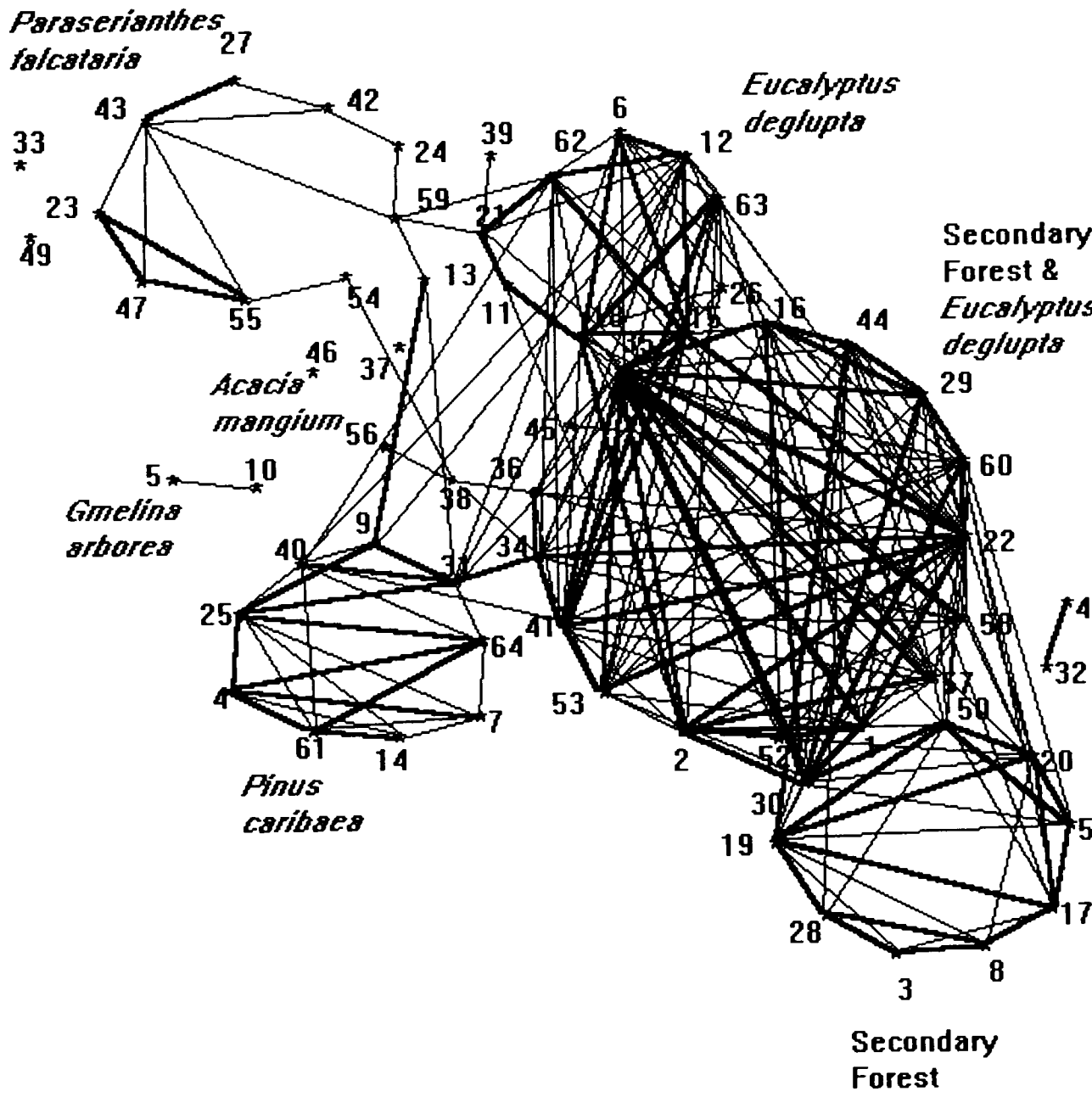


Fig. 2.12
Linkage diagram for species of Geometroidea captured with 25 individuals or more, based on dissimilarity coefficient (percentage). Brumas 1991.
——— Percentage dissimilarity 15 or below
——— Percentage dissimilarity 16 -> 21

Table 2.4 Checklist of Noctuidae with 50 individuals or more collected by light-trap at Brumas in 1991

			Am=	*Acacia mangium*					
			Ed=	*Eucalyptus deglupta*					
			Ga=	*Gmelina arborea*					
	NOCTUIDAE		Pf=	*Paraserianthes falcataria*					
	(sum >= 50)		Pc=	*Pinus caribaea*					
			SF=	Secondary Forest					
				Number of individuals					
No.	Species	Authority	Am	Ed	Ga	Pf	Pc	SF	sum
1	*Asota heliconia*	Linnaeus	16	21	6	35	3	75	156
2	*Bertula depressalis*	Snellen	68	35	61	141	28	9	342
3	*Bertula erectilinea*	Swinhoe	9	7	7	10	60		93
4	*Hadennia prunosa*	Moore	6	17	7	6	14	17	67
5	Herminiinae 1		29	11	56	27	83	7	213
6	*Hipoepa biasalis*	Walker	149	67	109	184	109	34	652
7	*Hipoepa fractalis*	Guenee	143	28	80	158	160	7	576
8	*Hydrillodes repugnalis*	Walker	7	6	16	31	24	3	87
9	*Mixomelia ?umbripars*	Hampson	39	4	12	19	26		100
10	*Nodaria cornicalis*	Fabricius	44	34	209	71	60	16	434
11	*Progonia sp. 1*		26	14	44	29	19	2	134
12	*Simplicia ?macrotheca*	Prout	31	59	20	33	35	54	232
13	*Simplicia circumscripta*	Walker	9	37	13	12	15	32	118
14	*Simplicia renota*	Swinhoe	19	6	8	25	11	24	93
15	*Simplicia rufa occidentalis*	Holloway	17	65	10	18	44	263	417
16	*Artena inversa*	Walker	11	12	1	11	1	41	77
17	*Ercheia cyllaria*	Cramer	14	15	6	30	10	92	167
18	*Hypopyra pudens*	Walker	46		2	17	6	1	72
19	*Anomis sumatrana*	Swinhoe	5	3	1	23	26	13	71
20	*Anticarsia creberrima*	Walker	4	17	7	6	13	40	87
21	*Bocula microscala*	Holloway	9	25	14	18	8	64	138
22	*Bocula tuhanensis*	Holloway	2	7	4	15	3	20	51
23	*Chilkasa falcata*	Swinhoe	8	7	1	9	1	36	62
24	*Claterna cydonia*	Cramer	10	8	4	16	2	57	97
25	*Diascia hayesi*	Holloway	13	8	26	11	19	69	146
26	*Dinumma ?combusta*	Walker	20	5	18	93	3	8	147
27	*Episparis costistriga*	Walker	14	12	10	19	7	96	158
28	*Ericeia ?inangulata*	Guenee	4	3	9	21	3	12	52
29	*Ericeia fuscipuncta*	Prout	9	2	6	39		9	65
30	*Erygia apicalis*	Guenee	6	13	4	7	3	38	71
31	*Masca abactalis*	Walker	12	3		11	1	27	54
32	*Neogabara plagiola*	Wileman & West	8	7	37	4	7	13	76
33	*Oxyodes scrobiculata*	Fabricius	145	50	11	75	1	185	467
34	*Pangrapta metagona*	Walker	10	11	3	4	3	31	62
35	*Tamba cosmoloma*	Prout	11	7	6	17	52	15	108
36	*Tiruvaca subcostalis*	Walker	2	11	7	29	5	31	85
37	*Amyna punctum*	Fabricius	12	7	10	8	6	17	60
38	*Eublemma ?abrupta*	Walker	22	10	13	20	3	2	70
39	*Chrysodeixis diehli*	Dufay	1	2	23	14	2	23	65
40	*Lophoptera acuda*	Swinhoe	57	28	54	20	55	79	293
41	*Lophoptera olivascens*	Moore	18	6	19	2	9	36	90
42	*Lophoptera pallibasis*	Holloway	86	10	85	22	159	95	457
43	*Odontodes seranensis*	Prout	26	12	9	10	5	54	116
44	*Atacira dimidiata*	Walker	4	8	9	4	4	22	51
45	*Asinduma exscripta*	Walker	46	10	56	55	14	73	254
46	*Nanaguna breviuscula*	Walker	20	5	21	7	1		54
47	*Carea metaphaea*	Hampson	7	25	5	8	4	56	105
48	*Chloroplaga nygmia*	Swinhoe	3	19	6	3	5	21	57
49	*Didigua cineracea*	Holloway	8	21	4	3	2	26	64
50	*Maceda mansueta*	Walker	49	22	20	20	55	35	201
51	*Maurilia iconica*	Walker	18	7	13	7	3	19	67
52	*Negeta signata*	Walker	6	14	7	8	26	9	70
53	*Athetis bipuncta*	Snellen	14	17	6	8	25	52	122
54	*Athetis nonagrica*	Walker	18	1	12	8	5	49	93
55	*Athetis thoracica*	Butler	13	7	23	11	10	33	97
56	*Callopistria emiliusalis*	Walker	20	6	11	15	9	14	75
57	*Callopistria maillardi*	Guenee	55	20	41	114	53	62	345
58	*Condica illecta*	Walker	23	15	13	60	23	65	199
59	*Corythurus nocturnus*	Hampson	2	9	1	6	2	35	55
60	*Dipterygina dorsipallens*	Holloway	16		19	46	18	4	103
61	*Dipterygina vagivitta*	Walker	104	12	63	203	45	31	458
62	*Elusa ceneusalis*	Walker	44	10	11	18	12	28	123
63	*Mythimna decississima*	Walker	6	6	3	9	5	25	54
64	*Tiracola plagiata*	Walker	3	5	4	21	8	70	111
		N	1676	951	1396	2004	1433	2476	9936
		S	64	62	63	64	63	61	64

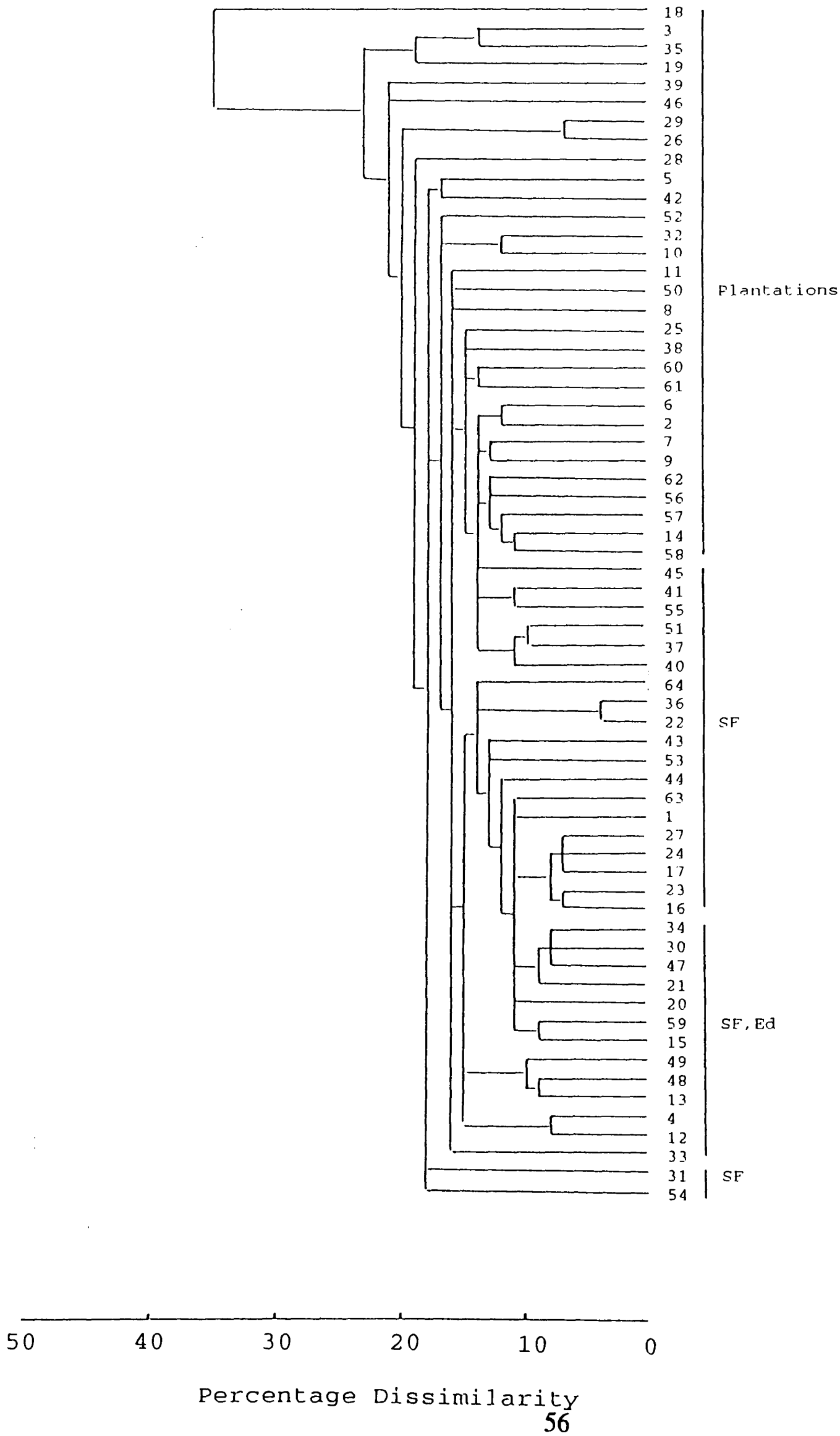


Fig. 2.13 Single-link dendrogram for species of Noctuidae captured with 50 individuals or more. Brumas 1991.
Numbers refer to species in Table 2.4.
Sites where species were most abundant are indicated at the bottom.

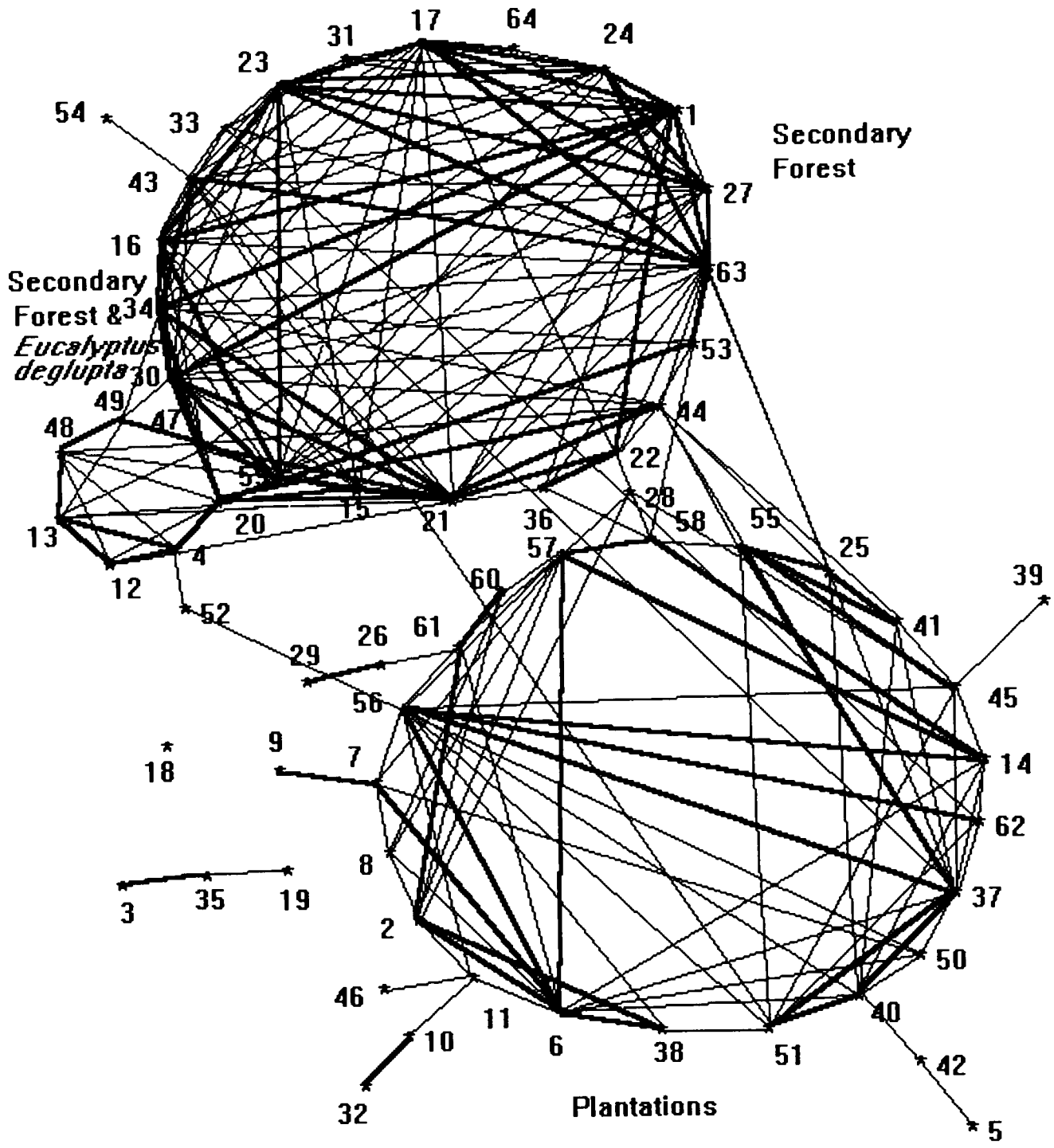


Fig. 2.14
Linkage diagram for species of Noctuidae captured with 50 individuals or more, based on dissimilarity coefficient (percentage). Brumas 1991.
——— Percentage dissimilarity 15 or below
——— Percentage dissimilarity 16 -> 21

deglupta, with small peripheral groupings (e.g. 14, 29, 47, 48 in *Gmelina arborea*) each associated mostly with one particular plantation type and more likely dependent on the plantation tree itself, two triplets i.e. 16, 20, 40 in *Acacia mangium*; 28, 31, 58 in *Pinus caribaea* remaining isolated. Several species were equally abundant in both *Paraserianthes falcataria* and *Acacia mangium* as both are legumes with taxonomic affinities. Some of the more widespread species in the plantations were likely dependent on the understorey floras, e.g. *Dipterygina* spp. on host plant *Callicarpa*, rather abundant in various plantation sites (see Chapter Five). The homogeneity evident in these plantations each with a large number of a single similarly planted tree species (unlimited food resource) seemed to appeal to a number of opportunist r-strategists which managed to exploit the situation to their best advantage, their reproductive potentials being enhanced by the abundant food supply, enabling them to colonize the introduced tree species successfully. Strong *et al.* (1984) provided reasons for certain insect species having high predilection for colonizing introduced plants, being either because the insects are highly polyphagous (with a wider niche breadth characteristic of colonizers of earlier succession stages), or the plants are taxonomically as well as biochemically close to the insects' normal hosts.

The second analysis for Geometroidea with 25 or more individuals (Figs. 2.11 & 2.12) again illustrated the affinities between *Eucalyptus deglupta* and Secondary Forest. The smaller number of individuals (25) enabled species indicative of certain sites which were omitted in the first analysis to be picked out e.g. *Ozola ?minor* Moore indicative of *Gmelina arborea* and had been reared from its leaves on numerous occasions by the author (see Appendix V). It is also of interest to note that quite a number of species clustered together rather well for *Pinus caribaea* which is likely to be their host plant.

The cluster analysis for Noctuidae with 50 individuals or more when compared to the previous two analyses was unable to produce good clustering to distinctly separate the various plantations (Figs. 2.13 & 2.14). Instead it lumped them all together resulting in a big and loose cluster. This was mainly due to the fact that a large number of the noctuids (e.g. the herminiines with many species feeding on detritus which was plentiful in plantation sites) were widespread in those plantation sites, and hence diminished the group's discriminant ability. Nonetheless it managed to distinguish *Eucalyptus deglupta* and Secondary Forest from the rest, as Secondary Forest and to a lesser extent *Eucalyptus deglupta* yielded certain noctuids more abundantly (in particular ophiderines, many being fond of secondary vegetation) than the other sites.

2.3.3.2 Q-mode analysis of site similarity

In addition to the above analyses of R-mode dissimilarity index ('Coefficient') showing species associations and distributions, the Q-mode Preston's index which analyzes samples made up of mixture of species from various associations was performed as well. Table 2.5 gives a trellis structure with the upper triangle having the number of shared species between sites of all macromoths collected, and the lower half the Preston's coefficients (calculated from one of G.S.Robinson's programmes) with lower value indicating more similar samples. It again shows that *Eucalyptus deglupta* was more similar to Secondary Forest in terms of species shared, with a Preston's coefficient of 0.391. The rest are all above 0.4. The clustering structure of the Brumas samples based on the Preston's coefficients however, was not as informative as the R-mode, as it lumped the various sites together.

2.3.4 TWINSPAN

For this analysis, the 6 sampling sites were divided into 72 'sites' where each of the

Table 2.5 Preston's coefficient of faunal resemblance* for light trap samples of macromoths at Brumas, 1991

		A. mangium	*E. deglupta*	*G. arborea*	*P. falcataria*	*P. caribaea*	Secondary Forest
	No. spp.	726	872	675	782	778	1048
A. mangium	726		487	444	483	452	527
E. deglupta	872	0.469		480	545	507	653
G. arborea	675	0.449	0.45		459	452	503
P. falcataria	782	0.442	0.421	0.45		474	586
P. caribaea	778	0.484	0.468	0.459	0.478		515
Secondary Forest	1048	0.465	0.391	0.465	0.423	0.507	

*Upper triangle = No. of shared species

Lower triangle = Computed Preston's coefficients

12 months in 1991 at each of the 6 sites was considered as a particular 'site' e.g. Am-i stands for *Acacia mangium*-January, Am-ii for *Acacia mangium*-February, and so on (Fig. 2.15). In this way the variations as well as similarities for each of the six sampling sites in the 12 different sampling months could be looked into in greater detail.

Three cut-levels were chosen i.e. 1st level at 0.5 (for 1-5 individuals), 2nd at 5 (6-25 individuals), and 3rd at 25 (>25 individuals) as these represent the levels of abundance for the moth species rather well. At step 1, the 72 'sites' are split into 45 on the negative or left-hand side which consists of almost entirely plantation sites, and 27 on the positive or right-hand side which is made up of mainly Secondary Forest and some *Eucalyptus deglupta* sites. *Hipoepa fractalis* Guenee (Herminiinae), which feeds on legumes and detritus (see Appendix I), *Scopula* sp. no. 10765 (Sterrhinae), an an unidentified Herminiinae 1, all three species are selected by TWINSPAN as indicative of the negative group (plantations) at the 1st cut-level as they were more numerous in the plantations than Secondary Forest, and *Eucalyptus deglupta* to a lesser extent. While *Hypochrosis binexata* Walker (Ennominae), a species which favours disturbed secondary forest, and *Ananepa doda* Swinhoe (Ophiderinae), more in Secondary Forest though not as abundant, are indicative of the positive group at the 2nd and 1st cut-level respectively.

For step 2, the 45 'sites' on the left are subsequently divided into 26 'sites' and 19 'sites'. The indicator species singled out for the 26 'sites' are *Pareuchaetes pseudoinsulata* Rego Barros (Arctiinae), a weed feeder recorded from the rather ubiquitous *Chromolaena odoratum*, and *Epiplema instabilata* Walker (Epiplemidae), which shows a preference for *Gmelina* as food plant. Both species were collected in higher numbers at *Gmelina arborea* and to a lesser degree *Acacia mangium*, these two plantations made up the majority of the 26

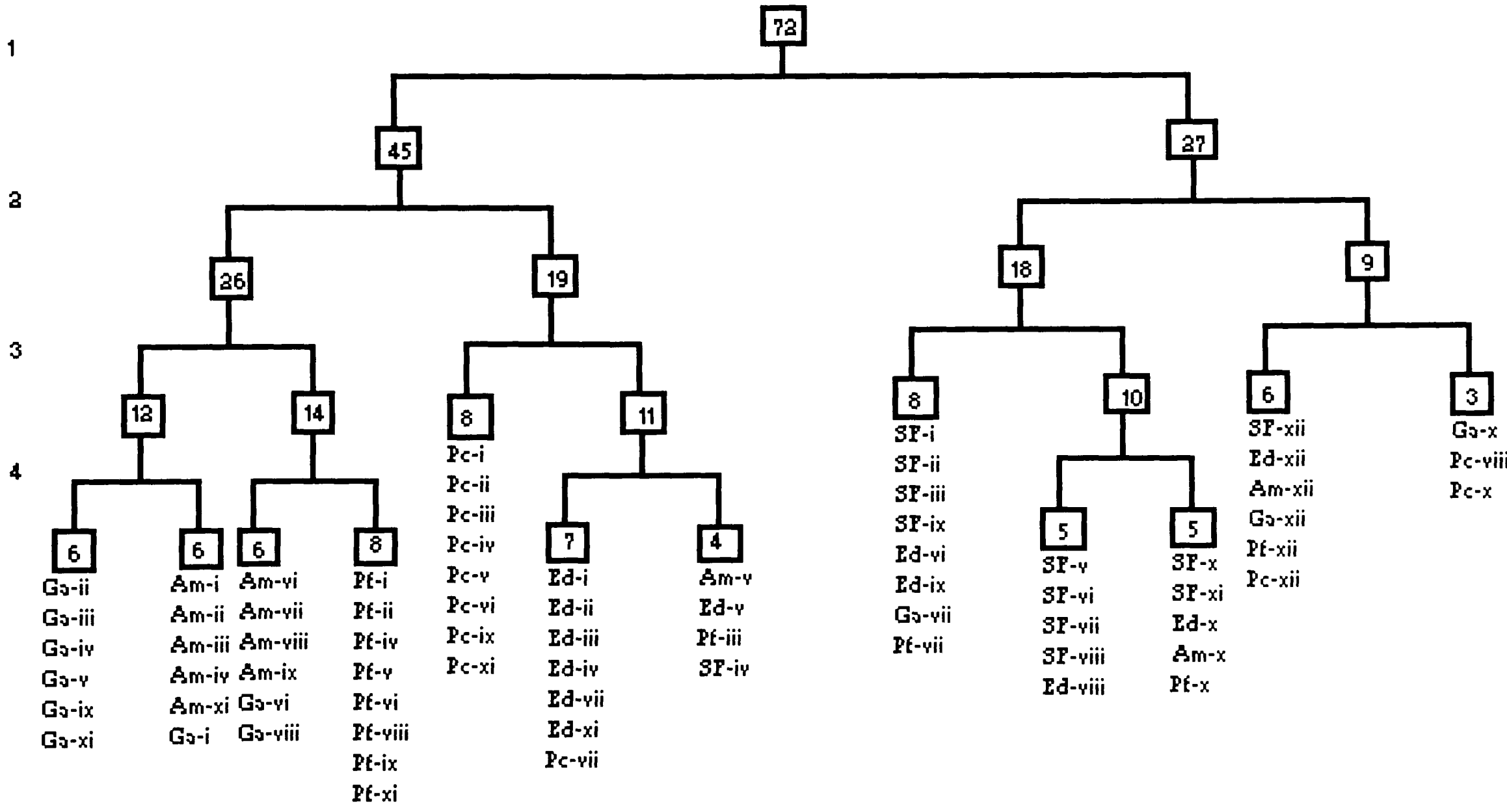


Fig. 2.15 TWINSPAN (Two-way indicator species analysis) diagram showing a hierarchical classification of the sites according to the different months in 1991, Brumas
Step numbers are indicated on the left.
i -> xii = January -> December

'sites'. As for the other 19 'sites', the indicator species include *Asura* sp. no. 2713 (Lithosiinae), *Eublemma* sp. nr. *brachygonia* Hampson (Acontiinae), both marked by their high numbers at *Pinus caribaea*, the latter having been reared by the author from flowers of *Pinus caribaea* (see Appendix V), and *Spilosoma hosei* Rothschild (Arctiinae), collected in bigger numbers from *Pinus caribaea* and *Eucalyptus deglupta* among the plantations, but more from Secondary Forest. On the right-hand side of division 2, the 27 'sites' are divided into 18 and 9 'sites'. Two indicator species are selected by TWINSPAN only for the group of 18 'sites': *Tanaorhinus rafflesii* Moore (Geometrinae), a species which feeds on oaks *Quercus*, and *Episparis costistriga* Walker (Ophiderinae), both species collected in large numbers from Secondary Forest with the first rather common at *Eucalyptus deglupta* as well. Out of the 18, 10 are Secondary Forest and 4 are *Eucalyptus deglupta* 'sites'. The other 9 'sites' on the other branch are mostly a mixture of plantation sites.

Worth pointing out at step 3 is the group of 26 'sites' which splits into 12 and 14, with the 14 on the right indicated at cut-level 2 by *Dipterygina vagivitta* Walker (Amphipyrinae), a species most abundant at *Paraserianthes falcataria* followed by *Acacia mangium*. Also the group of 19 'sites' which branches into 8 and 11, with the 8 on the left indicated by *Epiplema conflictaria* Walker (Epiplemidae) which was higher in abundance at *Pinus caribaea*, and all 8 are *Pinus caribaea* sites.

At step 4, the group of 6 *Gmelina arborea* 'sites' on the left are indicated by *Ozola ?minor* Moore (Oenochrominae), and *Xyleutes ceramica* Walker (Cossidae), both species feed on *Gmelina arborea*, the first a defoliator, the second a trunk-borer. On the other branch next to it is another group of 6 'sites' with 5 being *Acacia mangium* and indicated by *Godonela ozararia* Walker (Ennominae), important as the tree's defoliator (see Appendix V). Most of

these indicator species also came out in the R-mode cluster analysis performed earlier (see 2.3.3.1). As can be seen from the diagram, the TWINSPAN divisions resulted in mostly, and not surprisingly, end groups of 'sites' of similar locality: 'Am' with 'Am', 'Ga' with 'Ga', and so on. The results suggest that the intrinsic nature of each site, both structurally and biochemically, enables each to a greater or lesser degree to manifest its own identity, characterized in this case by certain moth species, which can, to a certain extent, be obscured by the more widespread species with greater ecological amplitude.

An intriguing result from this analysis is one of the divisions at step 3 which has 6 'sites', in fact all the 6 sampling sites from the month of December (xii). TWINSPAN unfortunately does not provide any indication why this should be so. A look at the figures of the monthly total captures (Table 2.6) shows that December had been a rather poor month both in terms of species and abundance. Supposing sampling effort had been consistent, the reasons behind this phenomenon could perhaps be ascribed to the weather.

2.3.5 Effects of Rainfall and Moonlight on catches

Analysis of variance (Table 2.7) showed that there was significant difference between months, as well as sites, in terms of both numbers of individuals (N) and species (S) for the various moth samples collected at Brumas in 1991. Rainfall as well as moonlight (temperatures in Borneo being relatively constant) were probably the two major abiotic environmental parameters influencing catch size. The numerous light-trapping nights spent in Brumas produced an impression not unlike the author's previous experiences. One could generally say that a wet afternoon preceding the night of light-trapping usually boosted the catch somewhat, while the glare of a bright full moon depressed it. These observations being merely visual, attempts were made to investigate the possible relationships between these two parameters and catch size by statistical analysis. However, the efforts were hampered by

Table 2.6 Total numbers of individuals (N) and species (S) of macromoths captured by light-trapping for the 24 sampling nights (2 nights per month) at each site, Brumas 1991

Acacia mangium	i1	i2	ii1	ii2	iii1	iii2	iv1	iv2	v1	v2	vi1	vi2	vii1	vii2	viii1	viii2	ix1	ix2	x1	x2	xi1	xi2	xii1	xii2	sum
N	186	171	212	215	512	246	172	152	164	228	383	388	570	590	112	424	329	230	149	132	242	243	287	265	6602
S	63	70	88	84	134	77	87	75	56	146	93	111	118	130	19	87	83	86	88	90	98	112	111	99	726
N(1+2)	357		427		758		324		392		771		1160		536		559		281		485		552		
S(1+2)	111		128		161		129		178		161		188		93		133		152		167		166		

Eucalyptus deglupta	i1	i2	ii1	ii2	iii1	iii2	iv1	iv2	v1	v2	vi1	vi2	vii1	vii2	viii1	viii2	ix1	ix2	x1	x2	xi1	xi2	xii1	xii2	sum
N	183	164	122	95	188	198	145	159	161	197	159	187	405	295	165	173	220	225	99	141	199	205	106	94	4285
S	116	96	79	70	113	128	101	113	120	122	110	122	221	174	105	97	133	133	66	78	134	107	58	55	872
N(1+2)	347		217		386		304		358		346		700		338		445		240		404		200		
S(1+2)	175		123		200		177		192		196		312		168		216		124		205		90		

Gmelina arborea	i1	i2	ii1	ii2	iii1	iii2	iv1	iv2	v1	v2	vi1	vi2	vii1	vii2	viii1	viii2	ix1	ix2	x1	x2	xi1	xi2	xii1	xii2	sum
N	168	184	161	159	167	183	84	52	234	213	214	273	216	176	190	225	264	117	154	147	129	153	160	141	4164
S	78	78	95	75	78	90	47	37	84	65	114	118	123	117	65	87	111	63	86	91	68	73	82	73	675
N(1+2)	352		320		350		136		447		487		392		415		381		301		282		301		
S(1+2)	125		144		132		71		116		173		197		124		137		151		113		127		

Paraserianthes falcataria	i1	i2	ii1	ii2	iii1	iii2	iv1	iv2	v1	v2	vi1	vi2	vii1	vii2	viii1	viii2	ix1	ix2	x1	x2	xi1	xi2	xii1	xii2	sum
N	269	297	193	116	118	299	262	311	654	548	312	363	219	231	222	217	338	333	164	138	331	333	125	130	6523
S	107	106	72	73	64	163	106	113	158	126	109	121	131	146	95	78	113	106	98	96	126	111	65	71	782
N(1+2)	566		309		417		573		1202		675		450		439		671		302		664		255		
S(1+2)	161		121		208		173		209		176		217		134		168		168		174		117		

Pinus caribaea	i1	i2	ii1	ii2	iii1	iii2	iv1	iv2	v1	v2	vi1	vi2	vii1	vii2	viii1	viii2	ix1	ix2	x1	x2	xi1	xi2	xii1	xii2	sum
N	170	102	212	137	231	190	157	159	348	291	145	149	327	236	111	139	213	223	148	168	233	204	61	59	4413
S	100	70	100	69	114	98	95	90	153	117	96	87	162	109	72	97	114	117	81	87	108	99	47	48	778
N(1+2)	272		349		421		316		639		294		563		250		436		316		437		120		
S(1+2)	141		146		171		143		208		151		223		149		182		147		164		81		

Secondary Forest	i1	i2	ii1	ii2	iii1	iii2	iv1	iv2	v1	v2	vi1	vi2	vii1	vii2	viii1	viii2	ix1	ix2	x1	x2	xi1	xi2	xii1	xii2	sum
N	364	330	206	302	327	333	325	379	555	258	448	334	500	630	312	333	387	301	230	224	582	405	189	236	8490
S	161	125	108	133	154	158	188	199	226	122	199	169	209	244	162	189	203	154	140	129	233	202	90	105	1048
N(1+2)	694		508		660		704		813		782		1130		645		688		454		987		425		
S(1+2)	217		189		252		304		280		294		336		288		290		220		336		157		

Brumas 1991	i1	i2	ii1	ii2	iii1	iii2	iv1	iv2	v1	v2	vi1	vi2	vii1	vii2	viii1	viii2	ix1	ix2	x1	x2	xi1	xi2	xii1	xii2	sum
N(1+2)	2588		2130		2992		2357		3851		3355		4395		2623		3180		1894		3259		1853		34477
S(1+2)	519		452		608		561		649		618		716		561		583		536		666		414		1642

several constraints. Firstly the rainfall data (see Appendix II) available were monthly records and not daily records based specifically on each sampling site. Secondly it was a daunting task to try to quantify moonlight, which could be subject to a host of inconsistent variables such as cloud conditions.

2.3.5.1 Rainfall

No regular trend or pattern seemed to emerge when the monthly captures (2 sampling nights per month) of both individuals (N) and species (S) of each site, as well as combination of all sites, were plotted with monthly rainfall (Figs. 2.16 to 2.22). Higher rainfall of the same month or the month before (time lag response) did not necessarily induce bigger sample, nor lower rainfall resulted in smaller catch. Tanaka & Tanaka (1982) while working on insect seasonality in the tropical island of Grenada, West Indies, reported that the average abundance of the arthropods is 2.3 times greater in the wet season. It is also logical to assume that since tropical trees have the tendency to flush during wetter months, the availability of a greater biomass of young succulent foliage would attract and support a larger and perhaps more diverse arthropod load. Wint (1983), in his paper on leaf damage in Papua New Guinean rain forest, stated that with Lepidoptera as one of the major herbivores, young leaves are preferred. The results obtained here failed to reflect this school of thought. Regression analysis (Table 2.8) also failed to reveal any meaningful relationship between catches and rainfall.

It is also of interest to note that in 1991, Brumas was not cursed by any prolonged dry spell. Even the driest month of September registered above 70mm of rain. This situation did not produce any drastic and hence more profound impact of rain on the moth populations.

2.3.5.2 Moonlight

Taking a moonlit night as one with a night sky gloriously bright with moonlight, with a moon of at least 30% full in size, and a moonless night as dark with little or no moonshine,

Fig. 2.16.1 Monthly captures of individuals (N) vs rainfall. Acacia mangium, Brumas 1991

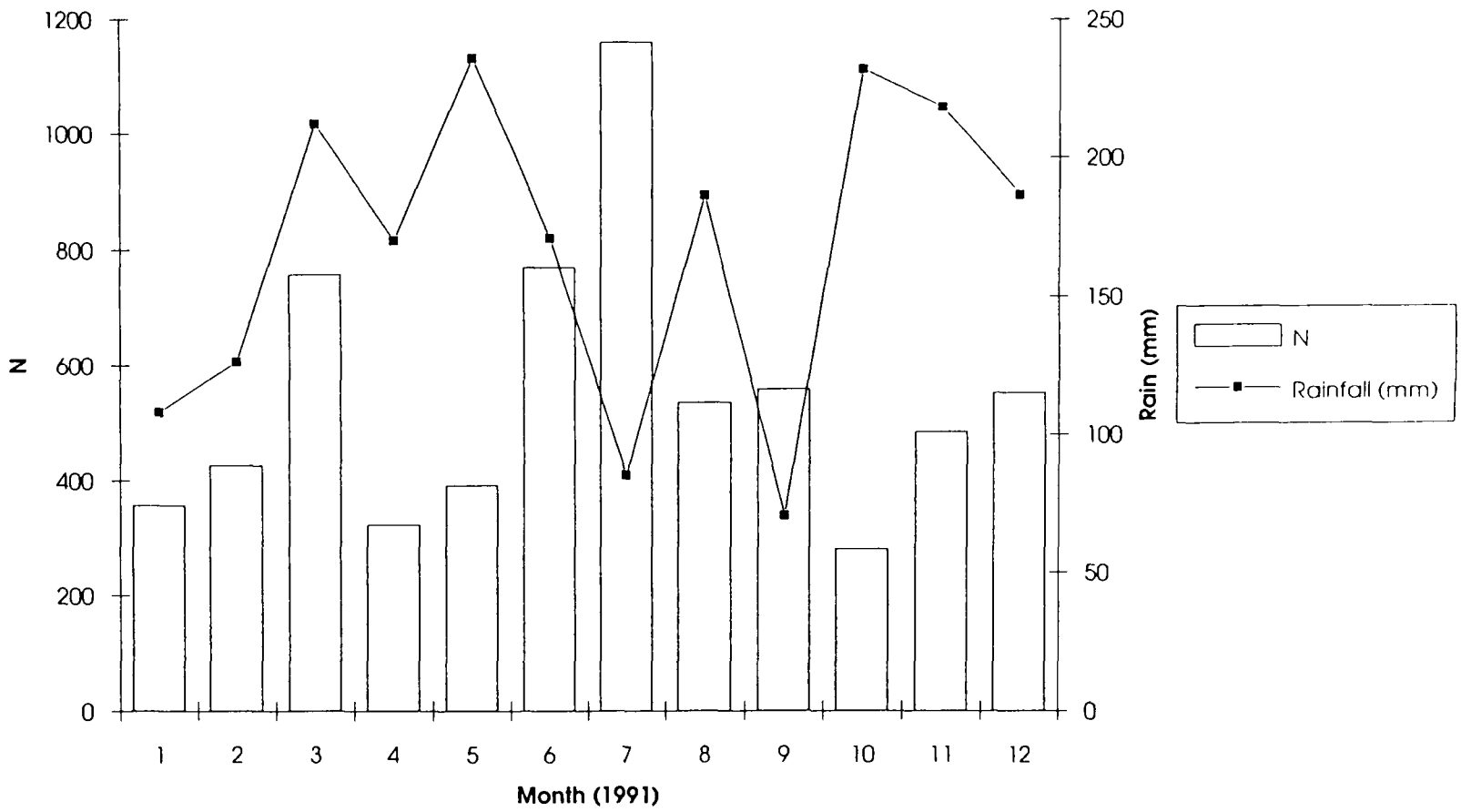


Fig. 2.16.2 Monthly captures of species (S) vs rainfall. Acacia mangium, Brumas 1991

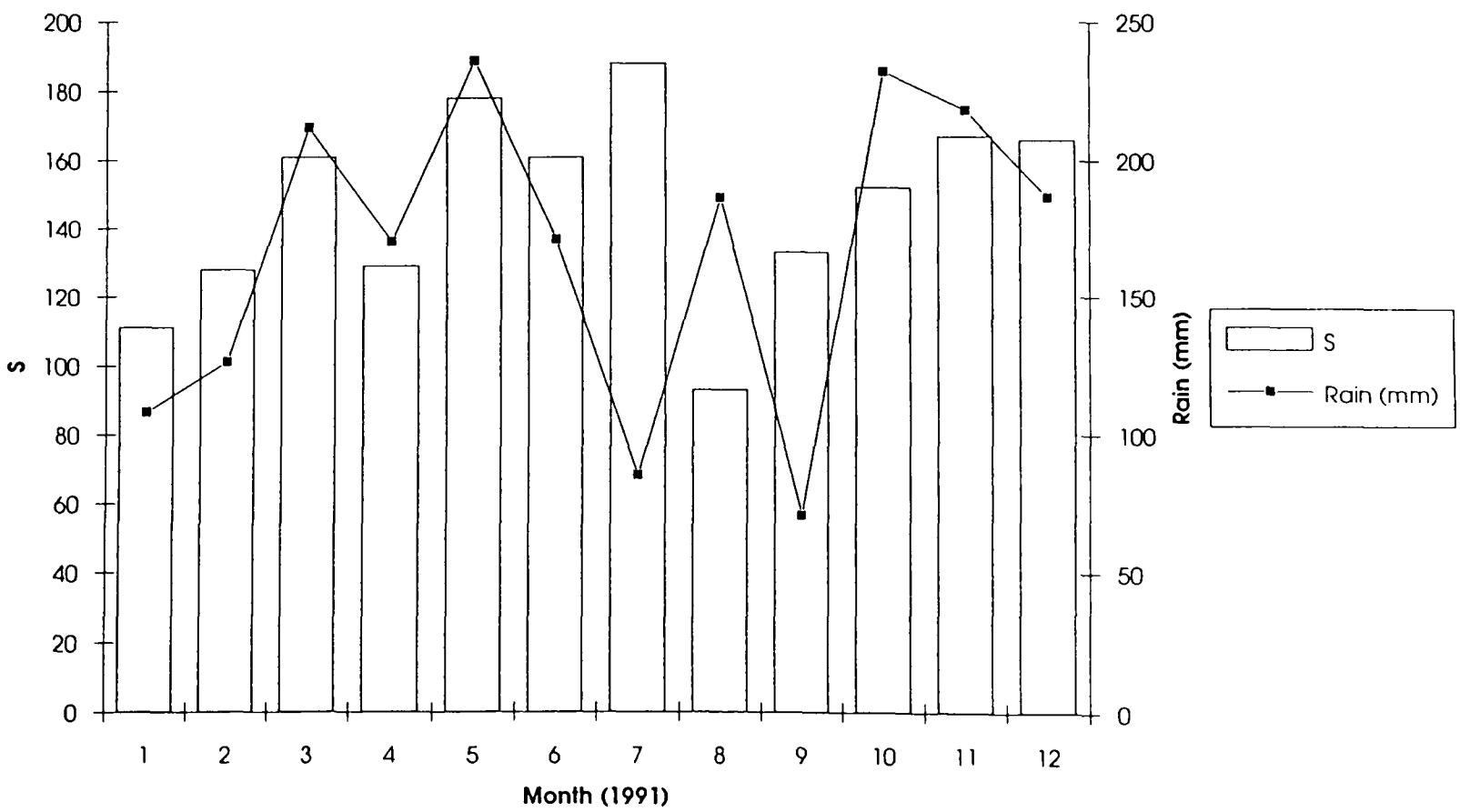


Fig. 2.17.1 Monthly captures of individuals (N) vs rainfall. Eucalyptus deglupta, Brumas 1991

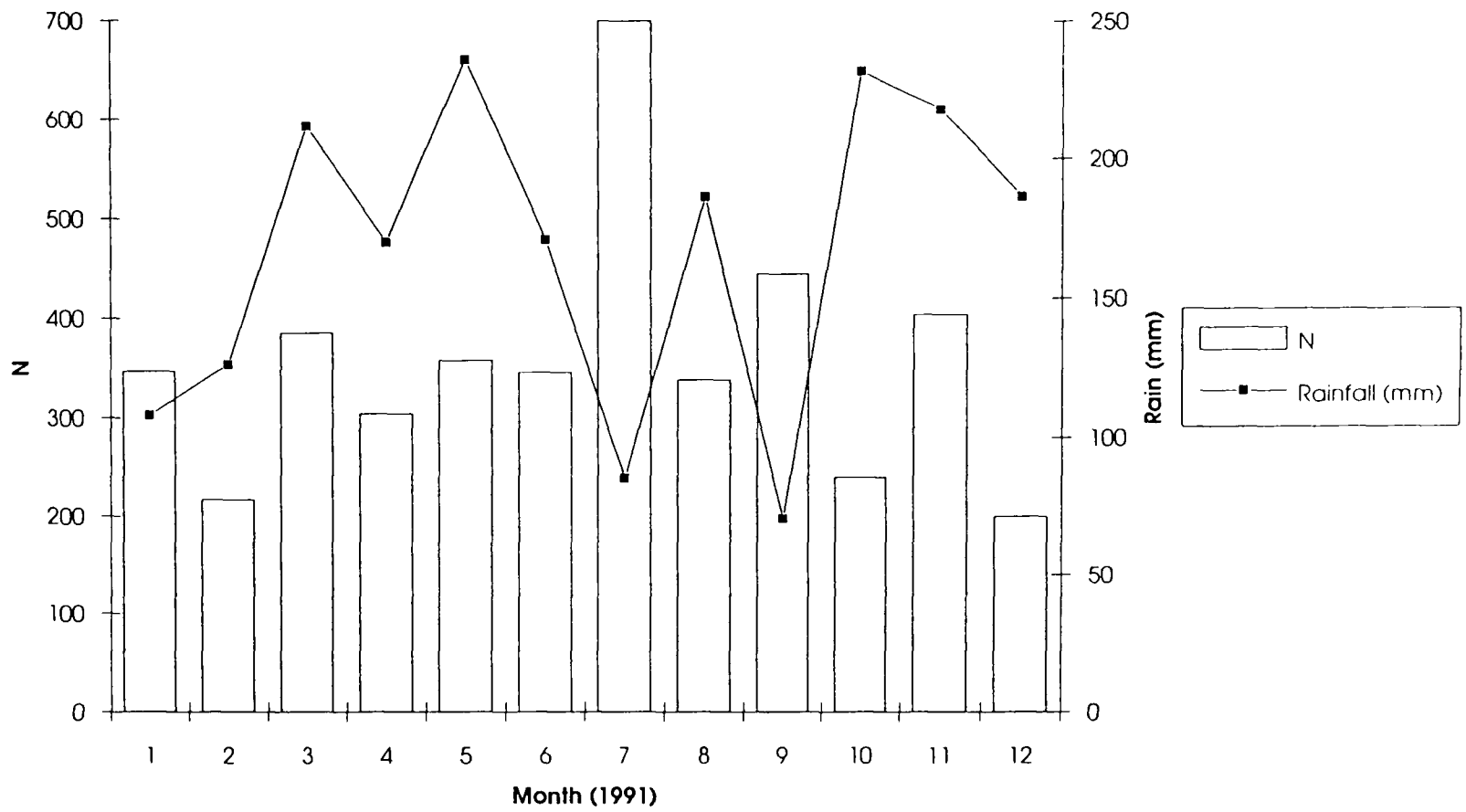


Fig. 2.17.2 Monthly captures of species (S) vs rainfall. Eucalyptus deglupta, Brumas 1991

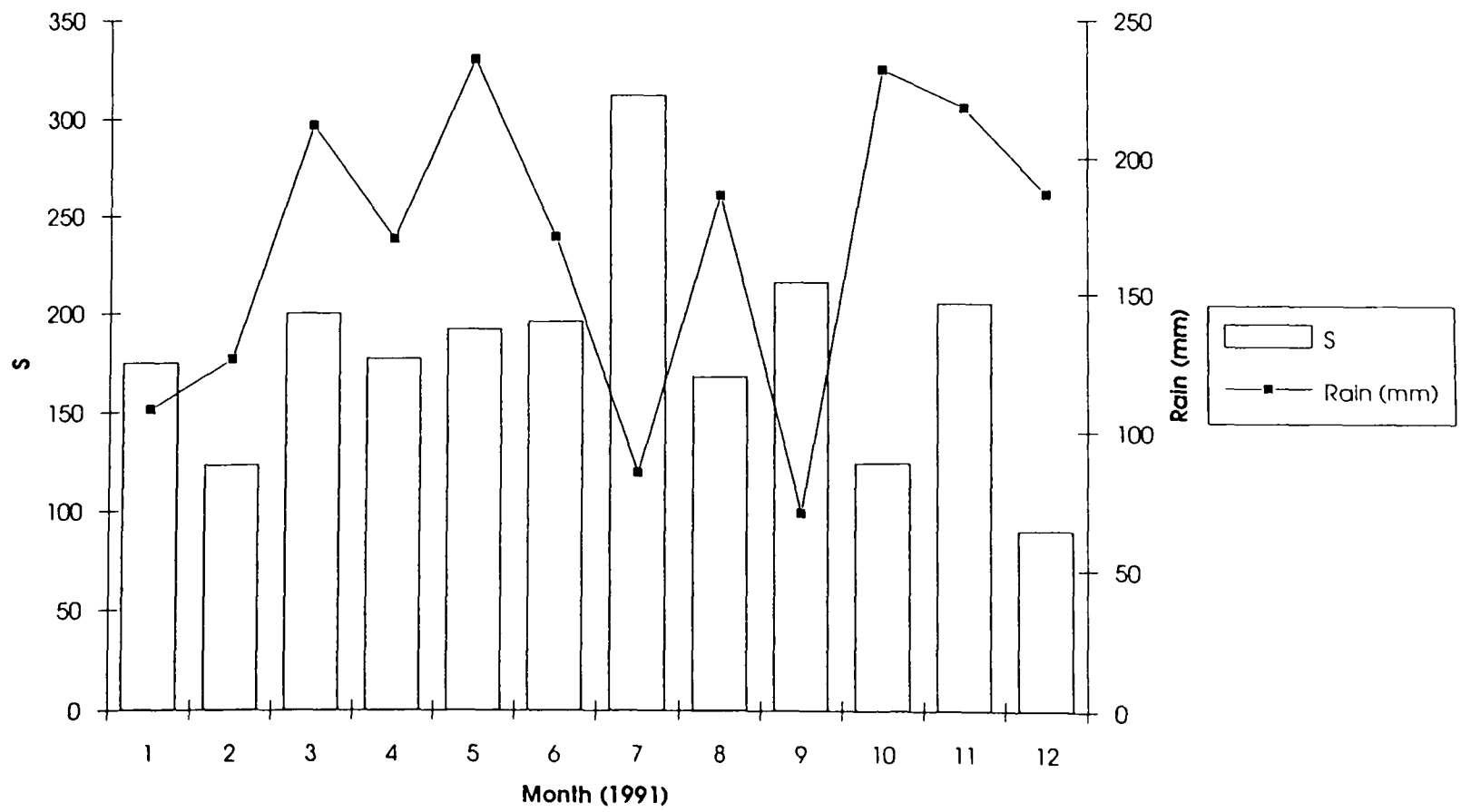


Fig. 2.18.1 Monthly captures of individuals (N) vs rainfall. Gmelina arborea, Brumas 1991

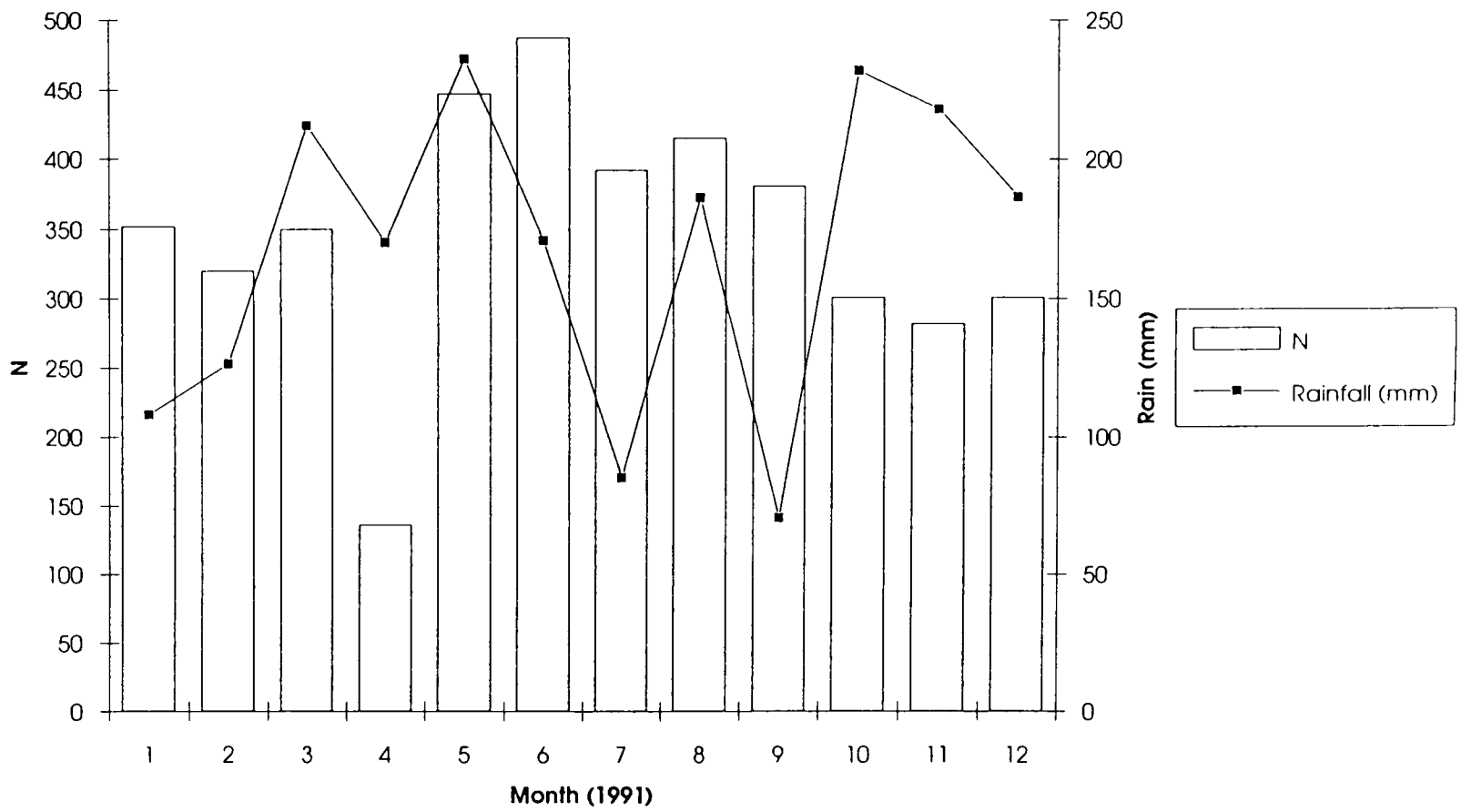


Fig. 2.18.2 Monthly captures of species (S) vs rainfall. Gmelina arborea, Brumas 1991

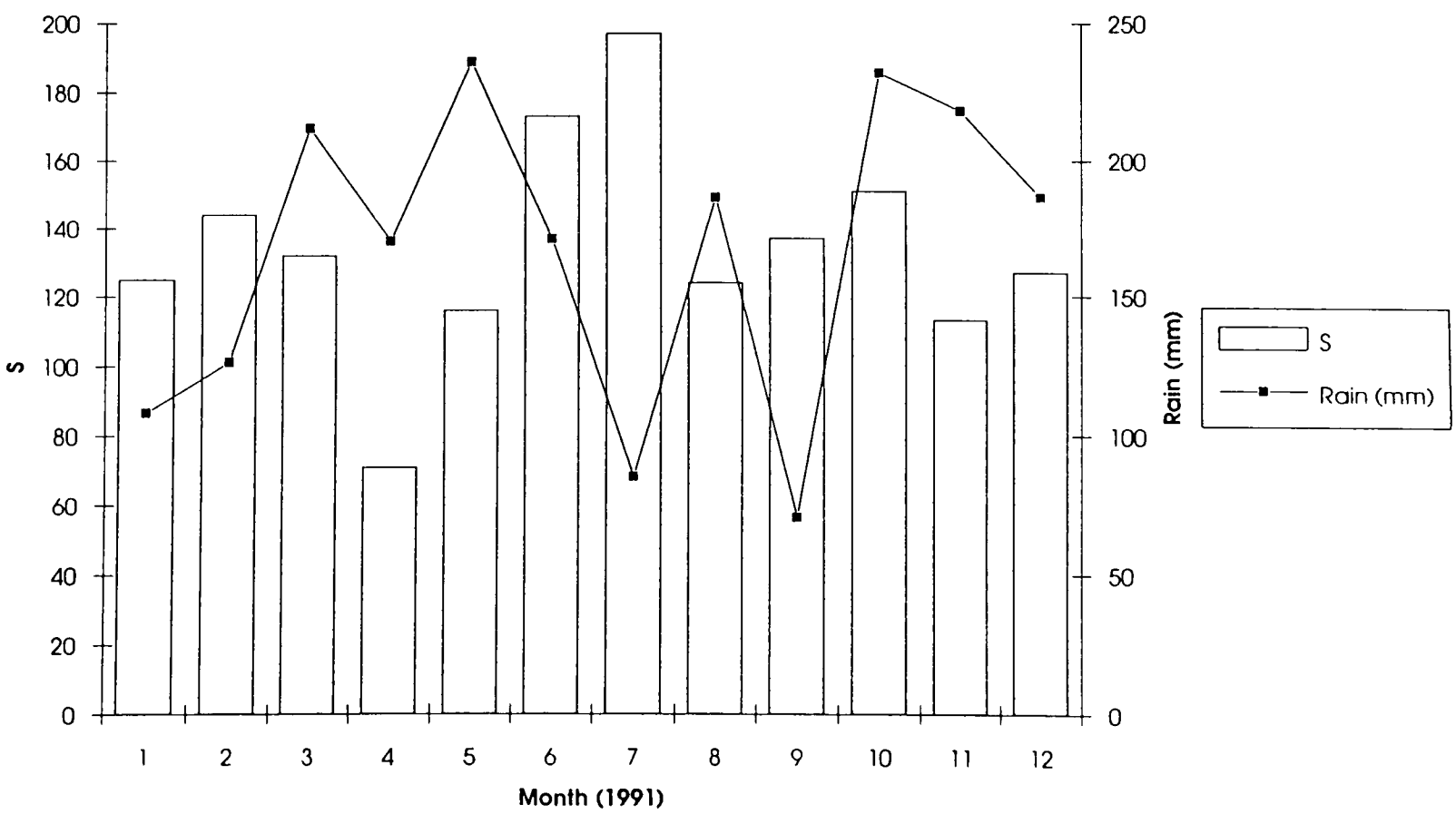


Fig. 2.19.1 Monthly captures of individuals (N) vs rainfall. Paraserianthes falcataria, Brumas 1991

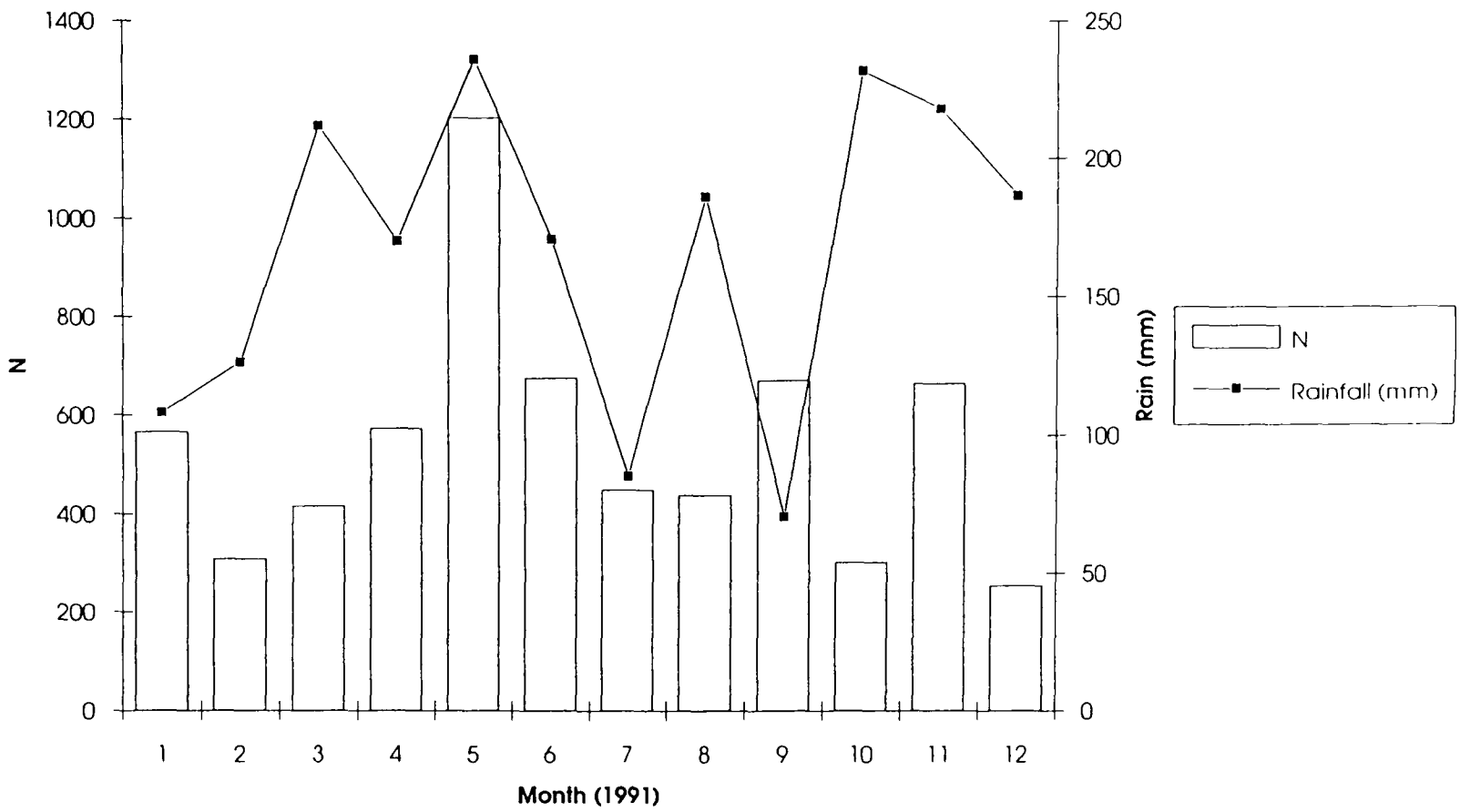


Fig. 2.19.2 Monthly captures of species (S) vs rainfall. Paraserianthes falcataria, Brumas 1991

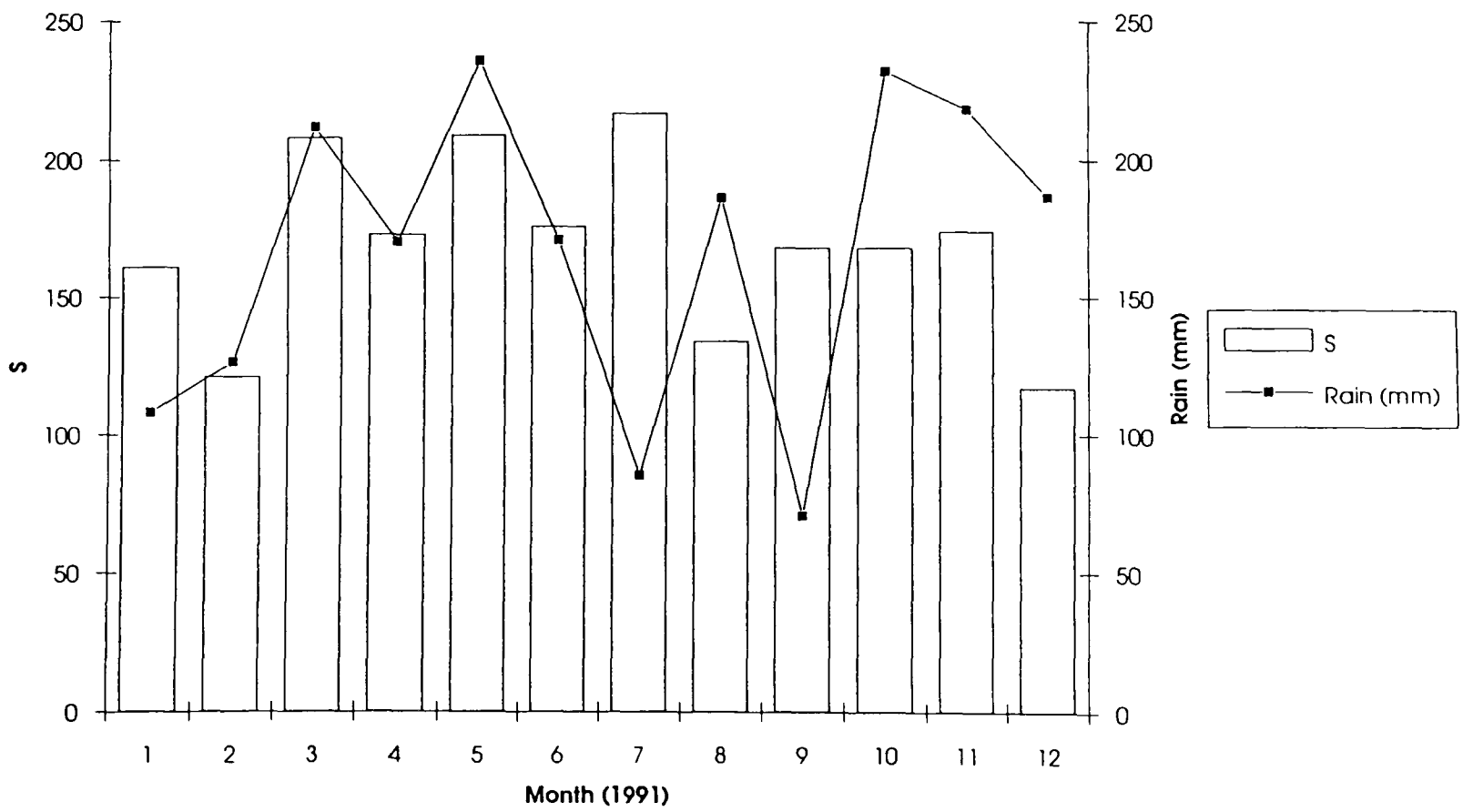


Fig. 2.20.1 Monthly captures of individuals (N) vs rainfall. Pinus caribaea, Brumas 1991

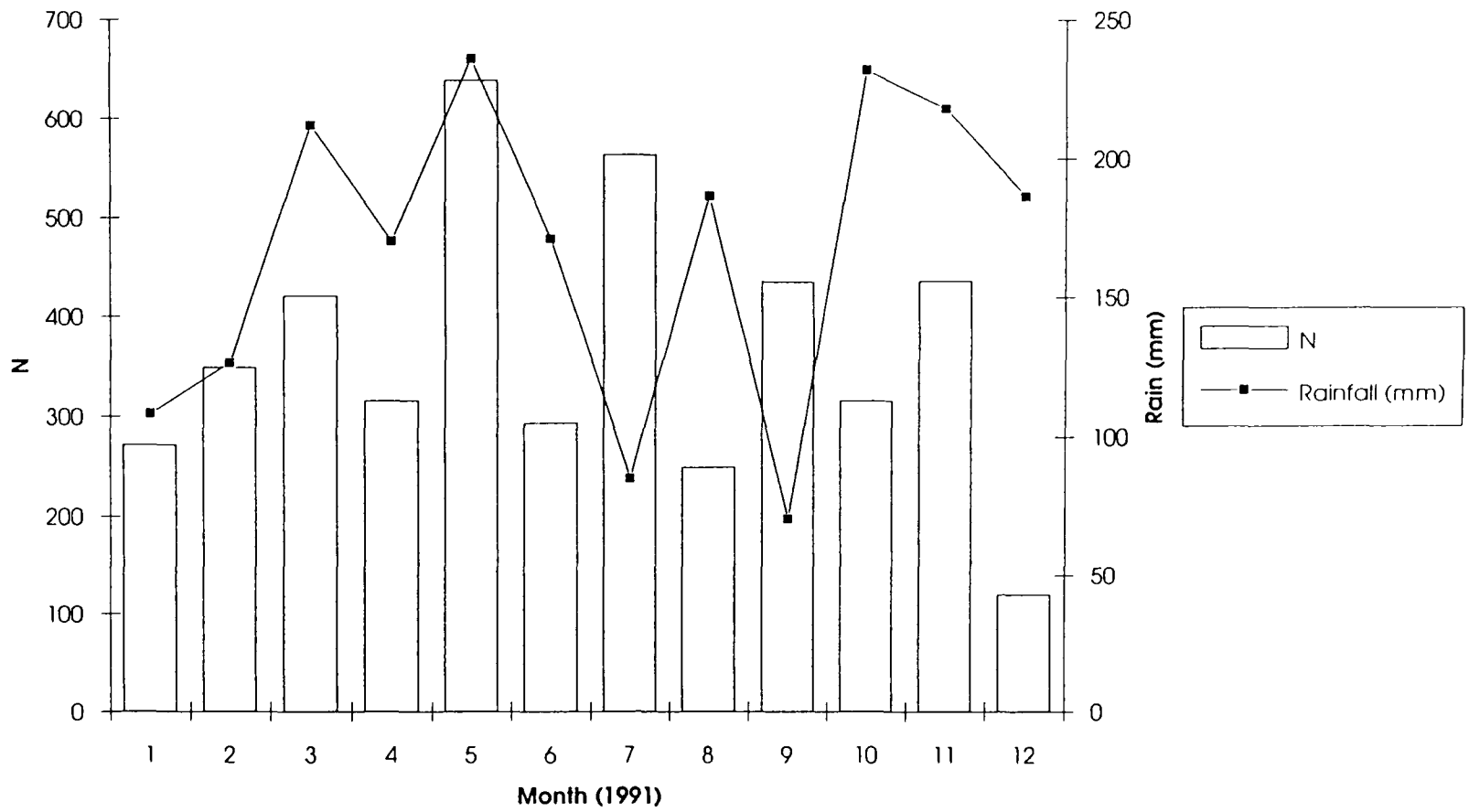


Fig. 2.20.2 Monthly captures of species (S) vs rainfall. Pinus caribaea, Brumas 1991

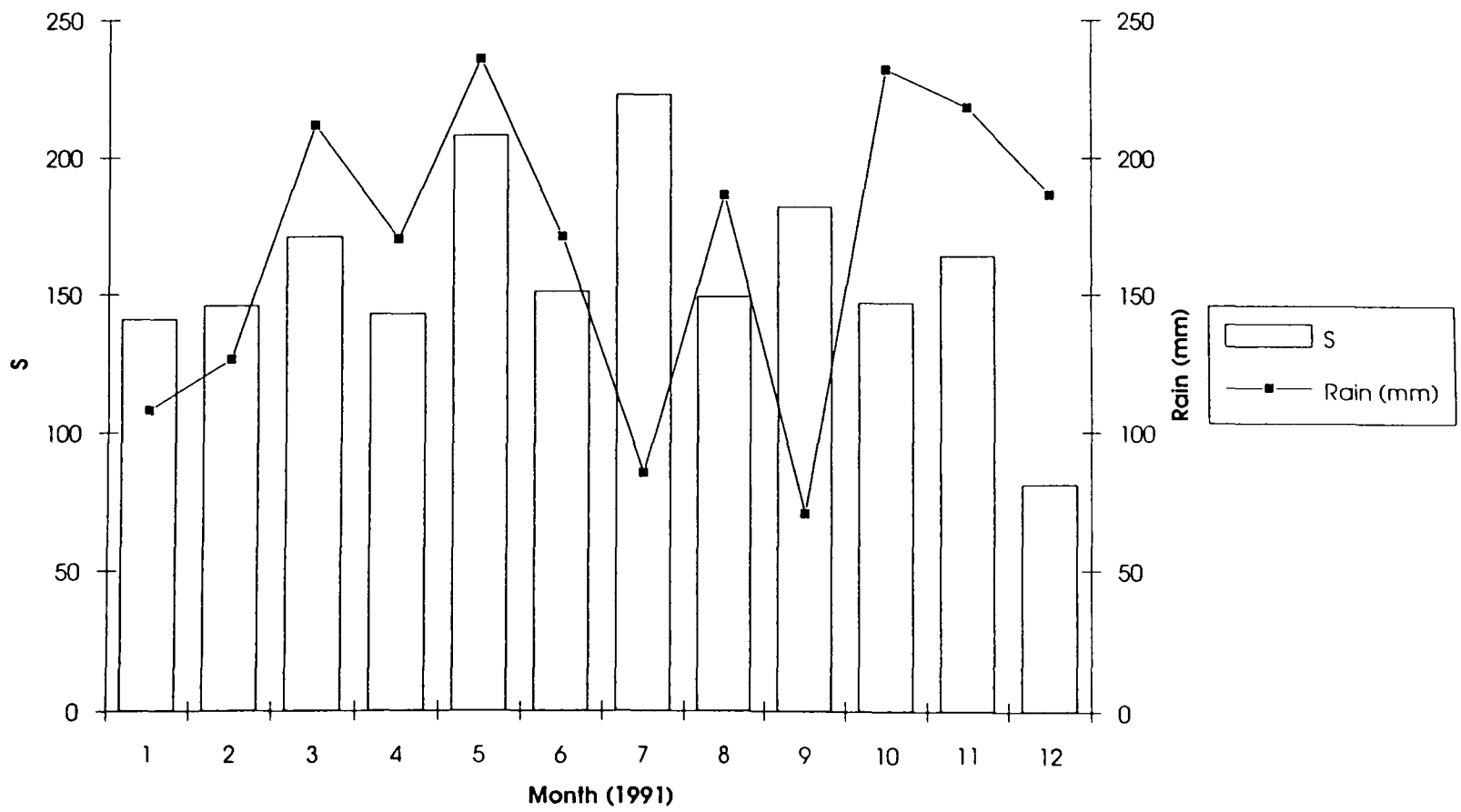


Fig. 2.21.1 Monthly captures of individuals (N) vs rainfall. Secondary Forest, Brumas 1991

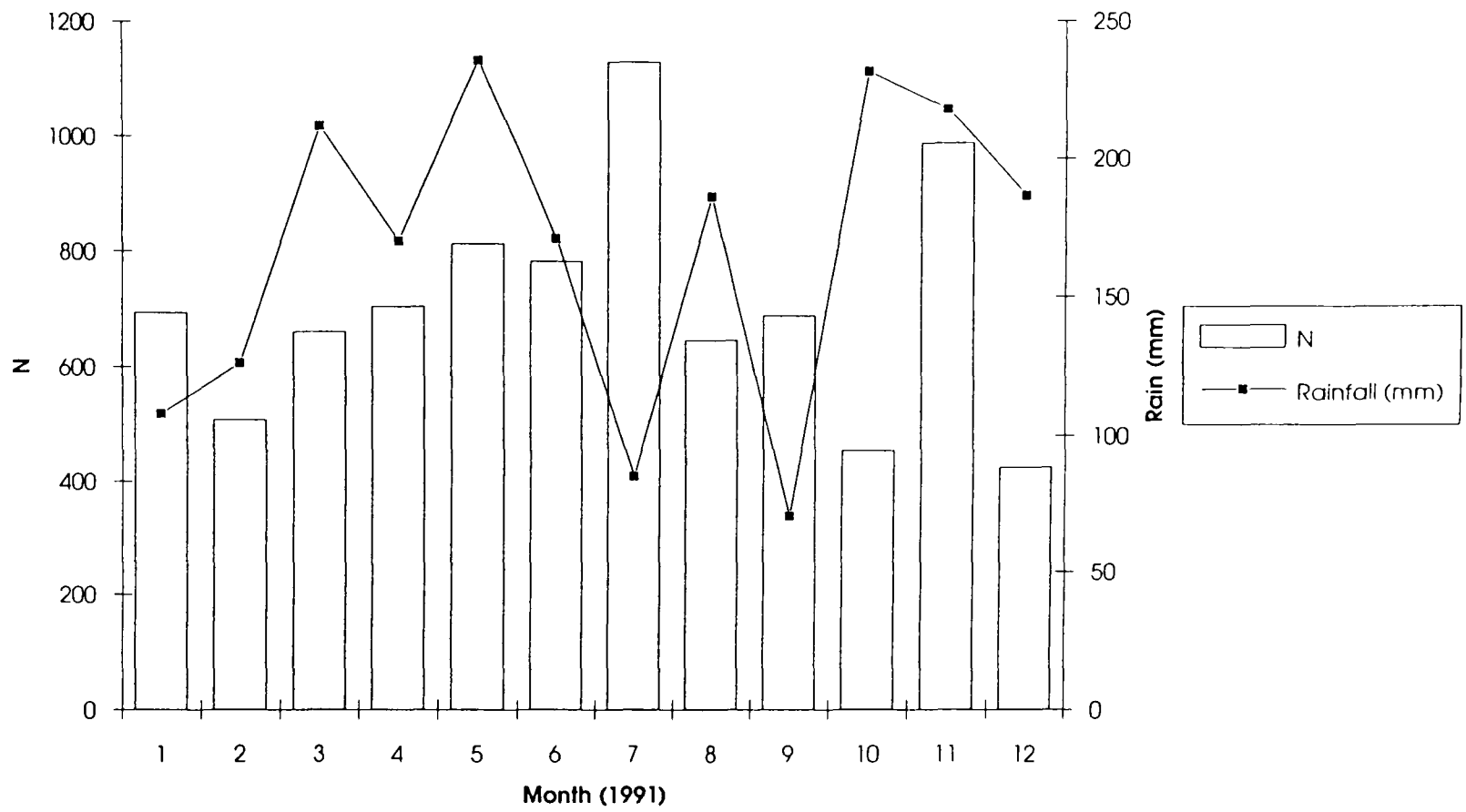


Fig. 2.21.2 Monthly captures of species (S) vs rainfall. Secondary Forest, Brumas 1991

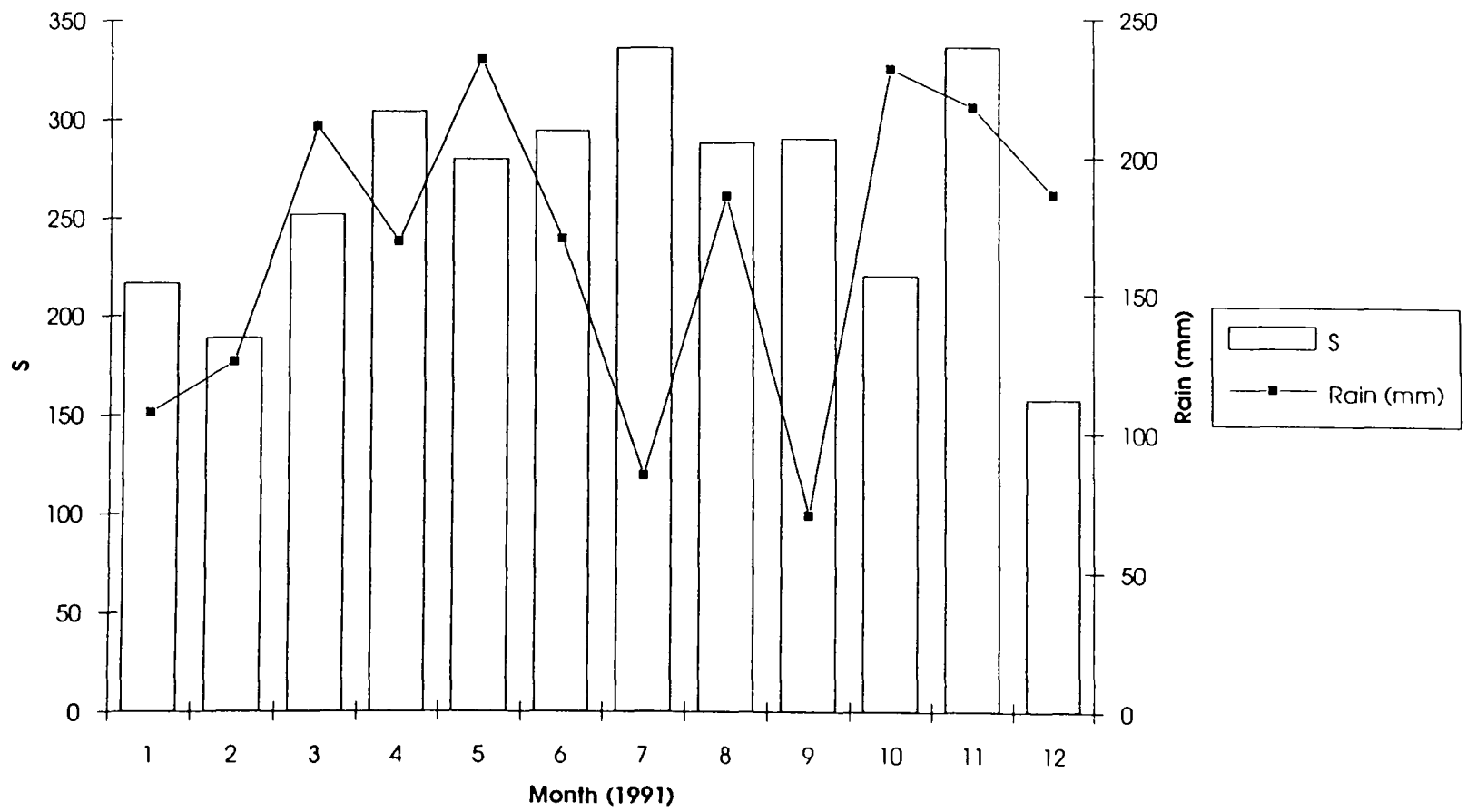


Fig. 2.22.1 Total monthly captures of individuals (N) vs rainfall. All sites, Brumas 1991

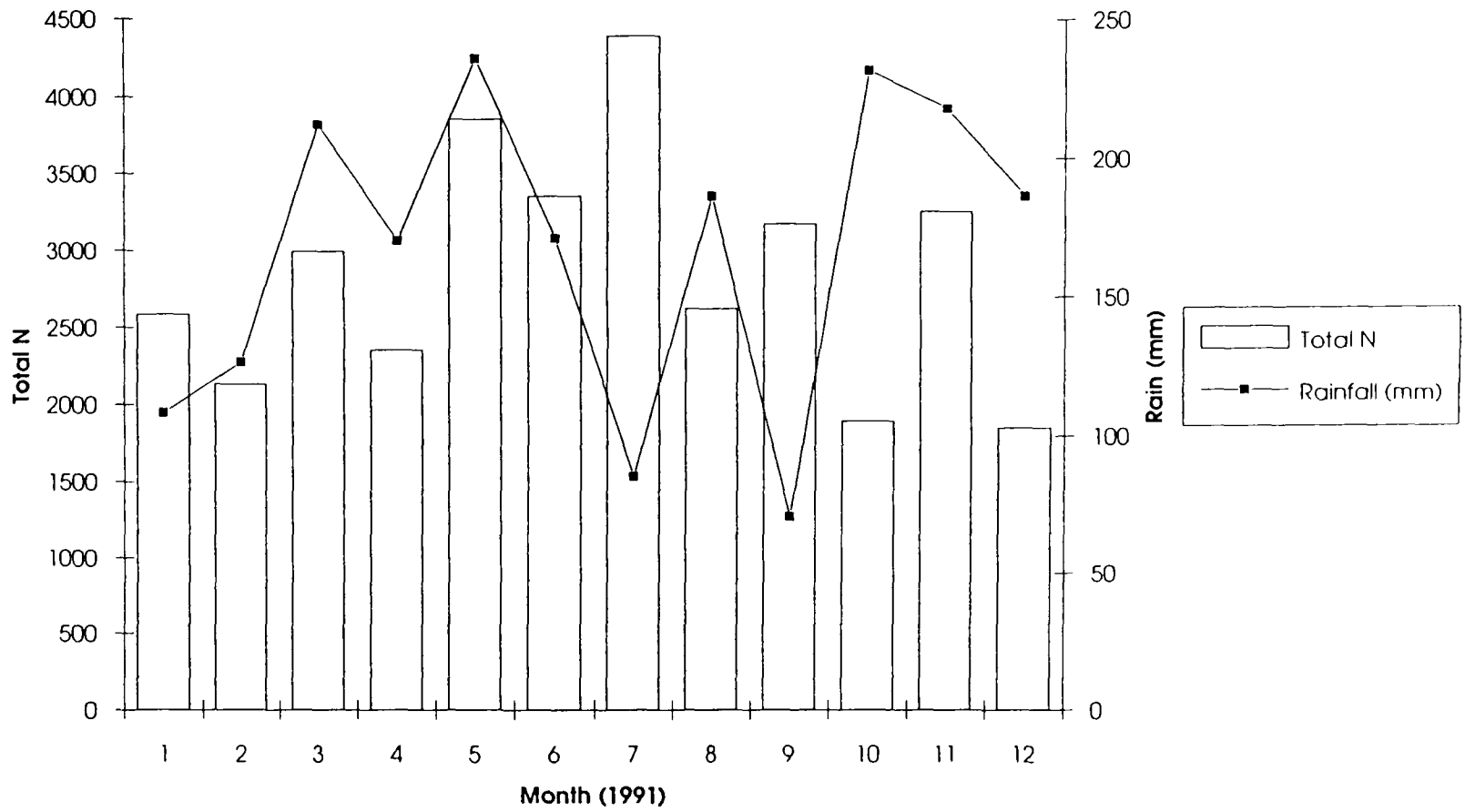


Fig. 2.22.2 Total monthly captures of species (S) vs rainfall. All sites, Brumas 1991

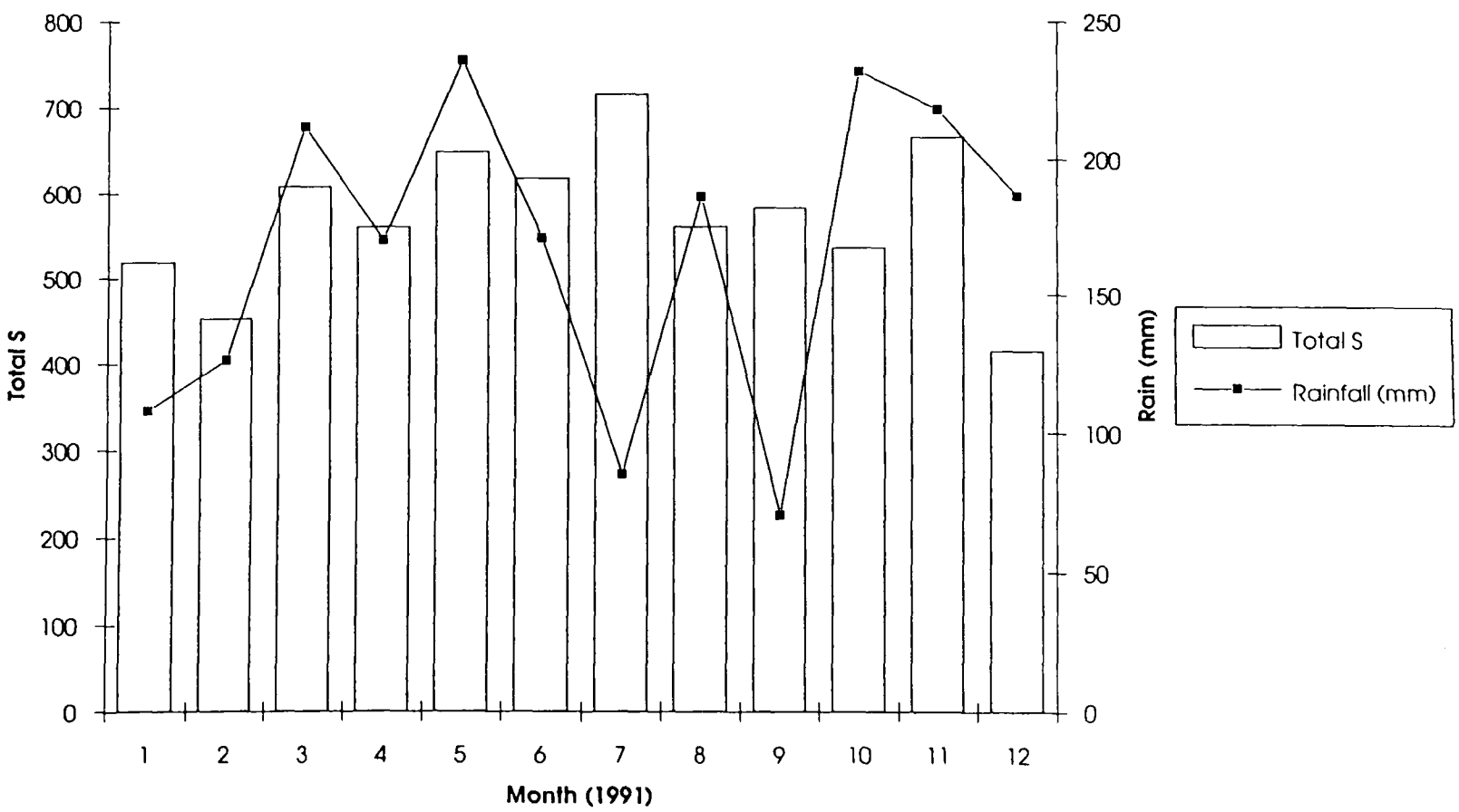


Table 2.7 Analysis of variance for between months and between sites effects

		N		S	
Main effects	DF	F	Sig. of F	F	Sig. of F
MONTH	11	15.05	< 0.001	12.688	< 0.001
SITE	5	37.623	< 0.001	48.35	< 0.001

Table 2.8 Results of regression analysis* for relationship between catches and rainfall**

		R square	
Site	DF	N & Rain	S & Rain
Acacia mangium	22	0.10719	0.0037
Eucalyptus deglupta	22	0.19315	0.16964
Gmelina arborea	22	0.006	0.09245
Paraserianthes falcataria	22	0.02666	0.00009
Pinus caribaea	22	0.00065	0.02019
Secondary Forest	22	0.03238	0.01395

* R square = 1 for perfect linear relationship.

** See Appendix II for rainfall data

Table 2.9 T- tests for independent samples* of catches for moonlit and moonless nights**

		Mean					
		Moonlit		Moonless		2-tail sig.	
Site	DF	N	S	N	S	N	S
Acacia mangium	22	225.5	85	299.875	95.3125	0.214	0.389
Eucalyptus deglupta	22	151	100.125	192.3125	115.625	0.16	0.337
Gmelina arborea	22	171.9167	76.0833	174.6667	90.4167	0.901	0.11
Paraserianthes falcataria	22	275.6	104	270.7895	107	0.943	0.83
Pinus caribaea	22	159	90	184.9565	97.3913	0.736	0.794
Secondary Forest	22	380.2857	182.8571	342.8235	160.1176	0.491	0.244

* No significant difference in catches (N or S) between moonlit and moonless nights if > 0.05

** Moonlit = Sky bright with moonlight, moon size > 30% full

** Moonless = Sky dark with little or no moonlight, moon size < 30% full

the moon at best 30% full, two-sample t-tests could be performed on the differences in the means of the captures between moonlit and moonless nights. Table 2.9 shows that usually, not always, moonless nights produced marginally superior samples both quantitatively (N) and qualitatively (S). The differences, however, did not seem to be statistically significant. Thus the visual presumption of a more productive moonless night in this case was proven to be just an illusion.

The influence of moonlight on light-trap catches is well documented but has produced no general consensus. Williams *et al.* (1956) with their comments on the depressant effect of moonlight on catches have already been mentioned in 2.1.1. Other workers have also come up with some intriguing observations. Hardwick (1972) found that in western North America, the lunar cycle has got no comparable influence whatsoever on the light-trapping survey of noctuid moths. Bowden & Morris (1975) working on a series of light-trap catches in Uganda and Ghana, managed to show that many species are even more abundant than expected at and near full moon, an example being the noctuid *Spodoptera triturata* Walker, which is 3-4 times more frequent at full moon. Such controversy persists mainly because hitherto there is no alternative sampling method which could rival the high efficiency of light-traps in terms of moth captures (Brown & Taylor, 1971). Hence the power of the mystic moon over the moths' behaviour remains much a mystery, a mind-boggling story which continues to keep us fascinated.

2.3.6 Fluctuations in the light-trapped moth captures

Both rainfall and moonlight have failed to explain the fluctuations in the overall moth samples which are shown in Figures 2.23 to 2.28 as variations in their alpha values. All the sites exhibit rise and fall in alpha values, which are dependent on the numbers of individuals and species of the catches, which in turn reflect the overall moth populations. The most

Fig. 2.23 Alpha values (95% confidence range) of the Acacia mangium plantation moth samples at Brumas in 1991

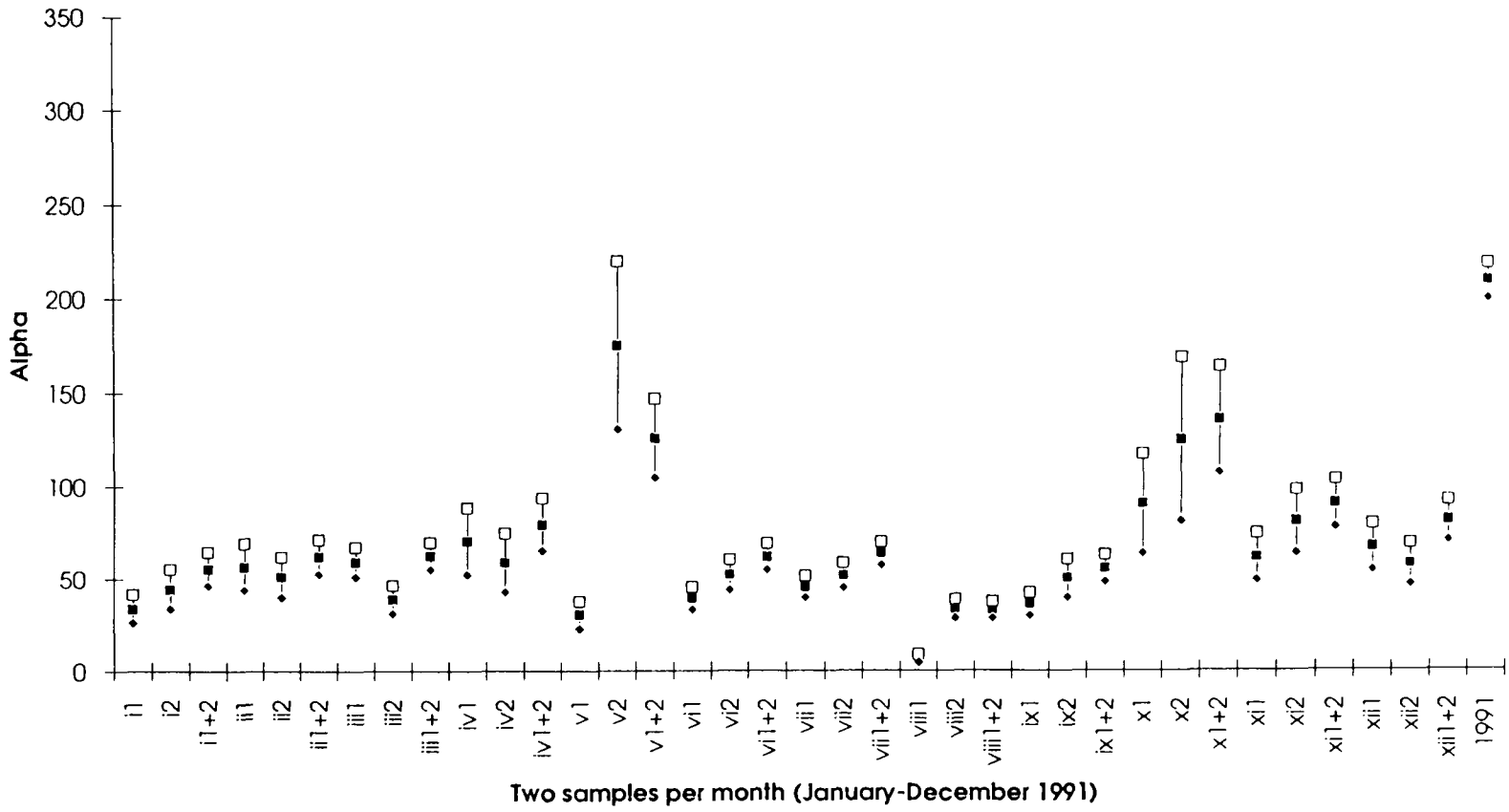


Fig. 2.24 Alpha values (95% confidence range) of the Eucalyptus deglupta plantation moth samples at Brumas in 1991

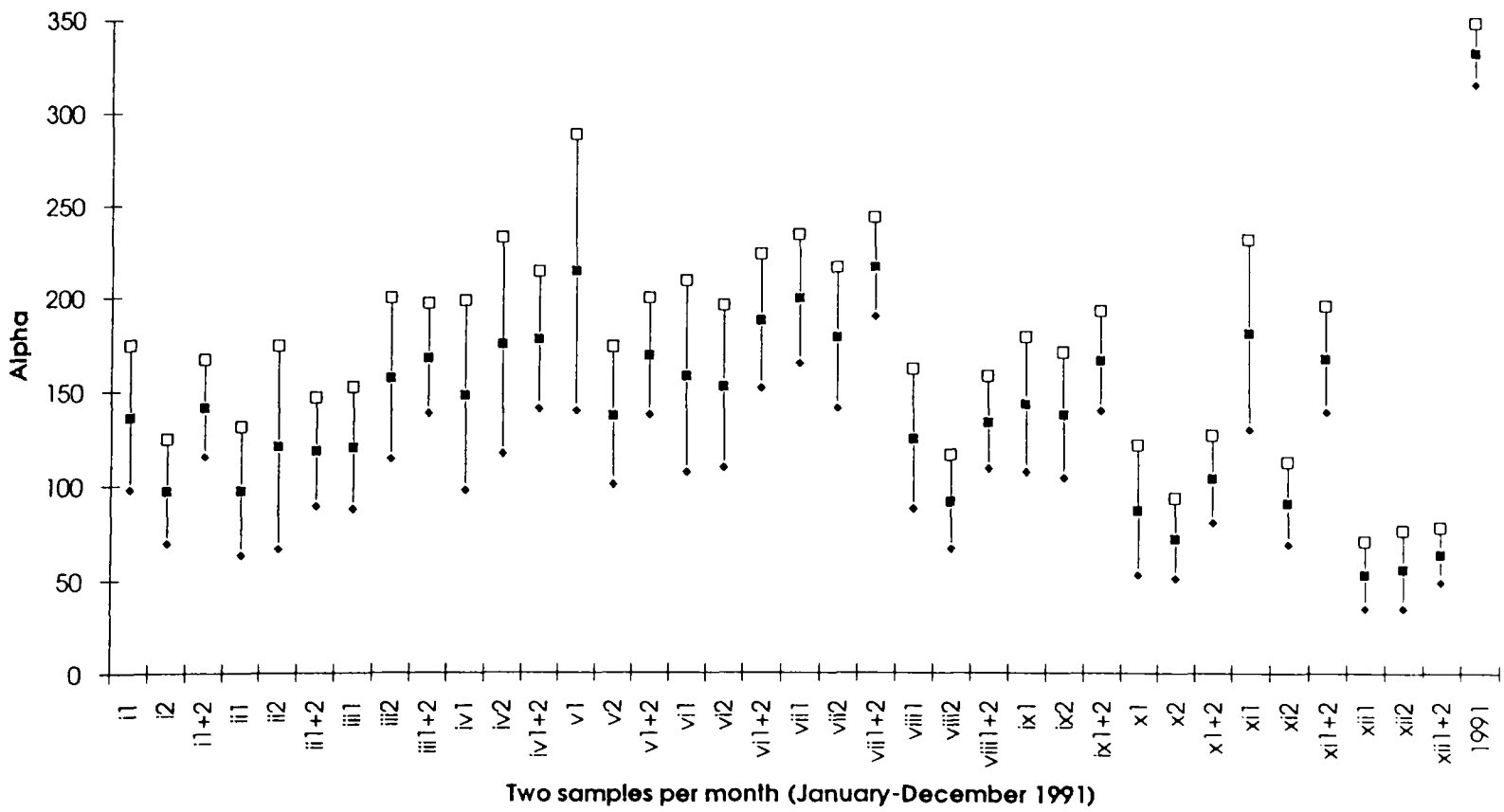


Fig. 2.25 Alpha values (95% confidence range) of the Gmelina arborea plantation moth samples at Brumas in 1991

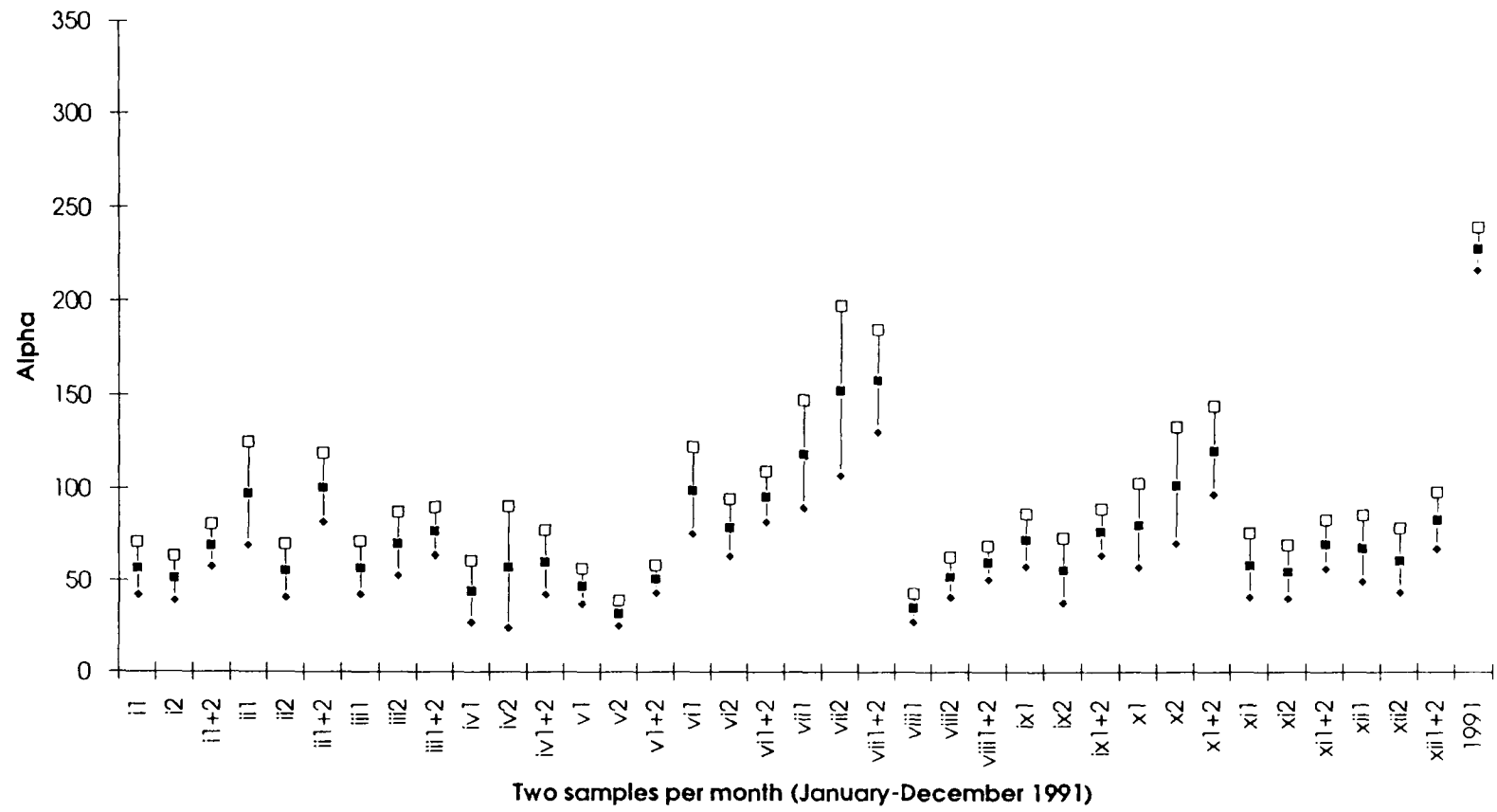


Fig. 2.26 Alpha values (95% confidence range) of the Paraserianthes falcataria plantation moth samples at Brumas in 1991

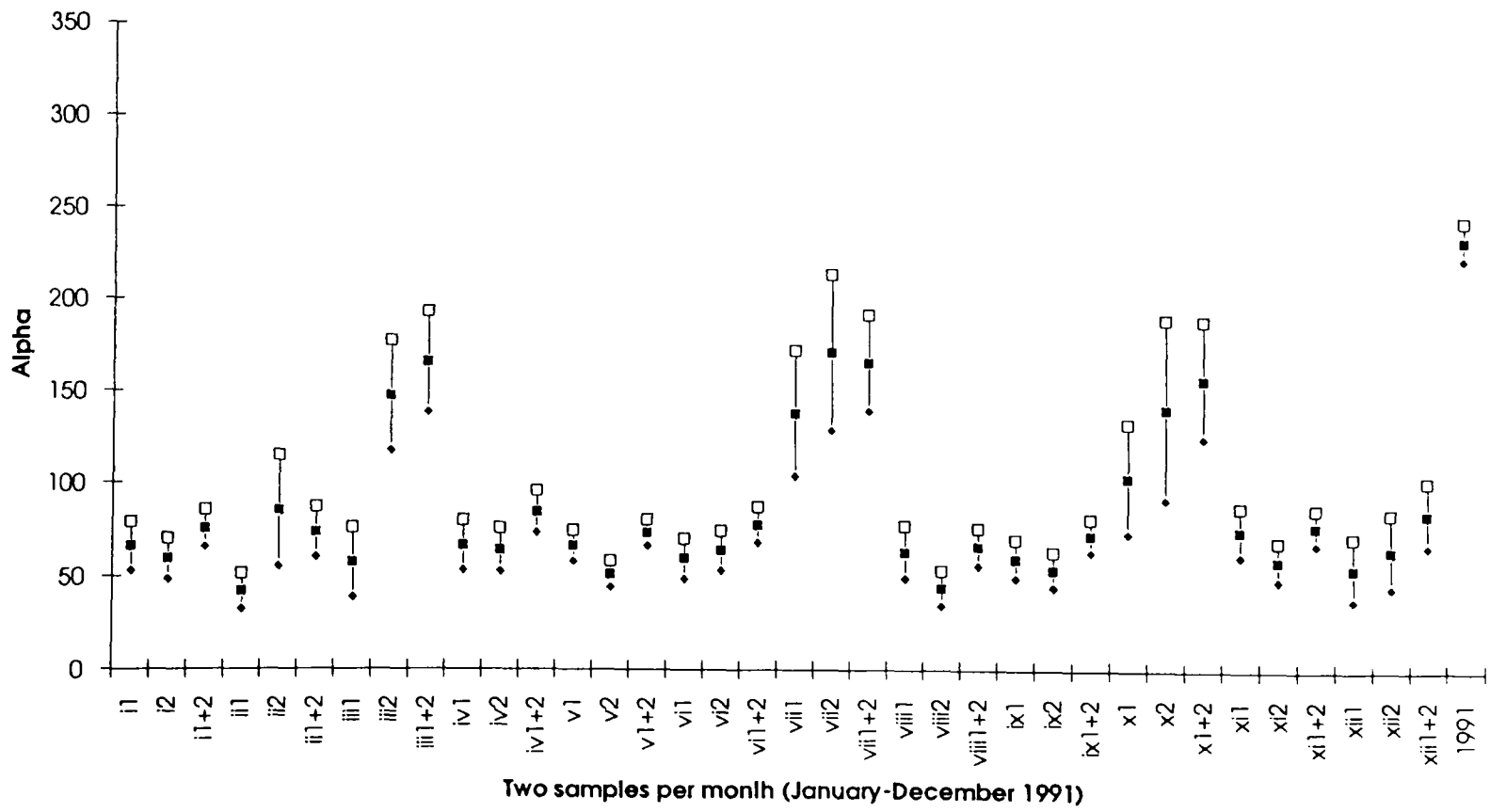


Fig. 2.27 Alpha values (95% confidence range) of the Pinus caribaea plantation moth samples at Brumas in 1991

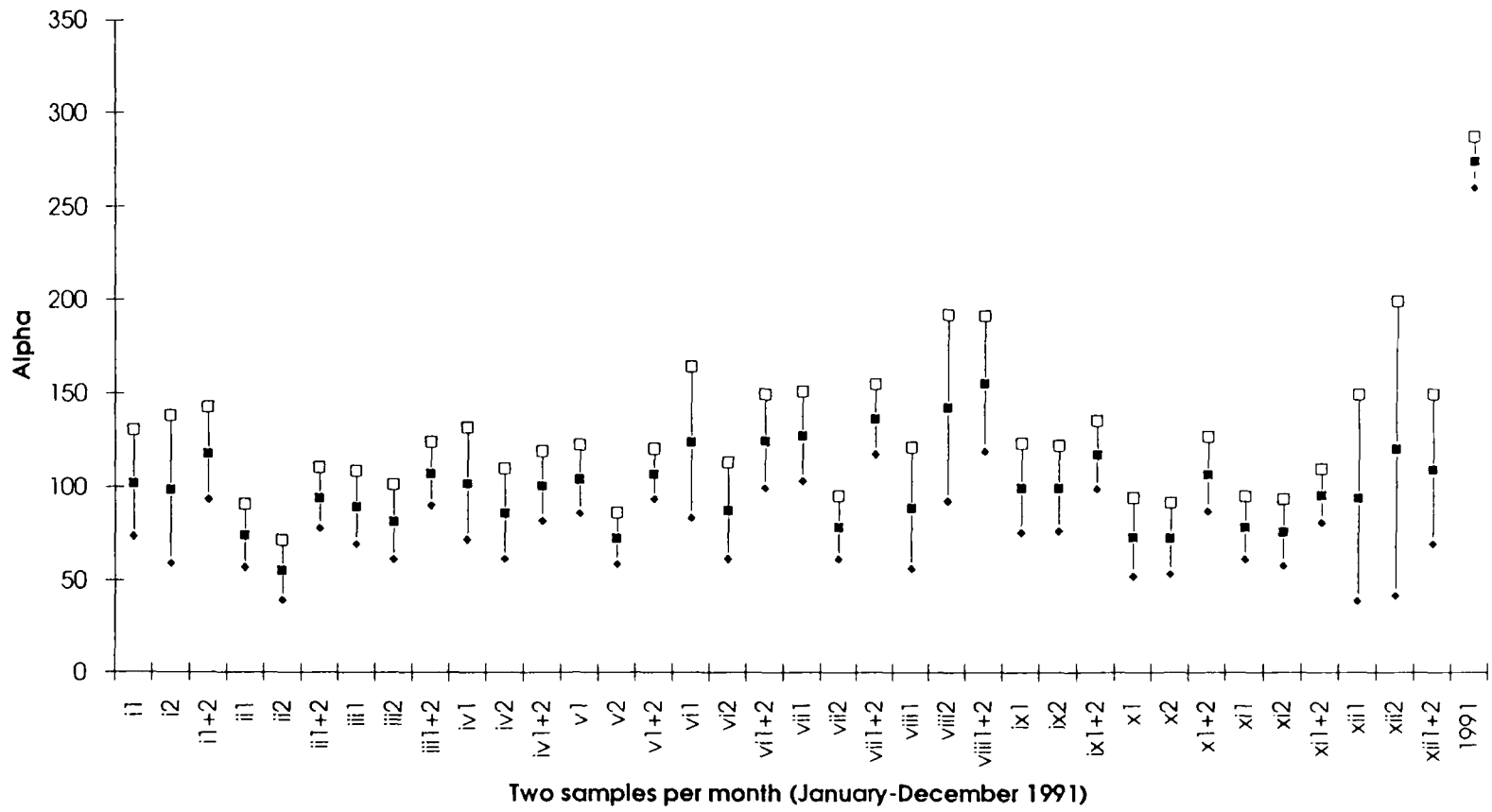
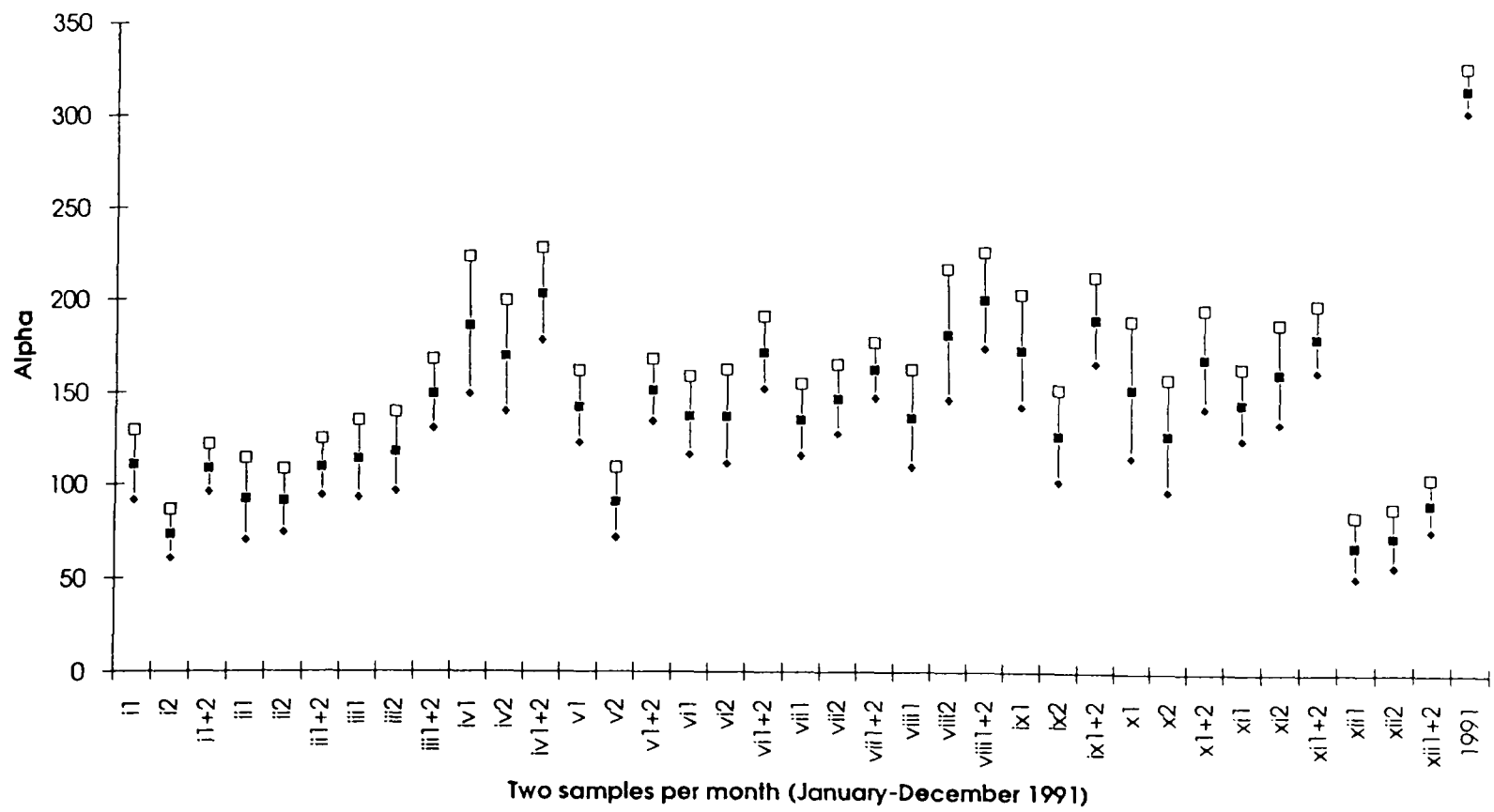


Fig. 2.28 Alpha values (95% confidence range) of the Secondary Forest moth samples at Brumas in 1991



abundant species in the samples, *Cleora decisaria* Walker, which on certain nights (from June to August) could reach 100-200 in number at *Acacia mangium* (Chey *et al.*, 1992), but in other months its population seemed to nosedive into oblivion. It was likely that the species being r-selected managed to multiply rampantly in reaching a peak in its population size in July-August, after which intra-specific competition but more importantly natural enemies could step in and keep its population in check. Various theories could be postulated and expounded on the possible causes for population fluctuations. Begon *et al.* (1990) believed that cycles in abundance in certain forest Lepidoptera may be driven by periodic environment fluctuations, or intrinsic density-dependent processes, which have to be particularly pronounced in order not to be blurred by random weather fluctuations. Strong *et al.* (1984) mentioned that populations of phytophagous insects often fluctuate markedly from generation to generation, and their communities are therefore at best only moderately constant and predictable in their structure.

As seen in the results of the various analyses, moths captured by light-trapping are reliably adequate indicators of the dynamics of the various plantation and natural forest ecosystems, and yielded diversity values in exotic fast-growing plantations comparable to those of native forest. This chapter has shown that exotic fast-growing plantation forests are by no means diversity deserts as prophesied by plantation-sceptics. How this relatively high diversity emerged out of the supposedly inferior monoculture system of introduced trees will be investigated in greater detail in the next few chapters.

A footnote on the apparent increase in α for combined sample.
Figs. 2.23-2.28 show the combined annual 1991 α values of the various sites to be higher than their respective individual nightly values. This trend of increase in α with progressive sampling was pointed out by Robinson & Tuck (1993a) for their Brunei samples and was also evident in the Genting samples of Barlow & Woiwod (1989). Even though the nightly α values do not seem to vary widely with little temporal change in diversity, seasonal differences in moth species composition are evident. It is also possible that each of the individual nightly samples is more inclined to draw moths from a particular area of the site influenced perhaps by wind direction, and repeated sampling of the same site may eventually enable the whole site to be covered adequately, at which point the α value may stabilize.

CHAPTER THREE

SUBSIDIARY LIGHT-TRAP TRANSECT SAMPLES

3.1 Introduction

In the previous chapter, moth diversity was compared for the different types of plantation forest as well as natural secondary forest, with the various sites as discrete separate units. It would be of interest to supplement these findings by investigating the changes in moth diversity from a plantation to an adjacent natural forest on a continuous transect, as the transition from plantation to natural forest shows a sharp edge with a discontinous vegetation gradient. The movement inherent in moths means that diversity measures in samples may reflect the sum of contributions from different associations of species. The transect would enable more thorough examination of the degree to which mobility of moths leads to tourists being present in the vegetation.

Light-trap transects were previously done in Sabah by Holloway (1970), who sampled moths on an altitude transect on Mount Kinabalu, and compared samples from disturbed habitats including lowlands. The results he obtained revealed a most fascinating shift in the moth fauna as the transect moved up the mountain, and various elements were recognized namely summit, upper montane, lower montane, foothill, lowland as well as widespread element. He found that the moth endemism increases with altitude, many species on higher altitudes show close affinity with Himalayan moths hence suggesting possible colonization of Borneo from that source area in the Pleistocene (when sea level was much lower and dry land connected the two regions), while the lowland elements belong mainly to centric groups of South-east Asian rain forest regions with centres of speciation coincident with the locality

concerned.

Likewise in the present project a light-trap transect was run to pick up the distributional patterns as well as discontinuities of the moth fauna from the middle of plantation forest to its adjacent natural forest. In this manner intermediate sites (plantation to natural forest) would be sampled, and a progressional shift in the moth diversity might be obtained. The link between plantation and natural forest would receive a more thorough treatment, and it would be interesting to see the levels of clustering.

3.2 Materials & Methods

Time constraints and site availability have limited the choice of plantations to the two main species viz. *Acacia mangium* and *Gmelina arborea* for the transect sampling. These two are getting to be the principal plantation species in Sabah, and coincidentally they also showed the two lowest alpha values as seen in the previous chapter. They could be therefore, expected to display a steeper gradient in moth diversity on a transect from the middle of plantation into the adjacent secondary natural forest. The other plantations which showed higher alpha values (closer to that of secondary forest) might not produce much difference, and therefore not as useful.

3.2.1 Light-trap sites on the plantation-secondary forest transects

Both the *Acacia mangium* and *Gmelina arborea* plantations used in the year-long sampling in 1991 were surrounded by plantations, and other plantations located next to the secondary forest would have to be chosen. The idea was to have a light-trap in the middle of the plantation (T1), another in the plantation but close to the secondary forest (T2), one at the boundary between plantation and secondary (T3), a subsequent one in the secondary but close to plantation (T4), and a final light-trap in the secondary further away from the plantation

(T5).

Information on the chosen *A. mangium*, *G. arborea* plantations as well as their adjacent secondary forest is given in Table 3.1. The light-trap locations on each transect are shown in Figures 3.1 and 3.2 (see also Fig. 2.2 in previous chapter). The distances between adjacent sites on the *G. arborea*-secondary forest transect were somewhat shorter due to the smaller size of the plantation as well as the patch of secondary forest next to it. Similar to the year-long sampling sites, the trap was set in a small clearing along a dirt road (see 2.2.2) which ran through the plantation into the adjacent secondary forest.

3.2.2 Sampling periods

The light-trap was run at one site at a time. The impression gained from past experience was that no apparent differences were discernible for the different hours of maximum moth activity immediately after sunset (i.e. *ca.* 1900hrs to 2200hrs), and hence to minimize the workload, only one hour, 1900-2000hrs, was sampled at any one time. Two replicate samples were collected per site, the sequence of sampling being totally randomized to minimize trap bias. The *Acacia mangium*-secondary forest transect was sampled in October/November 1992, while the *Gmelina arborea*-secondary forest transect was sampled in January/February 1993.

3.2.3 Additional sites

A completely clear-felled plantation area as well as a primary lowland dipterocarp forest both at different ends of the spectrum would provide interesting contrast to the transect samples. One such clear-felled area was available in Brumas (see Fig. 2.2 in last chapter) during sampling of the *Acacia mangium*-secondary forest transect, but there being no sizable primary forest left in Brumas, that of Danum Valley situated some 40km to the north of

Table 3.1 Details of the light-trap transect sites at Brumas 1992/93

Sampling Site	Area (ha)	Elevation (m)	Spacing (m)	Date Planted	DBH (cm)*	Est. Ht(m)	Understorey**	Remarks
Acacia mangium	68.94	120-240	3.05 x 3.05	May-89	12	15	Dense	
Adj. secondary forest	>160	120-240						Logged in 1972, 1991
Gmelina arborea	46.96	100-240	3.05 x 3.05	Apr-83	16	25	Mostly fern	
Adj. secondary forest	ca. 120	100-150						Last logged in 1990

* Average dbh

**See Chapter Five

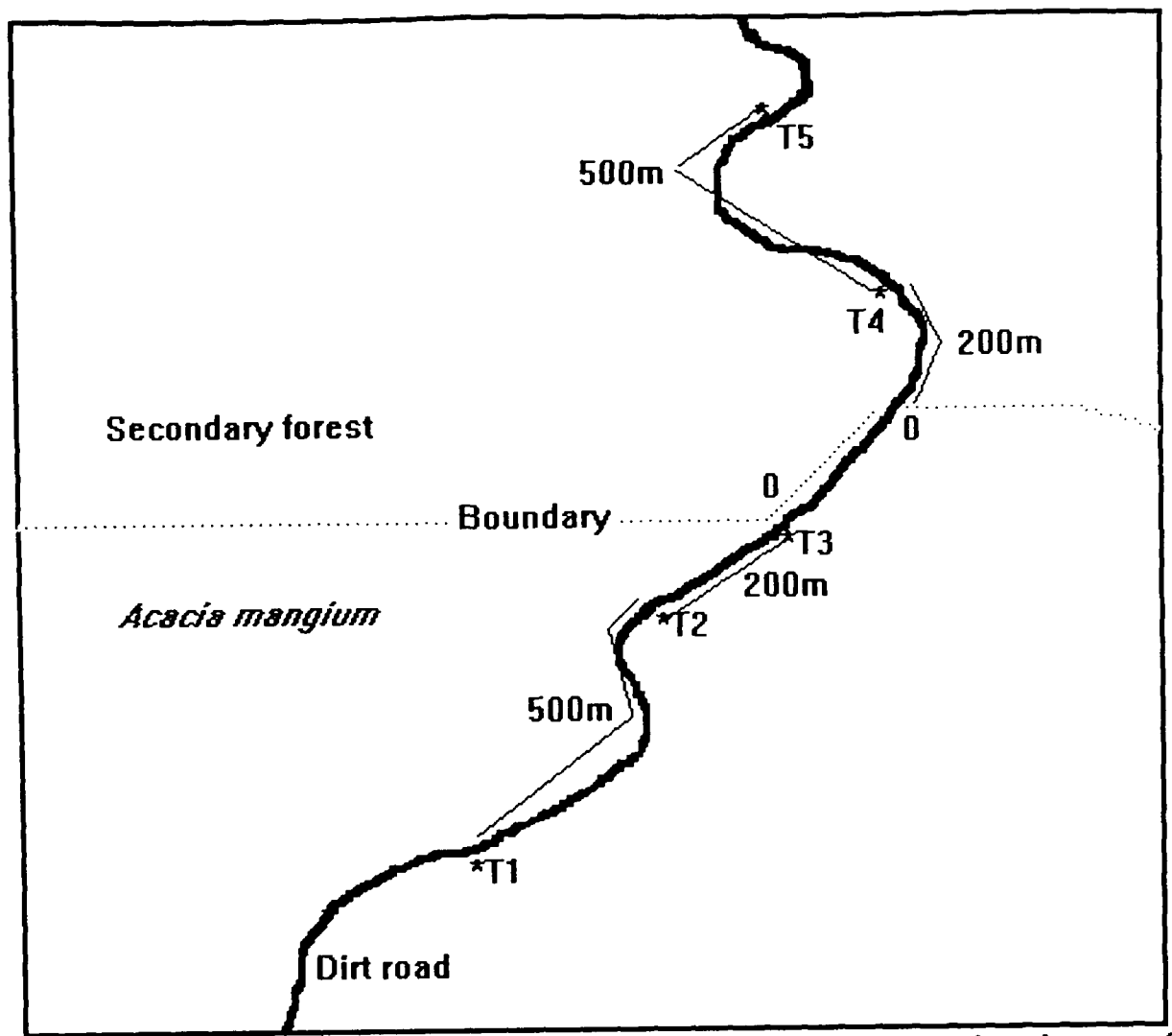


Fig. 3.1 A sketch showing the light-trap sites (T1-T5) on the *Acacia mangium* - secondary forest transect

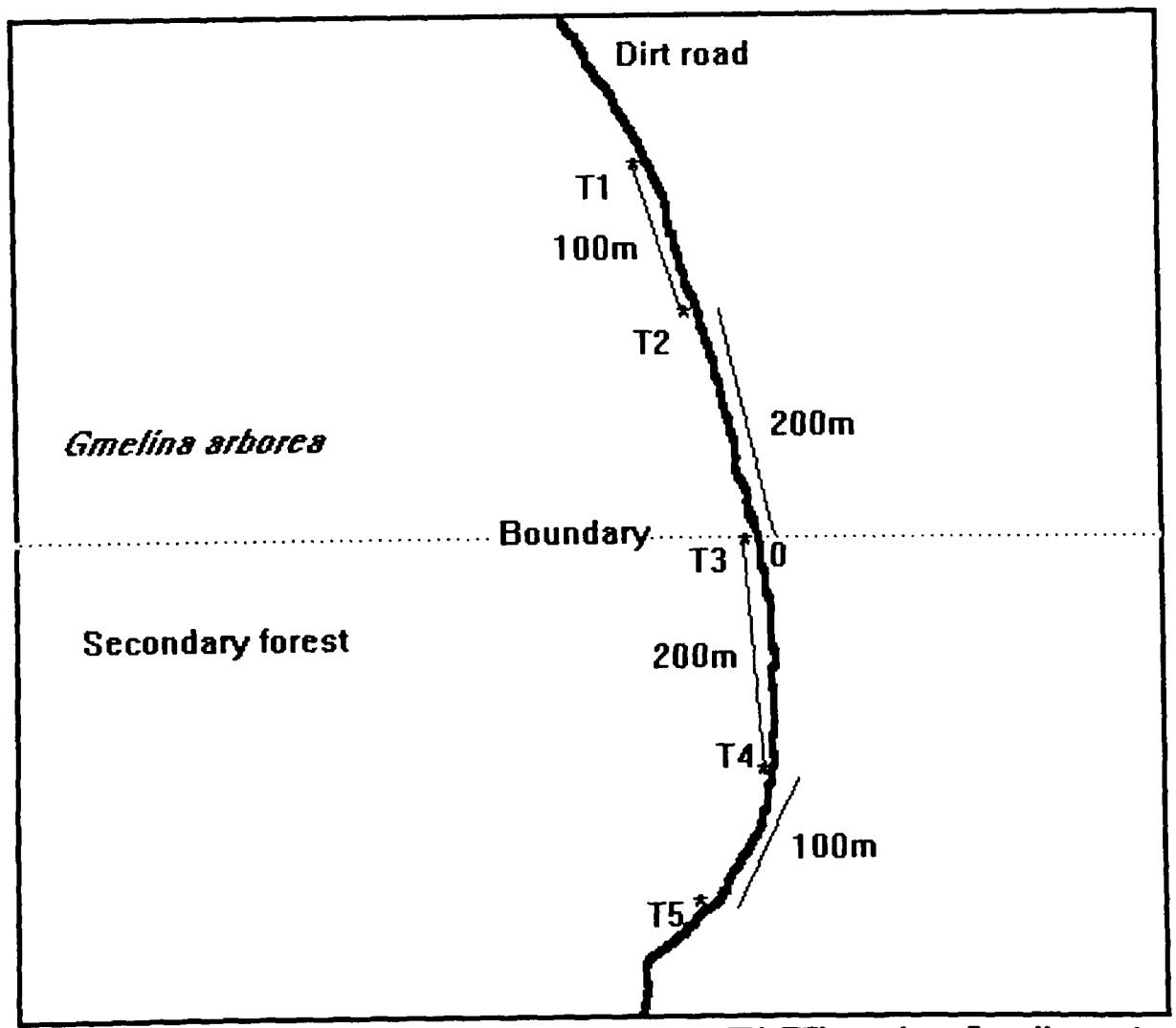


Fig. 3.2 A sketch showing the light-trap sites (T1-T5) on the *Gmelina arborea* - secondary forest transect

Brumas was chosen (see map on Fig. 2.1 in Chapter Two).

3.2.3.1 Clear-felled area (Herb layer)

The area was large, with some 205ha (elevation ranged from 150m to 330m above sea level), previously planted with *Eucalyptus deglupta*, but was at time of sampling denuded of plantation trees and had just been replanted with small seedlings of *Acacia mangium* and *Paraserianthes falcataria*. The area was predominantly covered with a herb layer of *Merremia borneensis* (Convolvulaceae), *Chromolaena odoratum* (Compositae), *Imperata cylindrica* (Gramineae), and *Nephrolepis biserrata* (Davalliaceae), and the light-trap was set in the middle of this herb layer for two nights from 1900hrs to 2000hrs.

3.2.3.2 Primary lowland dipterocarp forest at Danum Valley

The primary forest at Danum is a 438km^2 conservation area, 91% of which below 760m in elevation (Marsh & Greer, 1992). A research field station known as Danum Valley Field Centre was set up in 1985, as part of the Royal Society's South-east Asian Rain Forest Research Programme (Marshall, 1992). Newbery *et al.* (1992) surveyed the area in two 4ha plots and found that the trees (= or > 10cm gbh) in the area apart from Dipterocarpaceae (9% of the density), are mostly Euphorbiaceae (28%), Annonaceae (8%), Lauraceae (7%), and Meliaceae (6%). The most species-rich family is Lauraceae (83 spp.), followed by Euphorbiaceae (51 spp.), and Meliaceae (36 spp.).

The light-trap was set on an observation tower (in the Nature Trail area) about 9m above the forest floor (elevation *ca.* 150m above sea level), as the spot was believed to yield a better catch with its higher potential of bringing moths down from the canopy as well as attracting understorey species. Past experience of setting light-traps on the forest floor resulted in rather poor catch, in no small part due to the poor dissemination of light in dense primary

forest. The light-trap was run for two nights from 1900hrs to 2000hrs in each sampling round.

3.3 Results & Discussion

3.3.1 *Acacia mangium* - secondary forest transect

Appendix III is a checklist of the transect with additional sites of a herb layer at Brumas and the primary forest at Danum. It can be seen that for the Brumas samples, the vast majority of moth species had already been collected previously in the 1991 year-long samples except for a small number of species (marked with +). The different locations of sampling sites together with sampling periods meant that differences in species composition and abundance would be expected, but even so, similarities were apparent e.g. *Rhypotoses glebula* Swinhoe which was very abundant in the 1991 *Acacia mangium* samples and also relatively abundant in this transect *Acacia mangium* plantation. The secondary forest samples likewise produced species in rather close correlation with those of 1991. Figure 3.3 shows the total numbers of individuals and species collected at each site. The interior of the secondary forest (T5) was the most productive in terms of individuals (538) as well as species (217), and although the herb layer (HL) yielded a rather high number of individuals (500), the number of species was remarkably low (109). The results can be better interpreted by looking at the Williams alpha values representing the macromoth diversity measurements of the various sites (Fig. 3.4). A trend in a gradual rise in diversity is evident from the middle of the plantation (T1) to the interior of the secondary forest (T5), while the alpha value of T1 is low (78.96+-13.27), T2 to T5 (plantation closer to secondary forest until the middle of secondary forest) display values ranging from 106.01+-16.48 (T3) to 135.15+-18.84 (T5) which are comparable to, even higher than, that of the primary forest at Danum (115.56+-20.21). The herb layer, not surprisingly, produced a very low value at 42.97+-6.18. It would appear that in the absence

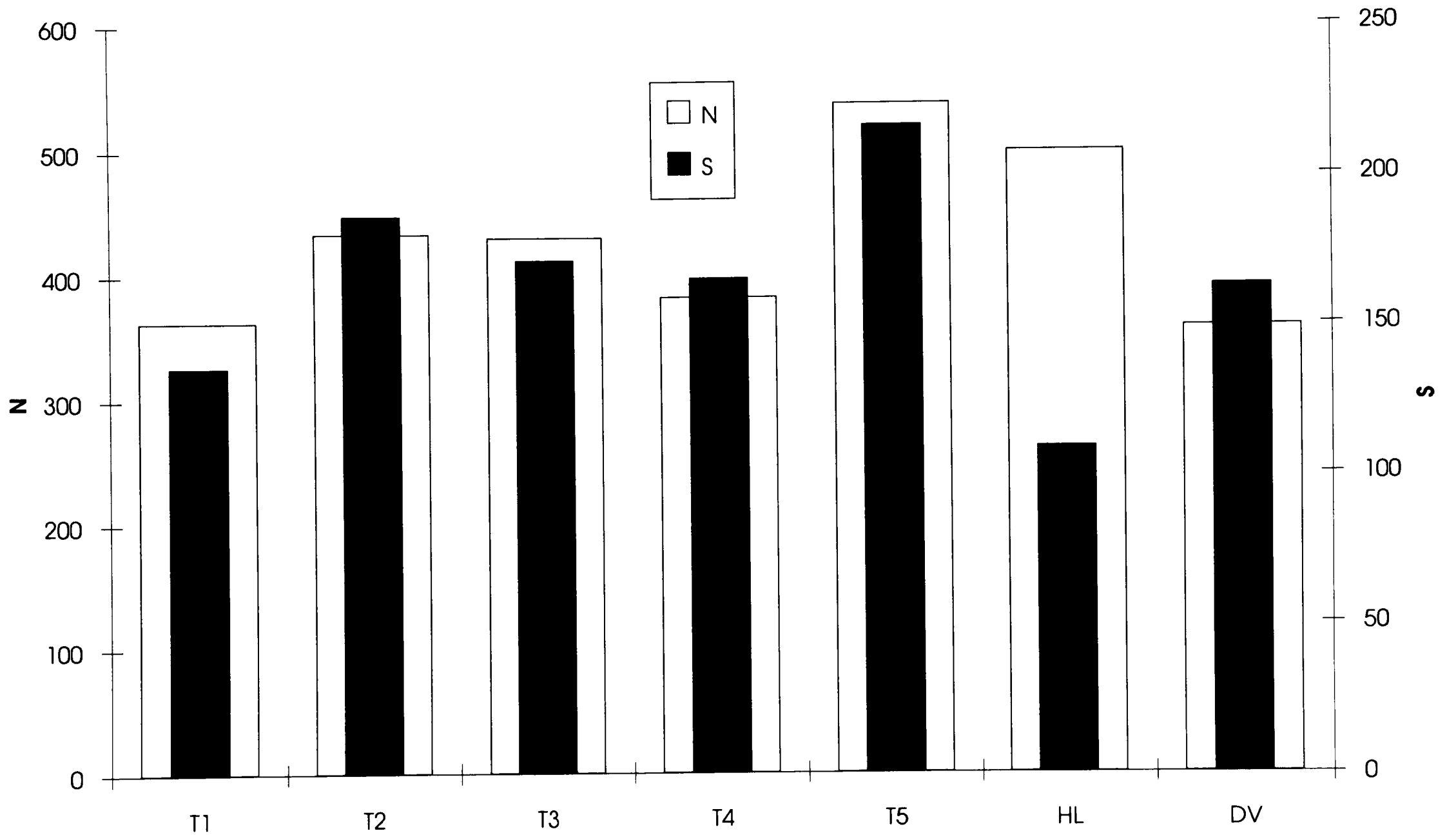


Fig. 3.3 Total numbers of individuals (N) & species (S) of macromoths collected at Acacia mangium plantation-secondary forest transect. T1->T5=Plantation->Secondary forest, HL=Herb layer, DV=Danum Valley

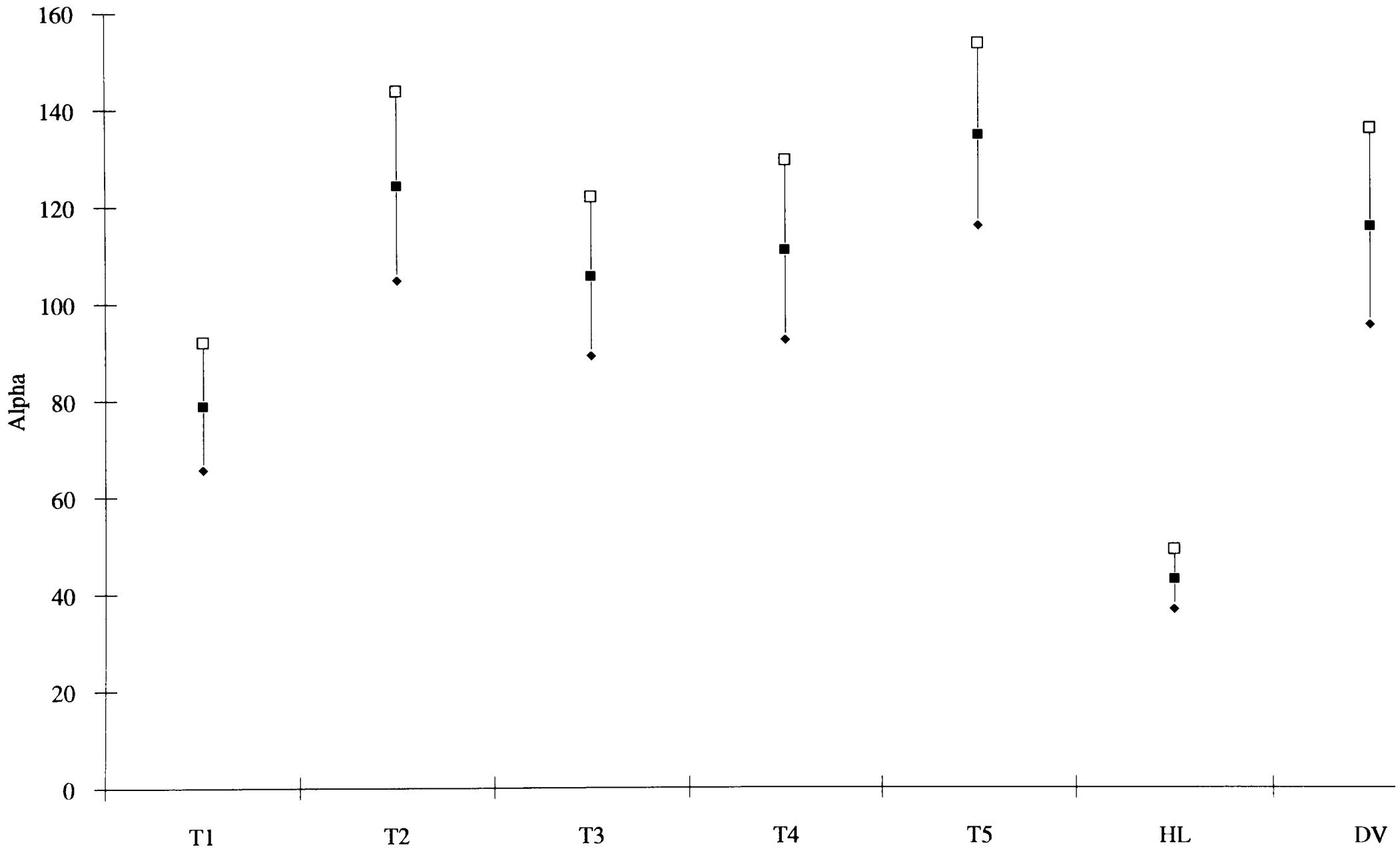


Fig. 3.4 Alpha values (95% confidence range) of the Acacia mangium plantation-secondary forest transect. T1->T5=Plantation->Secondary forest, HL=Herb layer, DV=Danum Valley

Table 3.2 Light-trap transect samples of macrolepidoptera species with 10 individuals or more

Transect from plantation forest to adjacent secondary natural forest in Brumas
With similar sampling at herb layer (area cleared for replanting) in Brumas &
primary natural forest in Danum Valley for comparison.

Plantation :
Acacia mangium

Sites :
T1 = Middle of plantation
T2 = Plantation site near secondary forest
T3 = Plantation-Secondary forest border
T4 = Secondary forest site near plantation
T5 = Middle of secondary forest
HL = Herb layer
DV = Primary natural forest in Danum Valley

Date :
October/November 1992

MACROLEPIDOPTERA **sum > = 10 individuals**

			No. of individuals captured.							
No.	Species	Authority	T1	T2	T3	T4	T5	HL	DV	sum
1	*Chalcocelis albiguttatus*	Snellen	2	1	9	1			2	15
2	*Scopelodes albipalpalis*	Hering			4	3	3		4	14
3	*Setora cupreistriga*	Walker	1	4	15	1	10	1		32
4	*Setothosea asigna*	van Eecke	1	4		1	3		1	10
5	*Paralebeda lucifuga*	Swinhoe	1	1	2	2	4		1	11
6	*Theretra latreillei*	MacLeay		4	2	4	5			15
7	*Theretra rhesus*	Boisduval	1	1	1	2	6			11
8	*Lyssa menoetius*	Hopffer		8		2	2			12
9	*Ozola ?basisparsata*	Walker	9	3	7	1			2	22
10	*Comibaena attenuata*	Warren	2	5	1			2		10
11	*Tanaorhinus rafflesii*	Moore	1	1	1	3	1		8	15
12	*Scopula vacuata*	Guenee	3	2	5	3	1			14
13	*Cleora decisaria*	Walker	1	2	2		2	23		30
14	*Cleora pupillata*	Walker	1			1	4		7	13
15	*Hypochrosis binexata*	Walker		6	2	3	7		6	24
16	*Hypomecis transcissa*	Walker	2	1	11	4	1		5	24
17	*Asura asaphes*	Hampson	2				3		6	11
18	*Asura birivula*	Hampson	1				1		11	13
19	*Asura subcruciata*	Rothschild	13	2			2	1	2	20
20	*Cyana costifimbria*	Walker	8	1	1			1		11
21	*Cyana malayensis*	Hampson	4	4	1	2	3	3	2	19
22	*Cyana perornata*	Walker	5	18	2	7	15	1		48
23	*Eugoa aequalis*	Walker	3	3	5	1	3			15
24	*Miltochrista roseororatus*	Butler	4	2	1	2		4		13
25	*Padenia duplicana*	Walker	1	2					8	11
26	*Amata egenaria*	Walker	25	19	4	9	24	2		83
27	*Amata prepuncta*	Holloway	47	54	29	22	62	2	10	226
28	*Creatonotos transiens*	Walker	1	1	3	1	2	9		17
29	*Spilosoma hosei*	Rothschild	1	1		5	2		1	10
30	*Ilema chloroptera*	Hampson	2	1	2	3	2		2	12
31	*Redoa ?camurisquama*	Collenette		3		1	2		7	13
32	*Redoa rhopica*	Toxopeus		2	1	10	1		2	16
33	*Rhypotoses glebula*	Swinhoe	2	9	41	9	17	7	1	86
34	*Asota heliconia*	Linnaeus	1	7	5	8	18	6		45
35	*Adrapsa ?ereboides*	Walker	8	5	2	1	3	3		22
36	*Bertula erectilinea*	Swinhoe	1	2	6		5			14
37	*Hadennia prunosa*	Moore		1	5	6	1	1		14
38	*Hipoepa biasalis*	Walker	4	2	4		4		1	15
39	*Hipoepa fractalis*	Guenee	10	2	4	2	1	8		27
40	*Hydrillodes repugnalis*	Walker	2	1	5	2		9		19
41	*Nodaria cornicalis*	Fabricius	10	3	11	8	5	77	1	115
42	*Simplicia ?macrotheca*	Prout	7	11		24	13	5		60
43	*Simplicia caeneusalis*	Walker	8	2		2				12
44	*Simplicia circumscripta*	Walker	5	6		17	12	1		41
45	*Simplicia rufa occidentalis*	Holloway	10	19		14		5		48
46	*Hypena kanshireiensis*	Wileman		1	4	1	3		2	11
47	*Ercheia cyllaria*	Cramer		2	3	1	4		2	12

			No. of individuals captured.							
No.	Species	Authority	T1	T2	T3	T4	T5	HL	DV	sum
48	*Erebus caprimulgus*	Fabricius	2	3	2	6	3		1	17
49	*Hypopyra pudens*	Walker	9	4	7	4	4	2		30
50	*Bocula tuhanensis*	Holloway		1	6	3	1		4	15
51	*Claterna cydonia*	Cramer		4	5	3	4		5	21
52	*Episparis costistriga*	Walker		3	7		3	1		14
53	Ophiderinae 20								10	10
54	*Pangrapta albiseriata*	Hampson	4	2	5					11
55	*Pangrapta metagona*	Walker	1		7	1	10			19
56	*Ugia disjungens*	Walker			2	5	1		2	10
57	*Amyna octo*	Guenee						11		11
58	*Risoba sp. 2*				1	1	5	1	6	14
59	*Carea metaphaea*	Hampson	1	2	2	6	4	1	3	19
60	*Carea nexilla*	Hampson			2	2	1		8	13
61	*Didigua cineracea*	Holloway	2	2	3		3		9	19
62	*Athetis bipuncta*	Snellen	1	2	6	3	16	94	1	123
63	*Condica illecta*	Walker			8			40		48
64	*Dipterygina dorsipallens*	Holloway	1		2	1	1		5	10
65	*Dipterygina vagivitta*	Walker	2	1	4	2	5	4	17	35
66	*Elusa ceneusalis*	Walker	14	2	4	5	9	17	5	56
		N	247	255	274	231	327	342	170	1846
		S	48	54	51	51	53	30	37	66

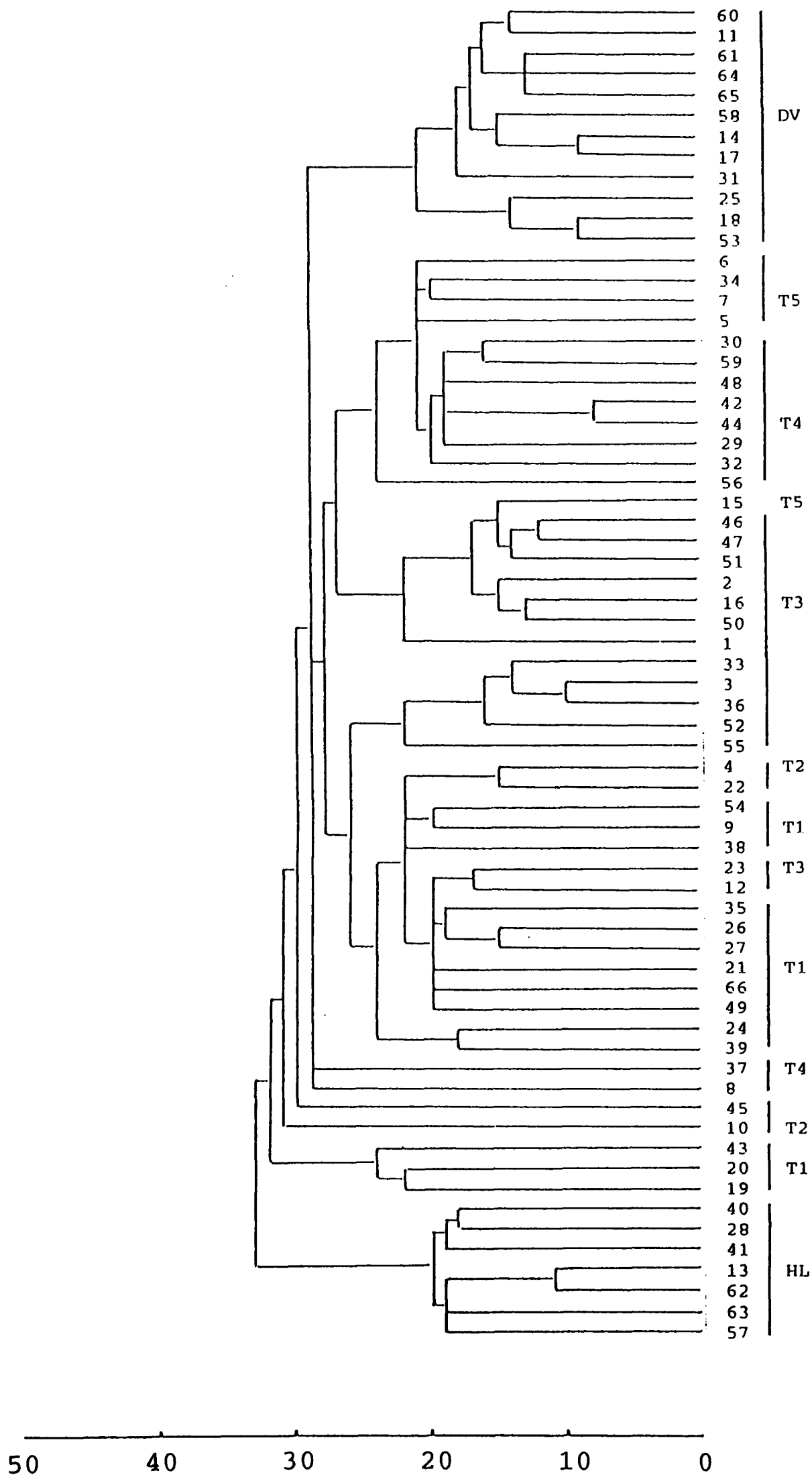


Fig. 3.5 Single-link dendrogram for moth species captured with 10 individuals or more for *Acacia mangium* to secondary forest transect (Brumas), with herb layer (Brumas) and primary forest (Danum), 1992.
Numbers refer to species in Table 3.2.
Sites where species were most abundant are indicated at the bottom.

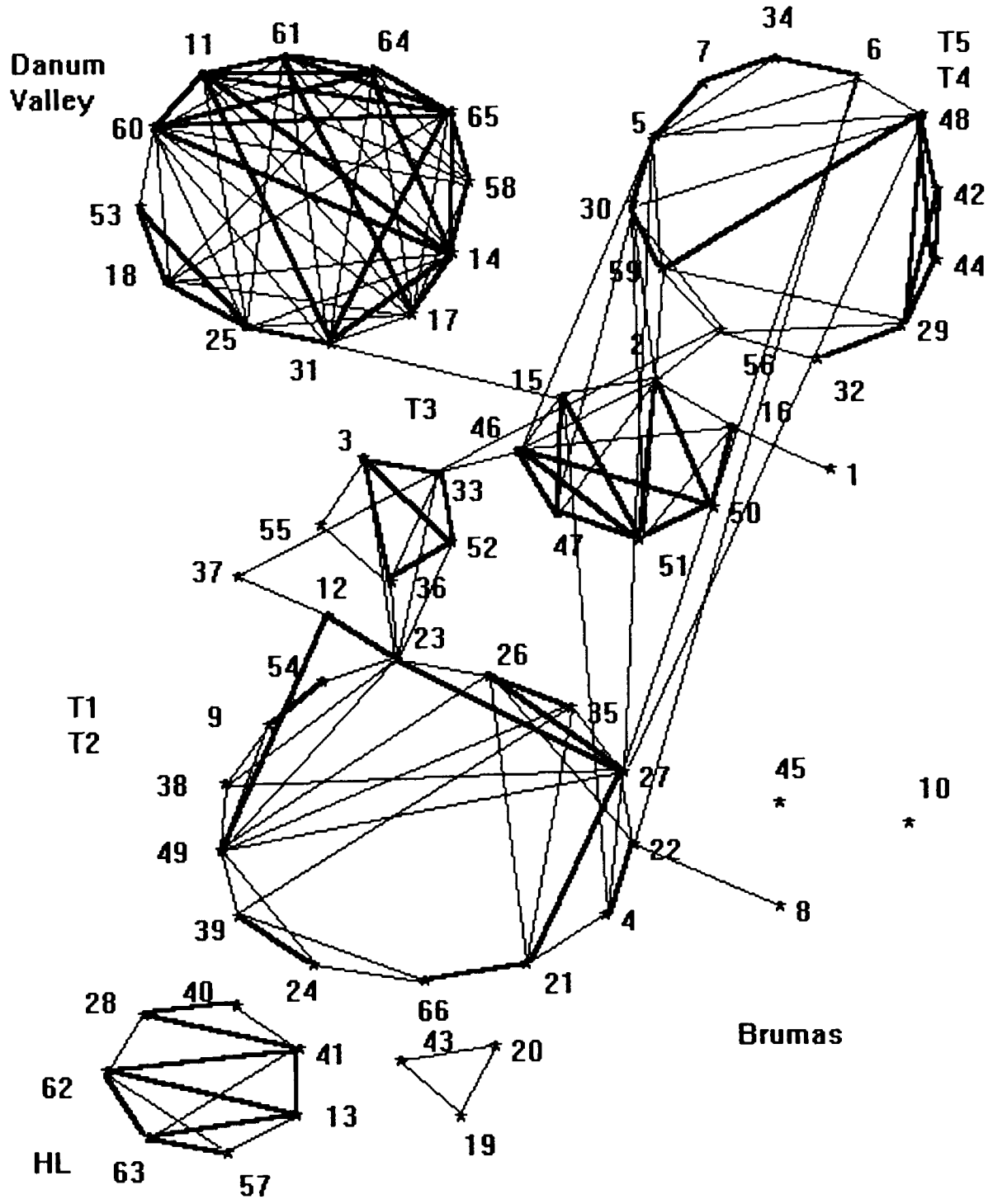


Fig. 3.6
Linkage diagram for moth species captured with 10 individuals or more, based on dissimilarity coefficient (percentage), for *Acacia mangium* to secondary forest transect (Brumas), with herb layer (Brumas) and primary forest (Danum), 1992.
——— Percentage dissimilarity 21 or below
——— Percentage dissimilarity 22 -> 29

of a forest canopy, where the microclimatic conditions were sufficiently altered resulting in higher insolation and lower humidity, only a handful of open habitat specialists would favour and frequent a habitat of that sort. It is of interest to note that quite a number of *Cleora decisaria* Walker (see Table 3.2) had already moved into the herb layer, probably attracted to the *Paraserianthes falcataria* and *Acacia mangium* seedlings which had just been planted.

Based on the numbers of individuals and species captured on the transect, species of 10 individuals or more were considered adequate for cluster analysis (see previous chapter). Table 3.2 lists the species included in the analyses which are diagrammatically represented in Figure 3.5 as a dendrogram and Figure 3.6 in the form of a linkage diagram. The clustering is rather good, with species more abundant at Danum as well as herb layer grouped together in distinctive clusters. The species which were more abundant at Danum are not exclusive to it, as they too were collected, though in smaller numbers, from the disturbed forest types at Brumas at various times during the entire length of this project. The herb layer contained a number of species of high abundance e.g. *Athetis bipuncta* Snellen and *Condica illecta* Walker (both Amphipyrinae), both species indicative of open habitats, and *Nodaria cornicalis* Fabricius (Herminiinae), with its congener on grass and detritus. The actual transect itself has the moth species showing greater abundance in plantation samples (T1, T2) clustered together, T3 (on the border between plantation and secondary forest) forming two minor clusters between plantation and secondary forest, while T4 and T5 (secondary forest) constituting another cluster linking rather closely (below 30% dissimilarity) with the plantation, which suggest that the secondary forest could function as the reservoir of the various moth species which, depending on their different levels of dispersal ability, preference for plantation habitat, and colonizing power, have seeped into the plantation more or less efficiently, some as

tourists, while the more efficient ones managed to establish sizable populations within the plantation.

3.3.2 *Gmelina arborea* - secondary forest transect

The second transect involving a second plantation species *Gmelina arborea* did not, perhaps, yield results as clear-cut as the *Acacia* one, as the catches in general were rather poor (Appendix IV, Fig. 3.7). The patch of adjacent secondary forest was more degraded than the 1991 Secondary Forest, which might help to explain the poorer catch size for this transect, and the small samples did not permit good comparison with the 1991 data. Even so, the trend in gradual rise of diversity from middle of plantation (T1) to that of secondary forest (T5) is evident (Fig. 3.8). Middle of plantation (T1) recorded the lowest alpha value at 45.48+-11.11, T2 (plantation site closer to secondary forest), T3 (site on border of plantation and secondary forest), and T4 (site in secondary forest closer to plantation) gave alpha values of 62.12+-17.4, 74.11+-21.83, 62.64+-16.65, respectively, which are rather similar. T5 (middle of secondary forest), with a value of 108.46+-17.59 seemed to be even more diverse than the primary forest in Danum which showed a figure of 105.4+-22.65, somewhat poorer than the previous sampling (115.56+-20.21), but not too far off. This set of results further strengthened the findings obtained from the previous transect involving *Acacia*, that the role of the secondary forest as a species source for the plantation, and the diversity of moths was not necessarily higher in the primary forest than the disturbed forest ecosystems, even though it must be pointed out here that the primary forest in Danum, as reported by Holloway *et al.* (1992), is not particularly moth rich.

The smaller samples obtained for the *Gmelina* transect did not permit more in depth cluster analysis, nonetheless a dendrogram for species of 10 individuals or more was

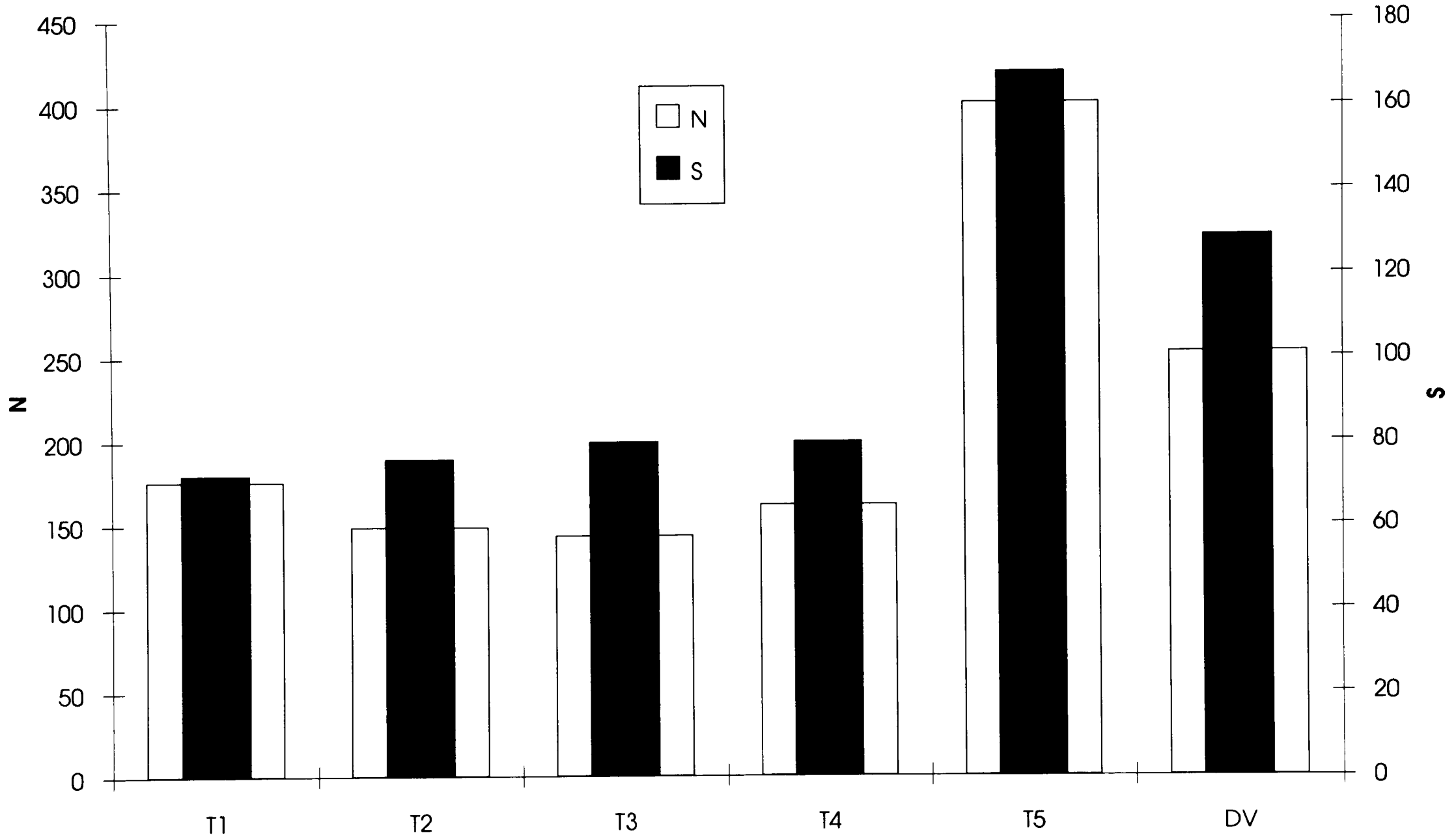


Fig. 3.7 Total numbers of individuals (N) & species (S) of macromoths collected at Gmelina arborea plantation-secondary forest transect. T1->T5=Plantation->Secondary forest, DV=Danum Valley

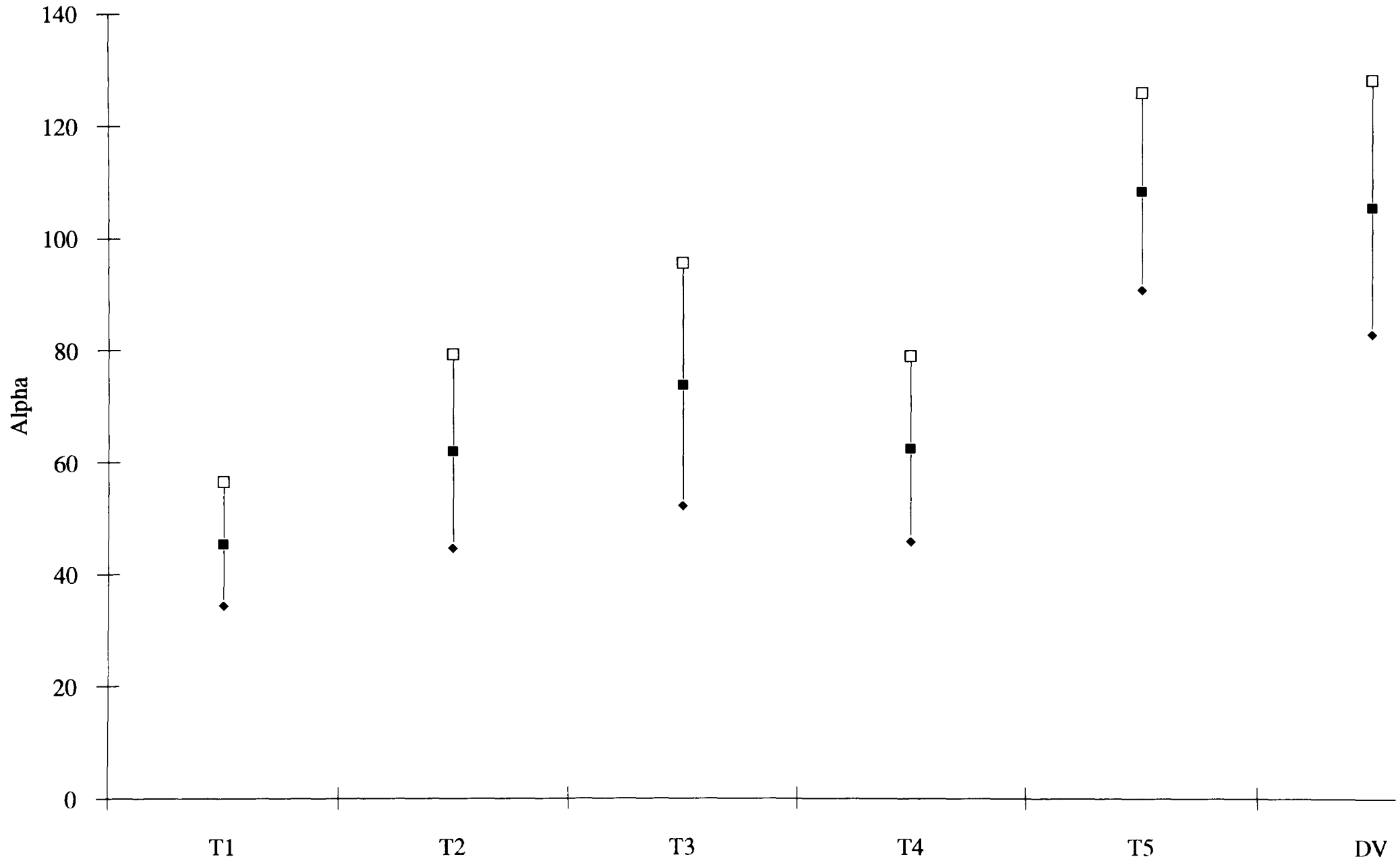


Fig. 3.8 Alpha values (95% confidence range) of the Gmelina arborea plantation-secondary forest transect. T1->T5=Plantation->Secondary forest, DV=Danum Valley

Table 3.3 Light-trap transect samples of macrolepidoptera species with 10 individuals or more

Transect from plantation forest to adjacent secondary natural forest in Brumas
With similar sampling at primary natural forest in Danum Valley for comparison.

Plantation :

Gmelina arborea

Sites :

T1 = Middle of plantation
T2 = Plantation site near secondary forest
T3 = Plantation-Secondary forest border
T4 = Secondary forest site near plantation
T5 = Middle of secondary forest
DV = Primary natural forest in Danum Valley

Date :

January/February 1993

MACROLEPIDOPTERA **sum >= 10 individuals**

			No. of individuals captured						
No.	Species	Authority	T1	T2	T3	T4	T5	DV	sum
1	*Chalcocelis albiguttatus*	Snellen		2	3	5	16	6	32
2	*Scopelodes pallivittata*	Snellen	1	3	5	2	3	4	18
3	*Setora cupreistriga*	Walker	4			4	11	1	20
4	*Paralebeda lucifuga*	Swinhoe	3	2	2		3		10
5	*Cleora decisaria*	Walker	34	12	15	26	13		100
6	*Curbia martiata*	Guenee		3	2	3	7		15
7	*Asura asaphes*	Hampson		1	5	1		8	15
8	*Asura biseriata*	Hampson	2	2		1	1	7	13
9	*Asura sp. no. 2740**		1		2		4	4	11
10	*Cyana costifimbria*	Walker		3	5	6	2		16
11	*Cyana perornata*	Walker	12	1		1	13	1	28
12	*Poliosia muricolor*	Walker		11	3	11	1		26
13	*Creatonotos transiens*	Walker	1	3	1	5	7		17
14	*Orgyia postica*	Walker	4	5	2	1	2		14
15	*Hipoepa biasalis*	Walker	2		1	1	12	1	17
16	*Hipoepa fractalis*	Guenee	5	10	1	1	4		21
17	*Nodaria cornicalis*	Fabricius	4	11	2	13	14		44
18	*Episparis costistriga*	Walker	2	3	5	1	5		16
19	*Amyna punctum*	Fabricius	4	1		1	4		10
20	*Plusia' nigriluna*	Walker	3	1	1	3	4		12
21	*Lophoptera acuda*	Swinhoe	3	1			10		14
22	*Athetis bipuncta*	Snellen	10		2	2	26	11	51
23	*Callopistria maillardi*	Guenee	3	2			11		16
24	*Dipterygina vagivitta*	Walker	5			1	6	5	17
25	*Elusa ceneusalis*	Walker	7	1	5	4	7	3	27
26	*Tiracola plagiata*	Walker	4		3	4	9		20
		N	114	78	65	97	195	51	600
		S	21	20	19	22	25	11	26

* Refers to slide number in the Natural History Museum in London Prepared by J.D.Holloway

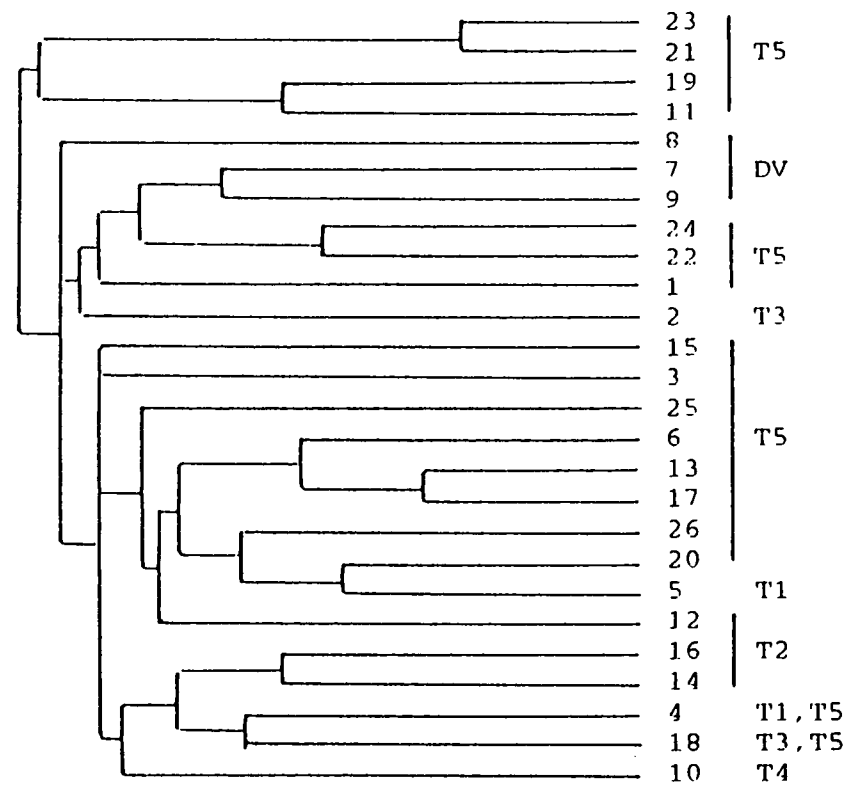


Fig. 3.9 Single-link dendrogram for moth species captured with 10 individuals or more for *Gmelina arborea* to secondary forest transect (Brumas), with primary forest (Danum), 1993.
Numbers refer to species in Table 3.3.
Sites where species were most abundant are indicated at the bottom.

constructed (Fig. 3.9 & Table 3.3). As shown in the single-link dendrogram, the majority of the moth species on this transect showed more abundance in T5 (middle of secondary forest) but the clustering structure did not exhibit good discriminant ability for the others due to the low numbers in catches.

3.3.3 Disturbed versus Undisturbed forest

At this point it is only appropriate to make a few comments on the diversity between the disturbed forest habitats in Brumas and the undisturbed primary forest in Danum as indicated by moths. The results in this chapter have shown that the primary forest need not display higher diversity of moths compared to the disturbed forests. Davis (1993) working on community ecology of dung beetles in Sabah comparing primary forest in Danum with adjacent disturbed logged forest also reported on the richness of species in logged forest which he considered as a composite biotope where species of primary forest overlap spatially with species of disturbed habitats. However there are also species which can only thrive in undisturbed environment which can be considered as stenotopic with very limited ecological tolerance. Table 3.4 lists out the moths (33 species) which were only collected from the undisturbed forest in Danum and never collected on the numerous sampling trips to Brumas, e.g. *Anarbudas ?bipartita* Walker represents the only member of Zygaenidae sampled in the entire project. It is also of interest to note that these moths were mostly collected in very low numbers (most were singletons), and they perhaps represent species which are more vulnerable to man-induced deforestation and hence extinction. These species represent 1.93% of all the species collected in the entire project (33 out of 1713), but the sampling at Danum was far from exhaustive. A more comprehensive sampling effort in the primary forest would be necessary to further identify these threatened species, but the results shown here have also underlined the importance of conserving natural forest cover to shelter vulnerable species.

Table 3.4 Macromoths collected only at the primary forest in Danum and not at Brumas

	Family	Species	Authority	N
1	Limacodidae	*Heringarosa trifurca*	Holloway	3
2	Limacodidae	*Parasa darma*	Moore	1
3	Zygaenidae	*Anarbudas ?bipartita*	Walker	1
4	Drepanidae	*Spectroreta hyalodisca*	Hampson	2
5	Geometridae	*Naxa guttulata*	Warren	1
6	Geometridae	*Epipristis minimaria*	Guenee	1
7	Geometridae	*Idaea phaeocrossa*	Prout	1
8	Geometridae	*Ectropidia exprimata*	Walker	1
9	Arctiidae	*Eilema tetragona*	Walker	1
10	Arctiidae	*Eugoa sp. no. 2768**		2
11	Arctiidae	*Lobobasis niveimaculata*	Hampson	1
12	Arctiidae	*Meteugoa sp.*		1
13	Arctiidae	*Miltochrista sp.*		1
14	Arctiidae	*Miltochrista vagilinea*	Walker	1
15	Arctiidae	*Scaptesyle aurigena*	Walker	1
16	Lymantriidae	*Euproctis sp. no. 1723**		12
17	Lymantriidae	*Redoa florella*	Collenette	1
18	Noctuidae	*Neochera inops*	Walker	1
19	Noctuidae	*Neochera privata*	Walker	1
20	Noctuidae	Herminiinae 9		1
21	Noctuidae	Herminiinae 10		1
22	Noctuidae	*Parallelia umbrosa*	Walker	1
23	Noctuidae	*?Throana sp.*		1
24	Noctuidae	*Dunira sp. 2*		1
25	Noctuidae	*Hypocala lativitta*	Moore	2
26	Noctuidae	Ophiderinae 26		1
27	Noctuidae	Acontiinae 32		1
28	Noctuidae	Sarrothripinae 4		1
29	Noctuidae	Sarrothripinae 5		1
30	Noctuidae	Chloephorinae 3		3
31	Noctuidae	*Eulepa niveigutta*	Walker	1
32	Noctuidae	*Prometopus asahina*	Kobes	1
33	Noctuidae	*Thalathoides conjecturalis*	Swinhoe	1

*Refers to slide number in the Natural History Museum in London prepared by J.D.Holloway

CHAPTER FOUR

KNOCKDOWN SPRAYING

4.1 Introduction

Critics of light-trapping are often quick to point out that the technique generates an element of uncertainty as to whether the insects captured are truly residents of the site or merely 'tourists'. In order to lend support to the use of light-trapping in this project, knockdown spraying in the form of canopy mist-blowing was conducted.

4.1.1 Mist-blowing

Canopy knockdown has most often been associated with fogging (Stork, 1987a, 1987b, 1991), in which a thick smoke containing non-residual insecticide is generated by a thermal pulse-jet machine, and allowed to drift into a particular canopy. Those arthropods incapable of escape would come into contact with the chemical, many being killed or knocked down, whereupon they fall to the ground. Mist-blowing is similar to fogging in principle, but instead of producing a thick smoke, it is more directional in its ultra low volume (ULV) emission, by discharging a thin mist of fine chemical droplets. This increases the surface area of the insecticide, and hence enhances the probability of coming into contact with its target. ULV emission (e.g. by means of mist-blowing) only requires a small volume of insecticide and does not depend on access to large volumes of water (chemical can be applied direct without water dilution), it is hence appropriate for treating remote areas, where contamination of non-target trees needs to be minimized (Speight & Wainhouse, 1989).

4.1.2 Guild structure

At this point it is relevant to consider the guild structure of arthropods on trees which

has been studied rather recently by various workers employing the technique of canopy knockdown. Moran & Southwood (1982) based their definition of guilds on feeding habits, and recognized seven guilds in all: 1. phytophages (subdivided into chewers and sap-suckers), 2. epiphyte fauna, 3. scavenging fauna, 4. predators (subdivided into insect predators and other predators), 5. parasitoids, 6. ants, and 7. tourists. Moths were mostly placed under the chewer-phytophage category as their larvae are mostly mandibulate, so formed as to exploit the food resources available in their host plants in the form of foliage as well as other plant tissues. And because of the relative immobility of their larvae compared to their adults, one would assume that any moth larvae being knocked down are truly residents rather than merely tourists.

Moran & Southwood (1982) discovered a strikingly constant proportion in the numbers of species in the major guilds on the trees they studied in South Africa as well as Britain. This interesting constancy is relevant to the theory of island recolonization (Simberloff & Wilson, 1969; Heatwole & Levins, 1972) which found that a year after the species on six islands had been insecticidally eliminated, the islands were recolonized by a similar uniform distribution of species within guilds, and this might reflect the existence of organized and regulated interacting communities of animals, rather than chance collections of organisms with similar physical requirements (Simberloff, 1976). Southwood *et al.* (1982) also saw a parallel between the accumulation of fauna on an introduced tree and the colonization of new islands. Based on their results in Britain and South Africa, they found that species richness and diversity for all guilds, other than the phytophages, is not significantly different on introduced trees from that on native trees. The phytophages, however, show a lower diversity on introduced trees, which suggests that they may have to undergo some measure of adaptation before successful colonization. This adaptation would be related to the similarity of the

introduced plant's defences compared to the native host (Southwood, 1961). Connor *et al.* (1980) from their work on leaf-mining insects suggested that range expansions of insects onto introduced trees often involve species that feed on native hosts taxonomically related to the introduced host, and taxonomic isolation of the host tree partially determines the size of herbivorous entomofauna of British trees.

These fascinating observations provide relevant backdrop for this project which compares the diversity of moths, a major phytophage, in the various introduced exotic plantation tree species as well as native trees in the rain forest of Borneo. Stork (1987a, 1987b, 1991) used fogging to study the guild structure of arthropods on ten native Bornean trees in Brunei, but none of the introduced species was examined. His findings concurred with Moran & Southwood's theory of proportional constancy in species for the various guilds, but he also found that taxonomic relatedness of native Bornean trees is not an important determinant in the faunal similarity for more than half of the groups examined including the phytophages, which led him to suggest that many phytophages in tropical rain forest may have low tree specificity, in other words, they would appear to be host plant generalists.

4.2 Materials & Methods

As mentioned earlier the aim of this canopy knockdown exercise was an attempt to provide some evidential support for the light-trap moth samples, and was not meant to be an exhaustive and comprehensive sampling method.

4.2.1 Mist-blower

The mist-blower used in the project was a Japanese made Maruyama Mist Blower MD 300 which was of a light-weight knapsack type (Plate 4.1). Attached to the end of its emission pipe was a ULV nozzle, designed by Maruyama specifically for this machine. The insecticide

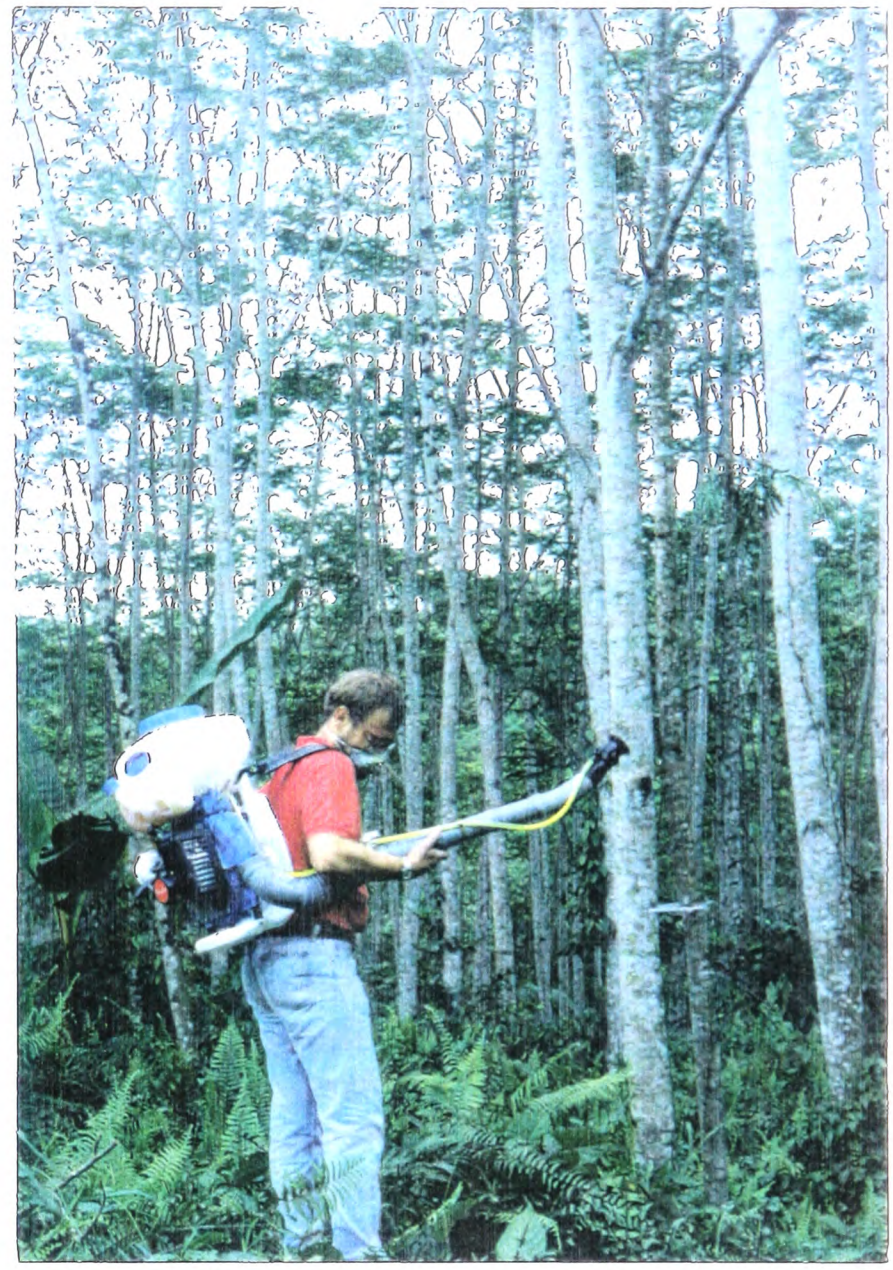


Plate 4.1 The mist-blower

was added directly to a small 100ml bottle just beneath the ULV nozzle, making it possible to dispense small but adequate amounts of chemical whenever needed instead of filling the much larger 13 litre chemical tank with surplus amount. This not only minimized the weight but also helped to prevent deterioration of the chemical which was better left inside its original tin can. The discharge rate was 25ml per minute, and could shoot up to a maximum height of 10m (see 4.2.5). The system's most desirable feature was that its fine droplets ensured a more directional emission with better coverage using the minimum amount of insecticide.

4.2.2 Insecticide

A non-residual quick knockdown pyrethroid, Pybuthrin 2/16 (Wellcome Foundation) was considered the best option. Its rapid knockdown effects on arthropods, short residual life coupled with low mammalian toxicity were its obvious advantages. Unfortunately it was not available in Malaysia and had to be shipped from England.

Pybuthrin is made up of a solution of natural pyrethrins synergised by piperonyl butoxide (1:8), in a high grade petroleum distillate (kerosene). Its main active ingredients are pyrethrin 1 and pyrethrin 11 mixed with small amounts of cinerins and jasmolins all extracted from *Chrysanthemum cinerariaefolium* (Ozanne, 1991). Its quick knockdown effect is attributed to repetitive axon firing, with knockdown being defined as the capacity to destroy co-ordination of movements e.g. that of wing with others (McFarlane *et al.*, 1971). Burt & Goodchild (1972) reported the knockdown rate is dependent on the penetration speed to the nerve membrane via the cuticle or spiracles. Piperonyl butoxide as the synergist attacks the detoxification mechanisms preventing recovery from the insecticide (Chen *et al.*, 1985).

4.2.3 Sampling procedure

A $1m^2$ white sheet was placed on the ground under the canopy of the tree to be

sprayed. The chosen tree was subsequently mist-blown from the ground for one minute. All arthropods knocked down and dropped onto the white sheet (its whiteness enabled better visibility) were collected after 15, 30, 45, and 60 minutes and kept in separate labelled vials containing 70% alcohol. Care was taken to exclude livelier insects which had actually hopped onto the sheet from the ground rather than having been knocked down from the tree.

4.2.4 Sampling sites & periods

The sites light-trapped previously in 1991 (see Table 2.1) were sampled with mist-blowing. As each of the sites chosen had a dirt road gashing through its middle, the trees could be conveniently chosen within five rows from the road with minimum edge effects, particularly in the plantations (size of each >30ha). The understorey within the area adjacent to the roadside was observed to be of little difference to that further in. Most plantation trees, however were rather tall (20-30m) but with canopy depth of 10-20m. This at least allowed the lower canopies of the plantation trees to be sprayed. Stork (1987b) reported that tree heights of native Bornean trees have little effect on their faunal similarity, and Kitching *et al.* (1993) by using pyrethrum knockdown in the tropical rain forest of Australia found that the distribution of insects across orders is not significantly different between lower and upper canopy even though their numbers may vary.

A total of 3 trees at each site was chosen for each spraying round. The trees were chosen mainly for the accessibility of their canopy to the Pybuthrin being mist-blown, with taller trees being rejected. The chosen trees were within 100m from the light-trap spot, assuming 100m being the area of influence of light (see 2.1.2). For ease of sampling the trees selected were of reasonable distance from one another. The sprayed tree was marked with paint to avoid future selection, as uncertainty loomed over the sprayed tree's recovery rate for its arthropod fauna. Various trees in the secondary forest were selected, and quite often their

trunks and branches were festooned with climbers of various sorts. In addition the denser understorey vegetation in the *Eucalyptus deglupta* plantation was sampled as well. The different plant specimens were collected and subsequently identified taxonomically (Table 4.1).

All together four sampling rounds were conducted between each an interval of three months: July/August 1992, October/November 1992, January/February 1993, and April/May 1993. To minimize the problem of drift, mornings (before 12 noon) which were generally calmer were considered suitable for spraying, provided the weather was dry with no rain.

4.2.5 Tracer fluorescent particles

Foliage characteristics (e.g. leaf size and density) clearly varied from one plantation tree species to the next. In order to measure the canopy penetration power of the Pybuthrin used and hence the chemical retention on both the upper and lower surfaces of the leaves of plantation trees, a particulate tracer Lumogen (BASF), was added to the Pybuthrin in one of the spraying rounds. (This study was not included in the Secondary Forest as it was felt that the varied nature of its vegetation and tree species did not permit direct comparison.) Lumogen is a formulation of bright yellow fine powder which fluoresces under ultra violet light. 0.5g of Lumogen was added to 100ml of Pybuthrin and mixed well before spraying. Bundles of leaves of the plantation species were fastened with strings to a 10m long pole (straight trunk of a tall sapling cleared of branches) with each bundle separated by a metre interval, and the pole was leant on the trunk of the tree to be sprayed. This arrangement facilitated the collection of leaf samples at different heights (from 1 to 10m above ground) after spraying, which were kept in labelled wax paper envelopes. One set of leaf samples was taken for each plantation species. From the number of Lumogen fluorescent particles (counted under ultra violet light) retained on the leaf surfaces at different heights, it would by

Table 4.1 Botanical names of forest plants chosen for knockdown spraying

Site : *Eucalyptus deglupta* Plantation understorey vegetation

Date	No.	Botanical name	Family	Remarks
29-Jul-92	1	*Uncaria cordata*	Rubiaceae	Climber
		Merremia borneensis	Convolvulaceae	Climber
	2	*Dillenia suffruticosa*	Dilleniaceae	Dbh 3cm
		Uncaria cordata	Rubiaceae	Climber
	3	*Macaranga gigantifolia*	Euphorbiaceae	Dbh 20cm
		Vigna sinensis	Leguminosae	Climber
31-Oct-92	1	*Durio sp.*	Bombacaceae	Dbh 6cm
	2	*Alstonia angustiloba*	Apocynaceae	Dbh 10cm
	3	*Nephrolepis biserrata*	Davalliaceae	Fern - abundant ground cover
		Blechnum orientale	Blechnaceae	
		Gleichenia hirta	Gleicheniaceae	
30-Jan-93	1	*Dillenia suffruticosa*	Dilleniaceae	Ht 3m, dbh 7cm
	2	*Alstonia spatulata*	Apocynaceae	Ht 3m, dbh 6cm
		Vigna sinensis	Leguminosae	Climber
		Chromolaena odoratum	Compositae	
	3	*Macaranga hypoleuca*	Euphorbiaceae	Ht < 8m, dbh 11cm
02-May-93	1	*Ficus aurata*	Moraceae	Fruiting, dbh 7.5cm
	2	*Alstonia spatulata*	Apocynaceae	Dbh 10cm
	3	*Glochidion rubrum*	Euphorbiaceae	Dbh 9.5cm
		Merremia korthalsiana	Convolvulaceae	Climber

Site : Secondary Forest

Date*	No.	Botanical name	Family	Remarks
30-Jul-92	1	*Macaranga gigantifolia*	Euphorbiaceae	Dbh 27cm
	2	*Nauclea orientalis*	Rubiaceae	Dbh 12cm
	3	*Macaranga borneensis*	Euphorbiaceae	Dbh 12cm
		Diospyros sp.	Ebenaceae	
		Dinochloa trichogona	Gramineae	Scrambling bamboo
		Passiflora foetida	Passifloraceae	Climber
31-Oct-92	1	*Duabanga moluccana*	Sonneratiaceae	Dbh 2.5cm
	2	*Macaranga hypoleuca*	Euphorbiaceae	Dbh 12cm
	3	*Macaranga winkleri*	Euphorbiaceae	Dbh 5cm
30-Jan-93	1	*Macaranga pruinosa*	Euphorbiaceae	Ht 4m, dbh 15cm
	2	*Ficus aurata*	Moraceae	Fruiting, ht 7m, dbh 15cm
	3	*Macaranga hypoleuca*	Euphorbiaceae	Ht 6m, dbh 15cm
02-May-93	1	*Anthocephalus chinensis*	Rubiaceae	"Laran", dbh 23cm
		Merremia korthalsiana	Convolvulaceae	Climber
	2	*Macaranga hypoleuca*	Euphorbiaceae	Dbh 24cm
		Mikania cordata	Compositae	Climber
		Merremia korthalsiana	Convolvulaceae	Climber
		Passiflora foetida	Passifloraceae	Climber
	3	*Neonauclea sp.*	Rubiaceae	Dbh 19cm

*1st & last samples taken near 1st light-trap site
2nd sample near 2nd light-trap site
3rd sample near 3rd light-trap site

implication show the total Pybuthrin retention (Ozanne *et al.*, 1988).

In the laboratory, five samples of leaves of 1 cm^2 were taken at random for each height (except leaf needles of *Pinus caribaea* for which 0.25cm length was taken), and their fluorescent particles density was measured. For the first five samples of each species, the numbers of fluorescent particles on both topside and underside were counted manually under a stereomicroscope illuminated by ultra violet light in a darkened room. This method was tedious and required many man-hours. A more sophisticated method was devised by M.R.Speight of the Zoology Department in Oxford University which incorporates the use of video-camera that picks up the fluorescent particles under ultra violet and displays the image on a television screen. The fluorescent spots on the video image were measured by a microcomputer using software packages: Firstly 'Vidiwin' (Rombo Ltd. 1992) which captured and digitised the image, then the 'Winjpeg' (Yee & Yee 1992, v.2.2) which enhanced the image ready for measurement in 'Aequitas' (Skye Instruments/Dynamic Data Links 1994) where image intensity thresholds for either the leaf topside or underside of the species were determined and kept constant for subsequent samples of the same species, and the fluorescent spots counted by the computer. To verify the accuracy of the video-microcomputer measurements, their numbers (in the first five samples) were compared to those measured manually under the stereomicroscope, and regression graphs were produced.

4.2.6 Identification of knockdown samples

All the knockdown samples in vials of alcohol were brought back to the laboratory and subsequently sorted. Since this project concentrated on the macromoths, only those of that particular fauna would be included here.

Most of the moth larvae collected could be identified down to the family level using the monograph on insect larvae by Peterson (1948), with additional reference to the

Lepidoptera handbook produced by the International Institute of Entomology (Holloway *et al.*, 1987).

Some later instar larvae are typical in form and shape and readily recognizable as to which family they belong to e.g. the tufted caterpillars of most lymantriids. A typical geometrid larva which is generally a 'looper' has a hunched body which can at times be confused with some noctuid larvae. The former has only two pairs of abdominal prolegs (one pair on the sixth abdominal segment and an anal pair on the last abdominal segment) compared with usually five pairs (on segments 3 to 6 and 10) for a noctuid larva. Confusion arises when the prolegs on segments 3 to 5 of the noctuid larva are reduced. An examination of the crochets on the prolegs could help in identification of the larva: the crochets on well developed prolegs of geometrids are usually biordinal arranged in a mesoseries; those of noctuids are often uniordinal; arctiids bear heteroideous crochets in a mesoseries (homoideous for the lithosiines); most larvae of micromoths possess crochets forming circle or penellipse, and so on. The arrangement of setae on the larva's prothorax, mesothorax and abdomen also helps in identification in the form of setal maps with the various setae either named in Greek characters (e.g. α, β, γ, etc.) or Arabic/Roman numerals. The armature on the body in various structures such as verrucae, scoli (prominent on some limacodids) can be important as well.

The majority of the moth larvae however, are not possible at present to identify to species level as they are still taxonomically obscure, the problem being compounded by the different larval instars which may not be morphologically similar. The few which could be named were those which had been reared to adults with studies on their life histories (see Appendix V).

4.3 Results & Discussion

4.3.1 Fluorescent Particles (FP)

4.3.1.1 Measurement of FP

Regression lines combining data from all five plantation tree species showed that the FP measurement made by the microcomputer method correlated positively with that counted manually using a stereomicroscope (Fig. 4.1)(Table 4.2). R^2 values of 0.78 and 0.62 were obtained for the leaf topside and underside, respectively. This validated the use of microcomputer image analysis in measuring the FP density on both leaf surfaces of the different plantation trees.

4.3.1.2 FP retention

Table 4.3 shows the retention of the FP on leaves for both topside and underside of the different species at different heights. The rather high standard error (s.e.) values could be due to the fact that a drop of insectide on impact with the leaf either fragmented scattering the FP in tiny droplets or remained relatively intact depositing the FP in a lump. Paired t-tests (Table 4.4) showed no significant difference in the distribution of FP between the leaf topside and underside of all species examined except for *Acacia mangium* which had the topside marginally better covered than the underside (see also Fig. 4.2):

Fig. 4.1 Regression lines for FP density (leaf topside vs leaf underside)

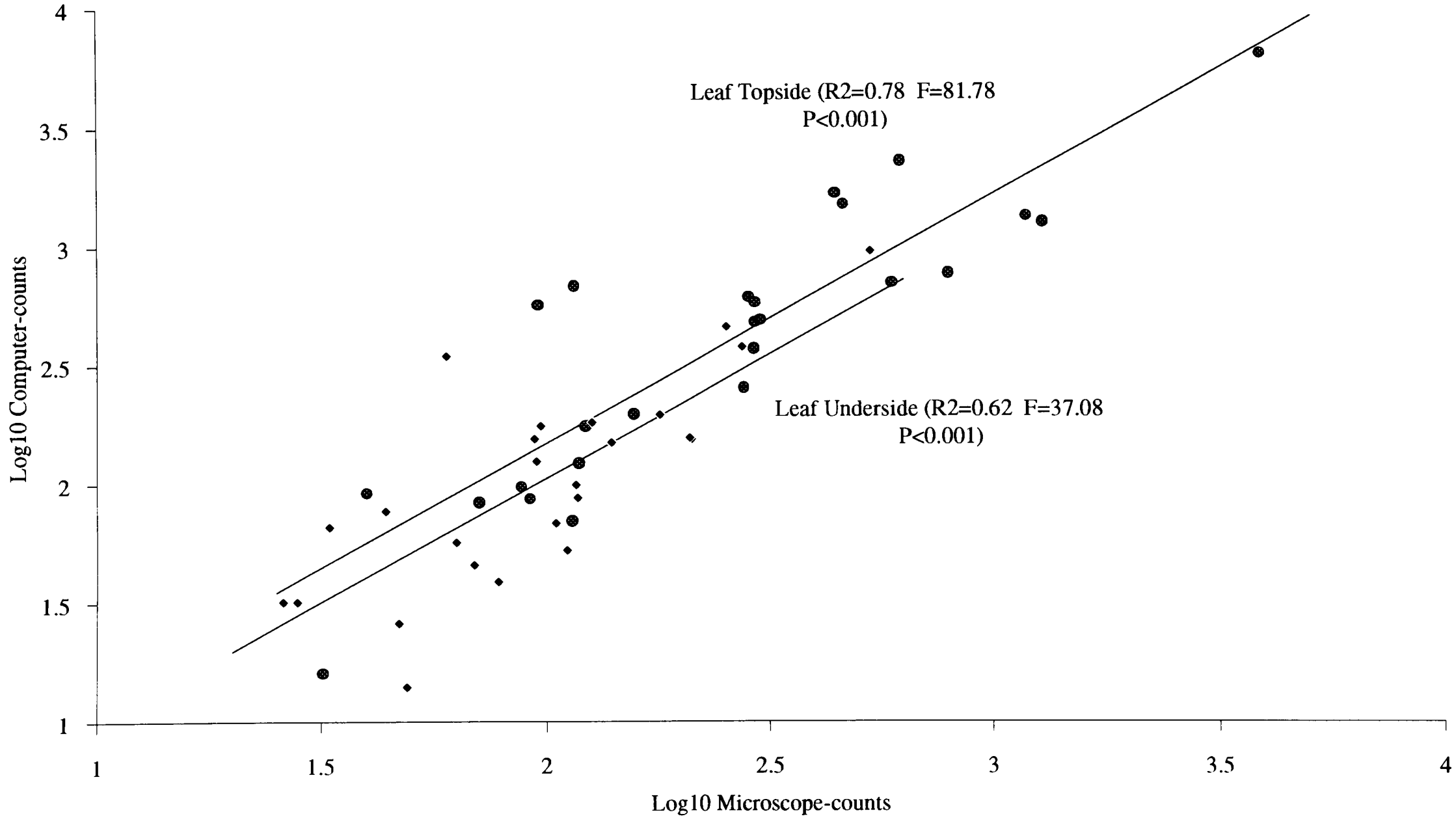


Table 4.2 Microscope vs computer counts of FP density						
Leaf per cm square except Pinus per 0.25 cm length						
Fluorescent Particles Density			Microscope-counts		Computer-counts	
		Rep.	X1 (Top)	X2 (Und)	Y1 (Top)	Y2 (Und)
A. mangium		1	1181	105	1356	69
		2	595	117	713	88
		3	3870	49	6462	14
		4	1285	126	1284	184
		5	793	78	778	39
G. arborea		1	156	94	198	156
		2	118	95	123	126
		3	122	116	176	100
		4	620	47	2322	26
		5	445	111	1693	53
P. falcataria		1	294	210	487	156
		2	92	63	87	57
		3	277	139	256	151
		4	88	97	98	177
		5	114	69	70	46
E. deglupta		1	302	253	496	465
		2	284	532	621	973
		3	464	178	1523	197
		4	294	274	587	382
		5	292	208	375	158
P. caribaea		1	71	28	84	32
		2	115	26	695	32
		3	96	60	575	350
		4	32	44	16	77
		5	40	33	92	66

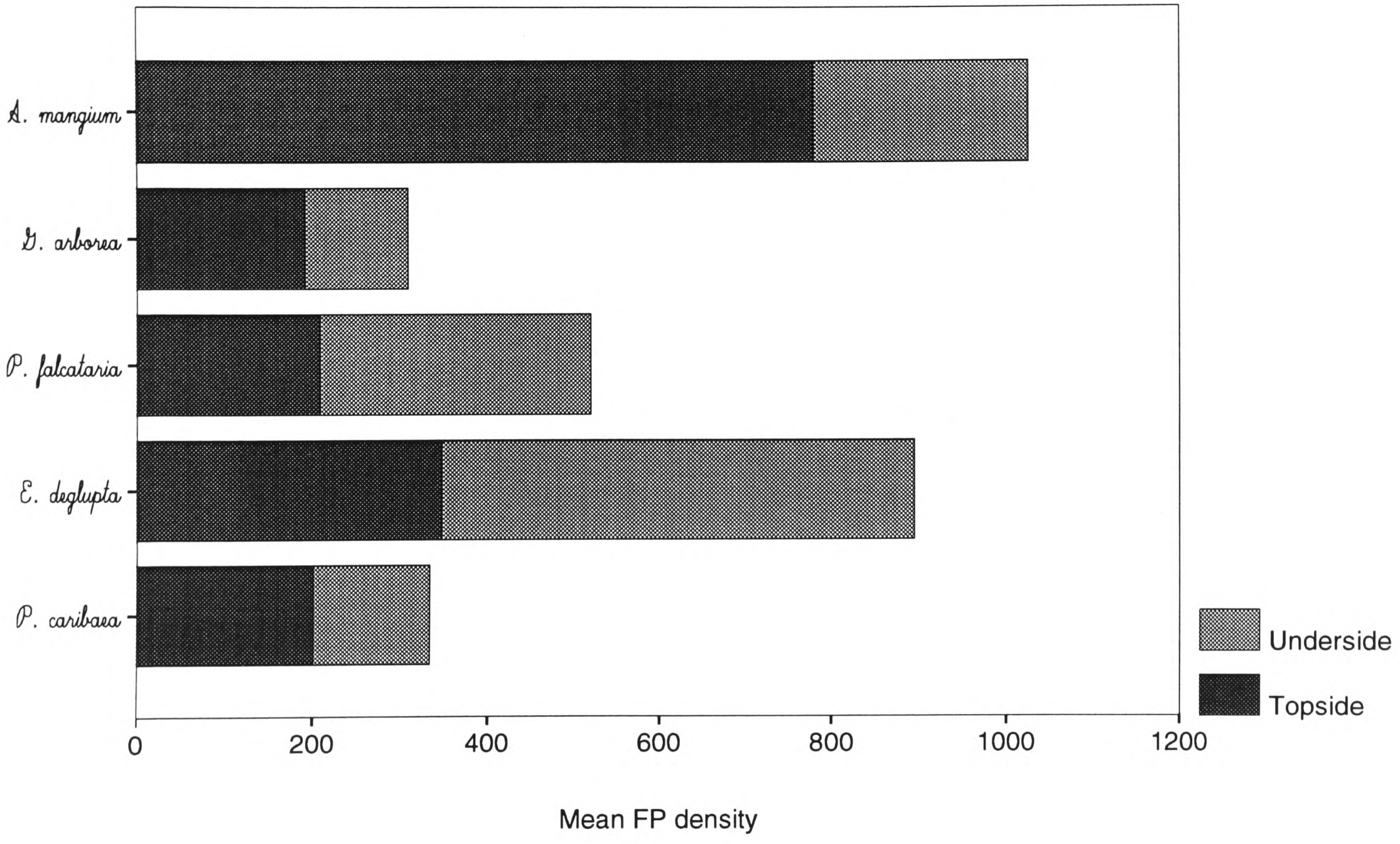


Fig. 4.2 FP density on leaf: topside vs underside

FP density per cm2 except P. caribaea per 0.25 cm length

Table 4.3 FP density at various heights											
		A. mangium		*G. arborea*		*P. falcataria*		*E. deglupta*		*P. caribaea*	
Ht.	Rep.	Top	Under	Top	Under	Top	Under	Top	Under	Top	Under
1m	1	1356	69	198	156	487	156	496	465	84	32
	2	713	88	123	126	87	57	621	973	695	32
	3	6462	14	176	100	256	151	1523	197	575	350
	4	1284	184	2322	26	98	177	587	382	16	77
	5	778	39	1693	53	70	46	375	158	92	66
	Mean	2118.6	78.8	902.4	92.2	199.6	117.4	720.4	435	292.4	111.4
	s.e.	1093.53	29.18	462.15	23.66	79.24	27.31	205.12	146.04	141.76	60.33
2m	1	2568	61	106	268	64	370	1014	714	138	656
	2	6926	90	50	276	10	219	1031	1169	11	126
	3	3665	38	107	225	278	144	428	6747	727	187
	4	2399	297	230	105	12	194	672	5732	1252	58
	5	390	236	209	198	84	355	726	480	14	401
	Mean	3189.6	144.4	140.4	214.4	89.6	256.4	774.2	2968.4	428.4	285.6
	s.e.	1073.22	51.44	34.06	30.84	49.26	45.03	113.15	1349.59	244.72	108.97
3m	1	464	6676	15	79	416	605	115	217	494	576
	2	903	418	194	67	522	483	246	295	708	595
	3	449	1941	23	26	1976	1053	2367	1111	66	258
	4	4445	269	12	56	878	1153	327	304	512	65
	5	3402	177	37	33	761	436	1028	433	606	769
	Mean	1932.6	1896.2	56.2	52.2	910.6	746	816.6	472	477.2	452.6
	s.e.	833.34	1237.68	34.72	10.02	278.76	149.17	418.69	163.47	109.64	127.22
4m	1	591	197	194	726	145	270	120	1049	25	116
	2	330	112	244	766	680	198	146	207	996	51
	3	184	177	143	629	395	965	288	2653	89	870
	4	141	172	170	452	506	251	641	231	13	39
	5	75	230	243	433	162	110	362	315	857	234
	Mean	264.2	177.6	198.8	601.2	377.6	358.8	311.4	891	396	262
	s.e.	91.80	19.31	19.95	68.58	102.18	154.07	93.74	467.16	218.07	155.89
5m	1	315	9	333	206	127	1421	102	326	83	52
	2	307	112	549	161	109	3411	97	789	799	18
	3	238	12	316	157	363	776	175	799	147	9
	4	255	123	199	327	68	930	251	364	155	491
	5	91	369	412	164	257	649	135	381	59	174
	Mean	241.2	125	361.8	203	184.8	1437.4	152	531.8	248.6	148.8
	s.e.	40.33	65.55	57.88	32.24	54.63	510.48	28.41	107.42	138.82	90.49
6m	1	45	62	167	0	476	162	1220	77	12	1
	2	49	17	117	1	330	119	371	76	3	191
	3	28	2	617	38	335	146	284	135	7	49
	4	16	13	235	33	210	161	811	113	595	8
	5	16	9	114	0	119	209	584	102	56	92
	Mean	30.8	20.6	250	14.4	294	159.4	654	100.6	134.6	68.2
	s.e.	7.00	10.64	94.34	8.65	60.74	14.63	168.36	11.18	115.49	34.75
7m	1	29	16	0	0	32	14	48	71	18	0
	2	21	11	2	0	50	25	15	69	7	0
	3	13	10	11	0	4	77	54	66	0	5
	4	35	10	8	0	16	40	8	65	0	6
	5	5	0	0	0	7	41	54	73	11	8
	Mean	20.6	9.4	4.2	0	21.8	39.4	35.8	68.8	7.2	3.8
	s.e.	5.38	2.60	2.24	0.00	8.57	10.65	10.04	1.50	3.43	1.62
8m	1	5	12	0	1	0	0	9	4	0	14
	2	0	14	0	0	11	5	4	0	2	5
	3	7	0	0	0	7	10	5	2	0	8
	4	0	0	0	0	2	0	0	2	28	0
	5	9	0	0	0	0	0	0	34	7	0
	Mean	4.2	5.2	0	0.2	4	3	3.6	8.4	7.4	5.4
	s.e.	1.83	3.20	0.00	0.20	2.17	2.00	1.69	6.43	5.31	2.64

Table 4.3 FP density at various heights											
		A. mangium		*G. arborea*		*P. falcataria*		*E. deglupta*		*P. caribaea*	
Ht.	Rep.	Top	Under	Top	Under	Top	Under	Top	Under	Top	Under
9m	1	1	0	0	0	0	0	0	0	0	0
	2	9	0	0	0	0	0	0	0	3	0
	3	0	0	0	0	2	0	0	0	0	8
	4	10	0	0	0	0	0	0	0	41	0
	5	9	1	0	0	0	0	0	3	3	3
	Mean	5.8	0.2	0	0	0.4	0	0	0.6	9.4	2.2
	s.e.	2.18	0.20	0.00	0.00	0.40	0.00	0.00	0.60	7.93	1.56
10m	1	0	0	0	0	0	0	0	0	0	0
	2	0	1	0	0	0	10	0	0	0	0
	3	0	0	0	0	0	7	0	0	0	0
	4	0	0	0	0	0	1	8	1	13	0
	5	0	0	9	0	1	18	0	2	0	0
	Mean	0	0.2	1.8	0	0.2	7.2	1.6	0.6	2.6	0
	s.e.	0.00	0.20	1.80	0.00	0.20	3.28	1.60	0.40	2.60	0.00
All leaf samples per cm square except P. caribaea per 0.25 cm length											

Table 4.4 Paired t-tests for FP distribution between leaf topside and underside

	Paired Differences				
Species	Mean	SD	SE of Mean	t-value 0.05, 49	2-tail sig.
A. mangium	535.000	1868.539	264.251	2.02	0.048*
G. arborea	73.800	438.770	62.051	1.19	0.240
P. falcataria	-104.240	560.623	79.284	-1.31	0.195
E. deglupta	-200.760	1256.579	177.707	-1.13	0.264
P. caribaea	66.920	342.318	48.411	1.38	0.173

This result indicated that both the topside and underside of the leaves were more or less equal in their FP retention and hence coverage of the Pybuthrin sprayed. It implied that the macromoth larvae present on either surface would get an equal probability of coming into contact with the insecticide.

Fig. 4.3 shows the FP density (both topside and underside considered together) at different heights for the various plantation trees. It can be seen that the FP density for all species was almost negligible beyond 7m. Beyond 5m *Paraserianthes falcataria* and *Eucalyptus deglupta* seemed to have higher FP density, both species possess smaller leaves which should permit higher chemical penetration in their canopies. *Acacia mangium* had the highest overall mean FP density (especially dense at lower levels) which could be attributed to its relatively coarser leaves giving better retention, while *Gmelina arborea* with its broad leaves assumably blocking spray penetration did not appear to be well covered with it having the lowest mean (see also Fig. 4.2). *Pinus caribaea* (its leaf needle measured per 0.25cm length for FP density as opposed to per cm^2 for the others) would seem to receive comparatively good insecticide coverage if its leaf area was multiplied forty times (needle width generally 1mm). All these factors will be considered in more detail with the analysis

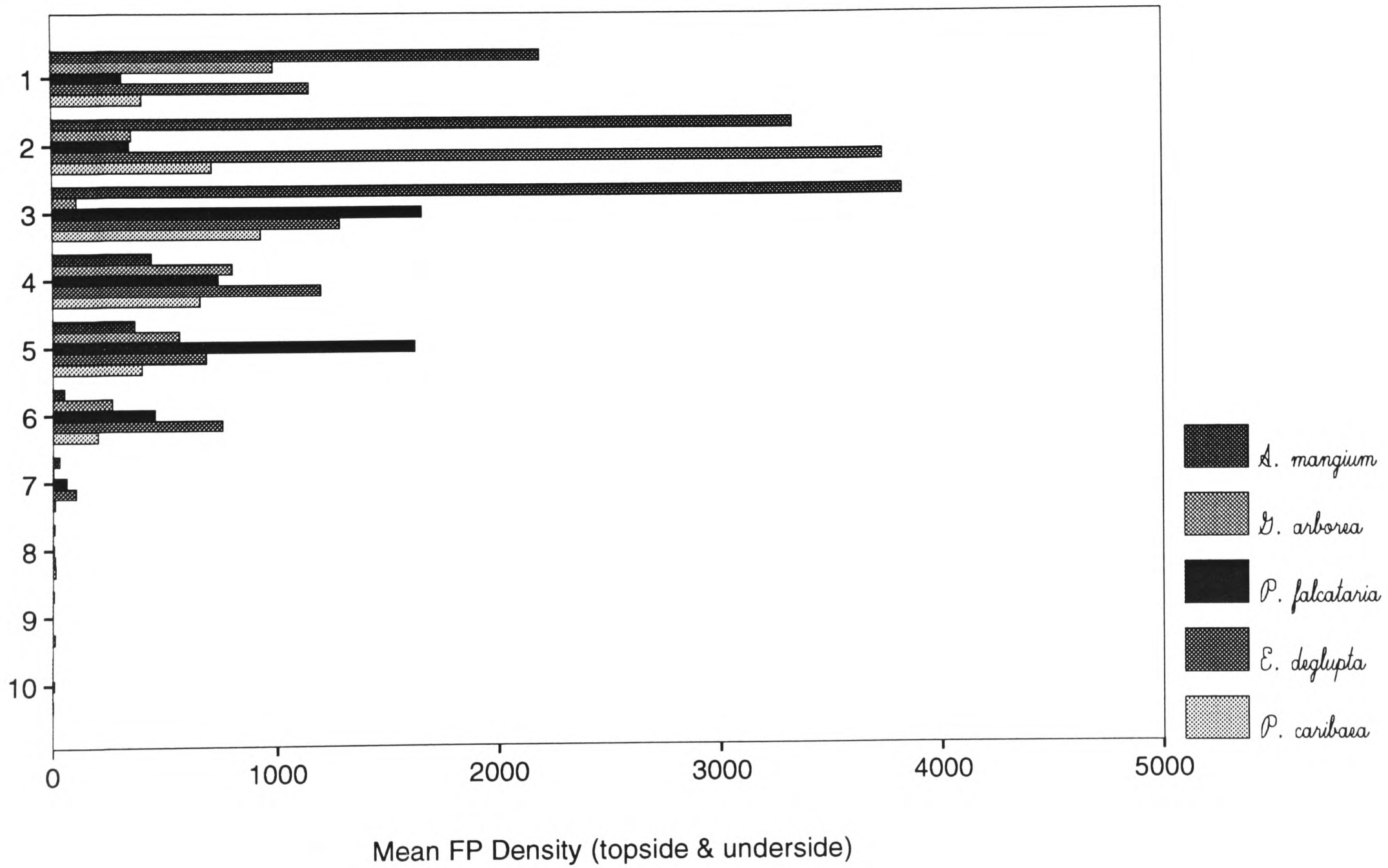


Fig. 4.3 FP density at different heights

FP density per cm2 except P. caribaea per 0.25 cm length

of the numbers of macromoth fauna sampled by mist-blowing.

4.3.2 Macromoth fauna in knockdown samples

Table 4.5 is a complete list of the macromoth fauna sampled by knockdown mist-blowing. Fig. 4.4 shows that most of them fell in the first 15 minutes after spraying, the number of which was significantly higher than other periods beyond 15 minutes (Analysis of variance: F Ratio = 5.3965, $P < 0.05$) as shown by LSD (Least significant difference) test (Table 4.6):

Table 4.6 Analysis of variance for time of knockdown

Mean	Minutes	45-60	30-45	15-30	0-15
0.5417	45-60				
0.7500	30-45				
1.2917	15-30				
2.8333	0-15	*	*	*	

* denotes significant difference

The quick knockdown capability of Pybuthrin was supported by this result. It is also obvious from Fig. 4.4 that there was a gradual decrease in the remaining low numbers of individuals knocked down beyond the first 15 minutes after spraying. Both *Acacia mangium* and *Eucalyptus deglupta* produced almost negligible numbers after 45 minutes. It was likely that most species were either knocked down in the first 15 minutes or escaped. Fig. 4.5 shows high proportions of individuals, almost exclusively larvae (Table 4.5), belonging to either Geometridae or Noctuidae. This trend was similar to the adult moths captured by light-trap (see Fig. 2.5.1). Also some larvae of both families were seemingly more exposed to the

Table 4.5 Knockdown samples of macromoth fauna

Order : Lepidoptera (Macromoth)#

* Larva

** Adult

*** Pupa

Site :

Acacia mangium (With three replicates : 1, 2, 3)

		Number of individuals knocked down												
	Minutes after spraying	0-15			15-30			30-45			45-60			
Date	Name	1	2	3	1	2	3	1	2	3	1	2	3	Sum
28-Jul-92	Arctiidae L9*				1									1
	Geometridae L2					1								1
29-Oct-92	Noctuidae L2	1												1
	Noctuidae L47							1						1
02-Feb-93	Geometridae L27		1											1
	Geometridae L28						1							1
	Noctuidae L18		2											2
01-May-93	Geometridae L22		1											1

Site :

Eucalyptus deglupta (With three replicates : 1, 2, 3)

		Number of individuals knocked down												
	Minutes after spraying	0-15			15-30			30-45			45-60			
Date	Name	1	2	3	1	2	3	1	2	3	1	2	3	Sum
29-Jul-92	Noctuidae A1**	1												1
	Noctuidae L5				1									1
	Noctuidae L6			1										1
31-Oct-92	Lymantriidae L8	1												1
30-Jan-93	Geometridae L21								1					1
30-Apr-93	Geometridae L35		1											1

Site :

Eucalyptus deglupta Undergrowth (With three replicates : 1, 2, 3)

		Number of individuals knocked down												
	Minutes after spraying	0-15			15-30			30-45			45-60			
Date	Name	1	2	3	1	2	3	1	2	3	1	2	3	Sum
30-Jul-92	Geometridae L20				1									1
	Lepidoptera L7		1											1
	Lymantriidae L4			1										1
	Noctuidae L7	1												1
	Noctuidae L8						1							1
	Noctuidae L9												1	1
31-Oct-92	Noctuidae L16			1										1
30-Jan-93	Arctiidae L10									1				1
	Noctuidae L16								1					1
	Noctuidae L17		1											1
	Saturniidae L1		1											1
02-May-93	Geometridae L36			1										1
	Lepidoptera L12											1		1
	Noctuidae L20 (?Callopistria sp.)	1												1

Site :														
Gmelina arborea		(With three replicates : 1, 2, 3)												
		Number of individuals knocked down												
	Minutes after spraying	0-15			15-30			30-45			45-60			
Date	Name	1	2	3	1	2	3	1	2	3	1	2	3	Sum
28-Jul-92	Arctiidae L8	1												1
	Geometridae L10	2									1			3
	Geometridae L11	1												1
	Geometridae L12		1		1									2
	Noctuidae L1						1							1
	Noctuidae L2												1	1
29-Oct-92	Limacodidae L1	1												1
02-Feb-93	Geometridae L29							1						1
	Lepidoptera L8					1								1
01-May-93	Noctuidae L19						1							1
Site :														
Paraserianthes falcataria		(With three replicates : 1, 2, 3)												
		Number of individuals knocked down												
	Minutes after spraying	0-15			15-30			30-45			45-60			
Date	Name	1	2	3	1	2	3	1	2	3	1	2	3	Sum
29-Jul-92	Geometridae A1										1			1
	Geometridae L13		1						1			1		3
	Geometridae L14			1										1
	Lymantriidae L1							1						1
	Lymantriidae L2		1											1
	Noctuidae L2							1		3			1	5
	Noctuidae L3 (Dinumma ?combusta)		1	1										2
	Noctuidae L4		1											1
	Noctuidae L9				1									1
28-Oct-92	Geometridae L14		2											2
	Lymantriidae L5	1												1
	Lymantriidae L6									1				1
	Noctuidae L11 (Felinia spissa)	3												3
	Noctuidae L12			1										1
	Noctuidae L13					1								1
	Noctuidae L14							2						2
	Noctuidae L15										1			1
	Noctuidae L3 (Dinumma ?combusta)	1			2								1	4
31-Jan-93	Geometridae L22	1												1
	Geometridae L23 (?Cleora sp.)			1										1
	Geometridae L24				1									1
	Geometridae L25				1									1
	Geometridae L26							1						1
	Geometridae L31			1										1
	Lymantriidae L10										1			1
	Lymantriidae L9 (Euproctis sp.)						1							1
	Noctuidae L3 (Dinumma ?combusta)	1												1
30-Apr-93	Arctiidae L11				1									1
	Geometridae L23 (?Cleora sp.)	4												4
	Geometridae L30	2		2					1		1			6
	Geometridae L32				1									1
	Geometridae L33 (?Gnamptoloma aventiara)				1									1
	Geometridae L34 (Cleora alienaria)		1											1
	Lepidoptera L10		1											1
	Lepidoptera L11											1		1
	Lepidoptera L9		1											1

		Number of individuals knocked down												
	Minutes after spraying	0-15			15-30			30-45			45-60			
Date	Name	1	2	3	1	2	3	1	2	3	1	2	3	Sum
	Lymantriidae L11 (Lymantria brunneiplaga)		1			2			1					4
	Lymantriidae L12		2											2
	Lymantriidae P1***(L. brunneiplaga)								1					1
	Noctuidae L12				2									2
	Noctuidae L3 (Dinumma ?combusta)		2											2
Site :														
Pinus caribaea		(With three replicates : 1, 2, 3)												
		Number of individuals knocked down												
	Minutes after spraying	0-15			15-30			30-45			45-60			
Date	Name	1	2	3	1	2	3	1	2	3	1	2	3	Sum
25-Jul-92	Arctiidae L1				1									1
	Arctiidae L2				1									1
	Arctiidae L3		1											1
	Arctiidae L4		1				1							2
	Arctiidae L5											1		1
	Arctiidae L6						1							1
	Arctiidae L7									1				1
	Geometridae L1		1	1	1		3			1				7
	Geometridae L2		1											1
	Geometridae L3		1	2									2	5
	Geometridae L4								1					1
	Geometridae L5			13			1			3				17
	Geometridae L6			1										1
	Geometridae L7			1										1
	Geometridae L8			2			1							3
	Geometridae L9						1							1
	Lepidoptera L1		1											1
	Lepidoptera L2			1			2							3
28-Oct-92	Noctuidae L10										1			1
Site :														
Secondary Forest		(With three replicates : 1, 2, 3)												
		Number of individuals knocked down												
	Minutes after spraying	0-15			15-30			30-45			45-60			
Date	Name	1	2	3	1	2	3	1	2	3	1	2	3	Sum
30-Jul-92	Drepanidae L1					1	1							2
	Geometridae L15	1												1
	Geometridae L16	1												1
	Geometridae L17	1									1			2
	Geometridae L18		1											1
	Geometridae L19			1										1
	Lepidoptera L4	1												1
	Lepidoptera L5	1												1
	Lepidoptera L6			1										1
	Lepidoptera P1						1							1
	Lymantriidae L3						1							1
31-Oct-92	Lymantriidae L7					1								1
30-Jan-93	Arctiidae L10			1			1							2
02-May-93	Geometridae L37		1											1
	Lepidoptera L13					1								1
	Lymantriidae L13			1										1
	# Number of species could only be estimated due to identification difficulties of larval instars													

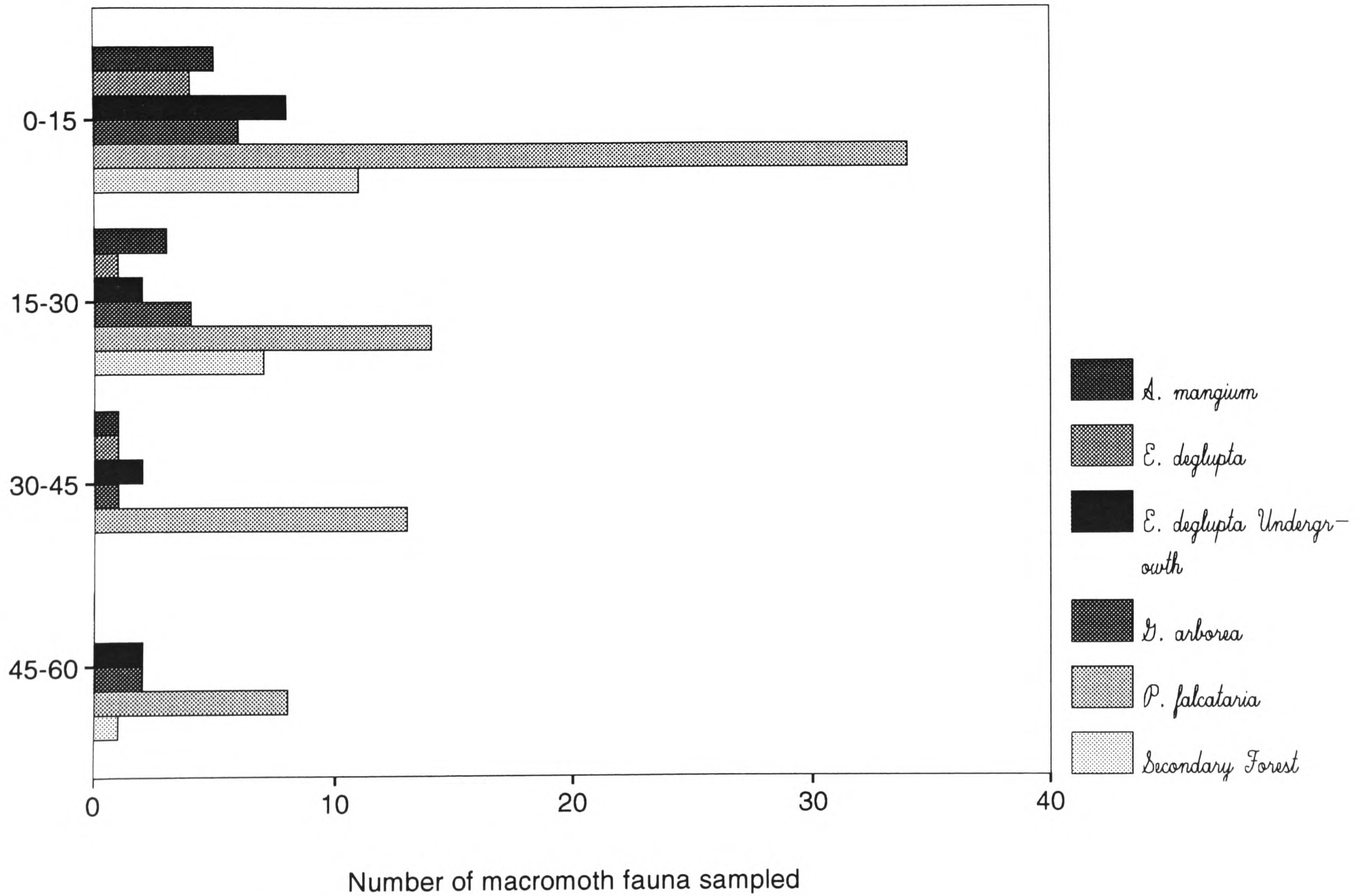


Fig. 4.4 Total individuals sampled for all spraying rounds

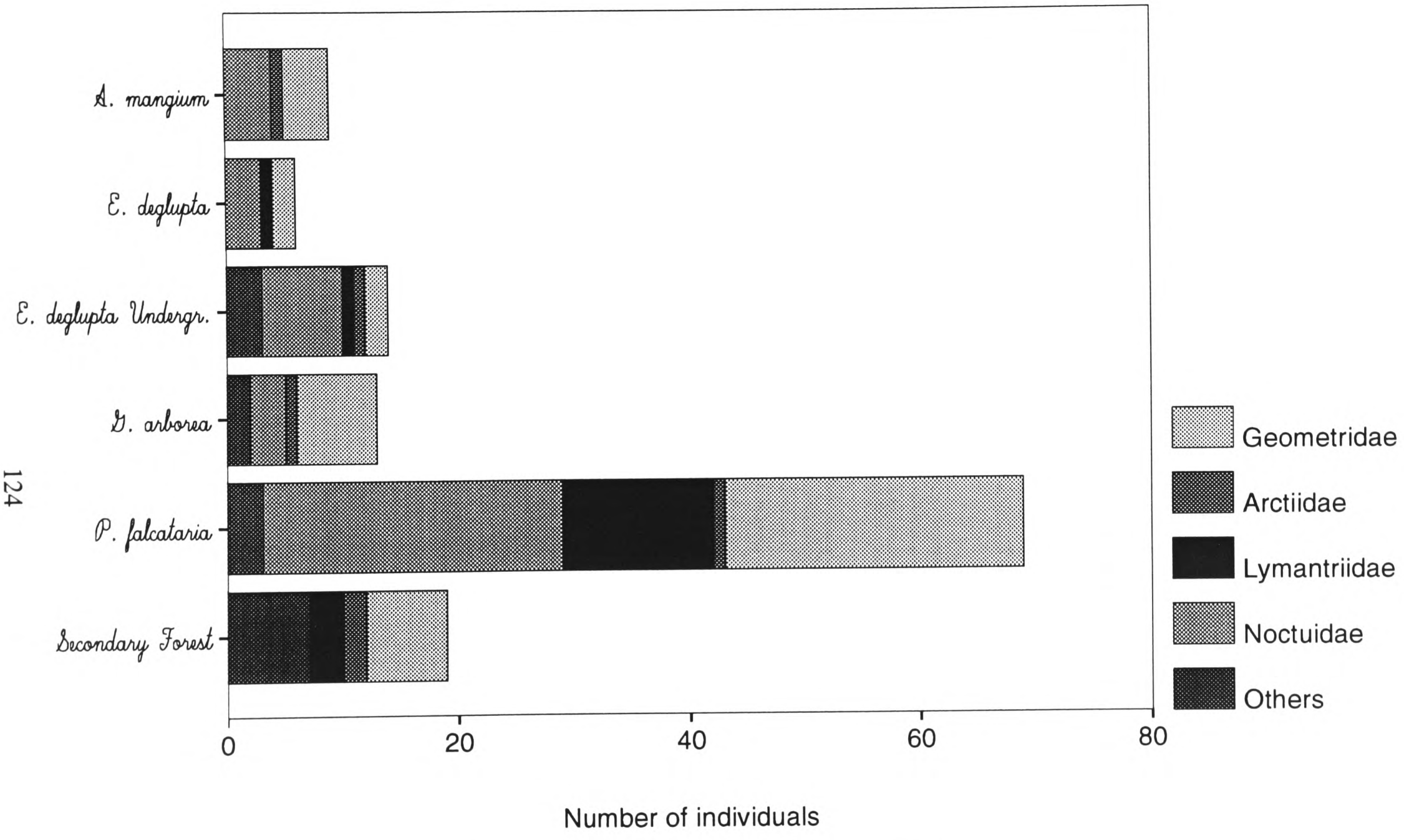


Fig. 4.5 Proportions of various families by numbers of individuals

Knockdown samples

contact insecticide, wandering freely on leaf surfaces devoid of protection by leaf-rolls, and they are not copious silk spinners, with bare pupae not enclosed within silky cocoons e.g. *Cleora* spp. (Geometridae), *Dinumma ?combusta* Walker (Noctuidae).

The presence of moth larvae as sampled by knockdown might help to substantiate in part for the light-trap adult moth samples but their apparently depauperate number requires further explanation. The number of macromoth fauna sampled overall was low (Table 4.5). This, however, might be expected as knockdown samples from both tropical as well as temperate trees also produced low number of macromoth fauna (Southwood *et al.*, 1982; Stork, 1991; Ozanne, 1991). It is likely that many moth larvae are either sheltered from the contact insecticide by their microhabitat in the form of leafrolls, hiding under bark, or they may simply hang on to the canopy tenaciously with their silken threads. Furthermore knockdown spraying covers mostly only the canopy, in this case only the lower canopy as explained in 4.2.4. Sutton (1983) reported that in tropical rain forests, high concentrations of Lepidoptera were found in the upper canopy. And canopy is but one of the five major biotope components (Holloway & Stork, 1991). The other components such as tree trunks, herb-layer, leaf litter and soil were not adequately, if at all, represented. Many larvae of the family Herminiinae are detritus feeders, those of Cossidae are twig and trunk borers, these and many others were not sampled. Some larvae e.g. *Ericeia* spp. (Noctuidae) have the peculiar habit of 'hibernating' under bark of tree trunk e.g. *Acacia mangium* during the day, only coming out to feed on the foliage after night has fallen (Chey, 1987). But Bornean nights are typically breezy, and such soothing breezes are considered detrimental to effective knockdown. Majer & Recher (1988) also commented on the undersampling of species which are only present on foliage at night using daytime mist-blowing. Despite these limitations, knockdown spraying is still the best option available in sampling moth larvae particularly canopy dwellers. The

mere height of the canopy precluded simpler methods such as sweep-sampling and handpicking.

When the samples of the various sites were compared (excluding *Pinus caribaea* as the plantation was being felled after the first spraying round, and totally annihilated after the second, yielding only two samples which will be discussed later), only *Paraserianthes falcataria* and Secondary Forest recorded a mean of larger than 1.5 using LSD test (ANOVA: F Ratio = 10.1863, $P < 0.05$) (Table 4.7):

Table 4.7 Analysis of variance for knockdown samples of macromoth fauna

Mean	Site	E. d.	A. m.	G. a.	E. d. U	S. F.	P. f.
0.5000	E. d.						
0.7500	A. m.						
1.0833	G. a.						
1.1667	E. d. U						
1.5833	S. F.						
5.7500	P. f.	*	*	*	*	*	

* denotes significant difference

The relatively high number sampled from *P. falcataria* could be attributed to several factors. As shown in Fig. 4.3, *P. falcataria* had a comparatively high FP density beyond 5m, implying its small compound leaflets permitted better insecticide penetration in its canopy, coupled with it being a legume (many members of Leguminosae are highly favoured by phytophages) of comparatively soft (and presumably more palatable) foliage, hence producing a higher catch (See also Fig. 4.5). *Eucalyptus deglupta* (Myrtaceae) with its small leaf blades also showed better insecticide penetration, but being an eucalyptus it also contains antifeeding compounds such as polyphenols (Majer & Recher, 1988), which might restrict its load of moth fauna. In contrast, its dense understorey vegetation of myriad plant species (Table 4.1)

yielded a much higher catch (see also Table 4.5). The number sampled from *Acacia mangium*, despite being a legume, was relatively low. This suggests that taxonomic relatedness of introduced species (*A. mangium* and *P. falcataria*) might not necessarily demonstrate similar insect abundance. The low number sampled from *A. mangium* might be due to its crown of comparatively tougher, and coarser foliage, acting as a feeding deterrent. Majer & Recher (1988) listed the structure (anatomy) of leaves together with the presence of secondary plant compounds and the nutrient level of foliage as reasons for different levels of invertebrate abundance. Leaves with thicker cuticle may be more difficult to chew and the nutritive reward per unit area would also be less. Scoble (1992) also commented that similarity between host plants for Lepidoptera does not reflect only taxonomic similarity, but also similarity in secondary plant substances. *Gmelina arborea* (Verbenaceae) with its much broader leaves only retained low FP density and its samples were not expected to be rich. That left us with the anomaly of the surprisingly low number sampled from the Secondary Forest. The answer to this could be two-fold. Heights of most trees in this regenerating logged-over natural forest were beyond the reach of the spray, and those trees of the desirable height (<10m) were mostly *Macaranga* spp. (Table 4.1) which also housed ant populations e.g. *Crematogaster* spp., *Anoplolepis longipes*, ?*Nylanderia* sp. in staggering proportions. Ants being voracious predators might have dislodged the various moth larvae, or restrict their presence (Grant & Moran, 1986).

The first knockdown sample from *Pinus caribaea* (Pinaceae) while the plantation was still intact produced an interestingly high number of larvae (Table 4.5). This could be due to the structure of its thin leaf needles permitting good insecticide penetration into its canopy (see last paragraph of 4.3.1.2). At the time of the second sampling round, much of the

plantation had already been felled, and the few remnant trees gave only one single larva.

The above data suggest that introduced trees *per se* in Borneo do not necessarily harbour a poorer moth fauna compared to individual native trees. But when a particular species of introduced tree (or native tree for that matter) is planted uniformly over a sizeable area, this produces a certain uniformity in structure both spatially and architecturally, and this reduction in both species and structural heterogeneity may bring about a decrease in diversity of its moth fauna compared to an area of natural forest of similar size.

CHAPTER FIVE

FLORISTICS OF MOTH SAMPLING SITES

5.1 Introduction

The floristics of the various moth sampling sites, ranging from plantation to secondary as well as undisturbed forest, are a vital element in determining the various levels of moth diversity. Monoculture plantations of exotic tree species tend to project an image of extremely depauperate system of floristics which has failed to catch the fancy of botanists, and instead generated much disinterest. Expeditions to remote areas of pristine tropical rain forest have been and still are the main preoccupation of many tropical botanists, disturbed or logged-over forest is shunned, botanical survey in tropical plantations unheard of. For what is there to survey where only a single species is planted?

An aspect which many tend to overlook in the plantation forest is its understorey. Many of the plantation species chosen in this project namely *Paraserianthes falcataria, Gmelina arborea, Eucalyptus deglupta* are considered as long-lived light-demanding pioneer species (Whitmore, 1984), with life-spans of more than thirty years. The forest plantations were established on areas previously occupied by lowland dipterocarp forest. What effect this large scale man-induced agglomeration of a single pioneer species on succession is unclear. Would the massive clearance (perhaps analogous to massive gap and with significant impact on light and moisture regimes) prior to planting debilitate or destroy the 'seed bank' normally present in the soil of the forest floor, or would the extant but dormant seeds of the shade-bearing climax species (as opposed to pioneer species) find sufficient stimulus in the shade of an artificially created environment (in the homogeneity of even-aged single pioneer

species), to germinate and grow so as to emulate the floristic shift from pioneer to climax species, as evident in successful succession under natural conditions? The answer to these questions obviously lies with an examination of the understorey floristics present in these plantations.

Various workers through their research findings have shown the importance of the understorey of various forest types in determining the size and composition of the corresponding arthropod community. Wong (1984) working in virgin as well as regenerating tropical rain forest in Pasoh, Peninsular Malaysia noted the variation in abundance of phytophagous arthropods being related to the scarcity and diversity of plants present at any given time in the understorey, and Hill & Roberts (1990) reported on the significant effect different understorey species (chestnut, hazel, hornbeam - all growing under oak) could exert on the invertebrate abundance and biomass in Kent, England. Understorey plant species are also used to indicate site productivity, for example in the mature pine forest in Finland (Nieppola, 1993), and in the eucalyptus forest in Australia, where 75% of the above-ground productivity was reported to be in the understorey (Turner *et al.*, 1992).

However, an assumed simplistic nature of the plantation forest undergrowth in Sabah has made a more systematic and detailed survey wanting. Information available so far is patchy, and merely conspicuous, common weedy and herbaceous species being cursorily mentioned (Chey, 1990; Stuebing & Gasis, 1989; Tan, 1986). The moth diversity as evident in the various plantations at Brumas called for further investigation into the plantation understorey to produce a fuller profile of its floristics. Natural logged-over regenerating Secondary Forest at Brumas as well as natural primary forest at Danum Valley (which together constitute the various moth sampling sites in this project) were also surveyed for comparison.

5.2 Materials & Methods

5.2.1 Botanical survey: Plantation forest

For each of the plantation sites sampled for moths at Brumas, a 5m x 5m plot was botanically surveyed, with 25 grids of $1m^2$, the plot being within 100m of the spot where the light-trap was set. Within the plot, understorey vegetation was differentiated into various categories namely herbaceous plants (grasses, ferns, herbaceous creepers and climbers), shrubs, as well as vines and saplings (if present). Diagram illustrating the extent of ground cover of these plants was drawn, the position of each understorey species as well as each plantation tree within the plot was determined, heights and dbh (where appropriate) were measured, and specimens were collected for identification.

For sites with saplings (defined as plants to 2.7m tall, 0.3m girth (Whitmore, 1984)) in their understorey, an additional 20m x 20m plot was surveyed for each. This larger plot was considered essential in view of the more diverse species of understorey vegetation as evident by the presence of saplings of numerous tree species. The 20m x 20m plot was of similar location of the 5m x 5m plot, with the smaller plot contained within the larger one. Unlike the 5m x 5m plot, the 20m x 20m plot was not gridded as it was not meant to be comprehensive, its main purpose being to provide some idea of the variety of sapling species present within (qualitative rather than quantitative). Specimens of saplings were collected for identification, their heights and dbh noted.

5.2.2 Botanical survey: Natural forest

5.2.2.1 Natural logged-over regenerating Secondary Forest

It was clear from the outset that secondary forest was significantly more complex in terms both of the number of plant species and the structure of the plant community, so a different approach to floristic survey was required. Considering the radius of the light-trap

influence to be about 100m (see 2.1.2), a plot in the form of a strip of 100m x 5m (a width of 5m would enable the forest structure to be depicted by a profile diagram) was chosen in the logged-over Secondary Forest at Brumas, and located adjacent to the first regular light-trap spot.

The plot was divided into continous subplots of 5m x 5m, the amount of ground cover was mapped, and other procedures taken as in plantation survey.

5.2.2.2 Natural primary forest

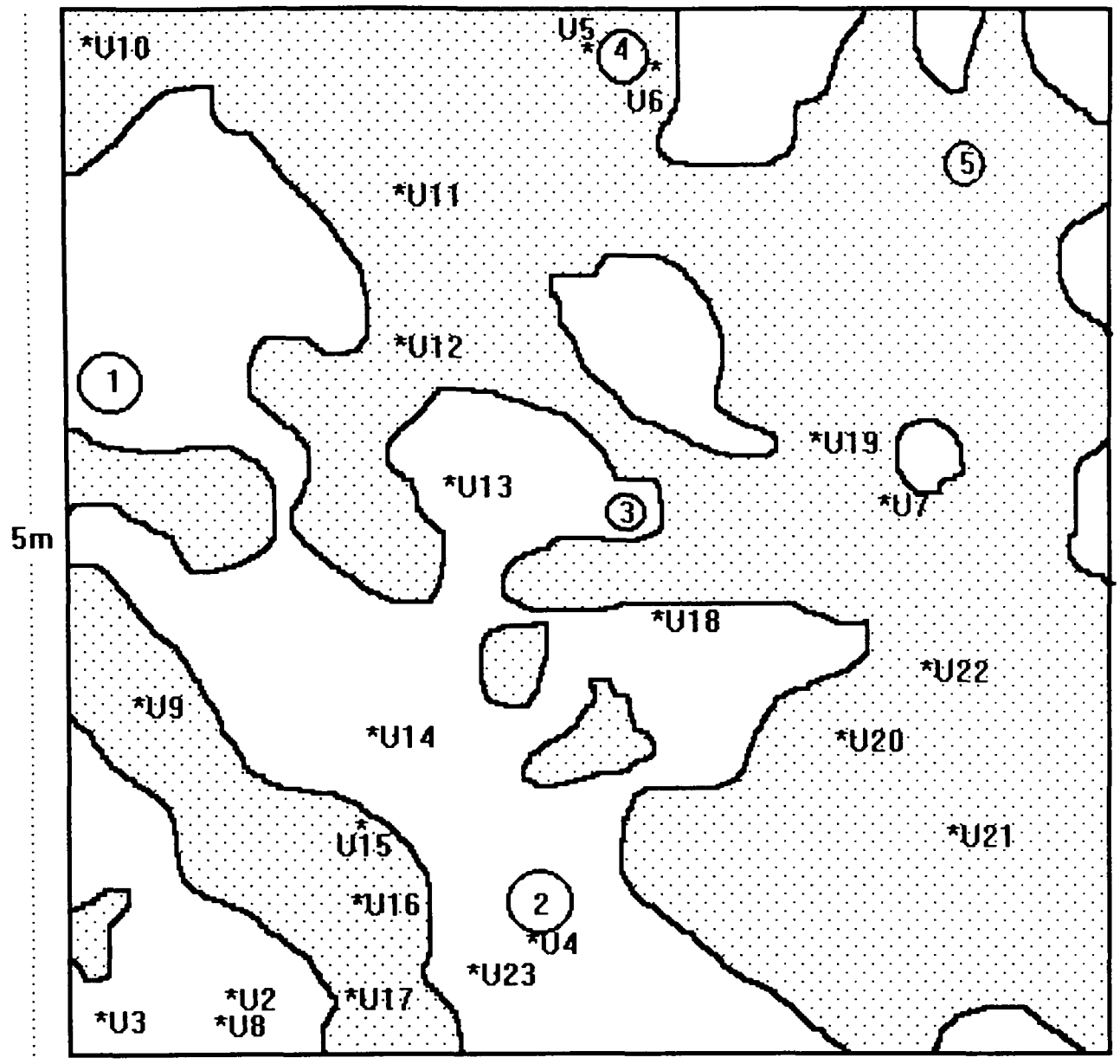
The botanical diversity of the primary lowland dipterocarp forest at Danum Valley has been well documented (Newbery *et al.*, 1992), but nonetheless a 100m x 5m plot similar to that of the secondary forest at Brumas was set up adjacent to the light-trap spot at Danum. This would enable more direct comparison.

5.2.3 Plant identifications

The collected specimens were identified at the Sepilok Herbarium in Sandakan, Sabah. The botanical names took on a more problematic colour when verifications were being made. Synonyms abound, and many names have since been made defunct. The tedious task was mitigated by a CD-ROM package 'Index Kewensis' (Oxford University Press 1993), available in the Oxford Forestry Institute. The names of most plants collected were checked using the Index.

5.3 Results & Discussion

The floristics of the moth-sampling sites in the various forest plantations, both disturbed secondary forest and undisturbed primary forest, are better presented in diagrams (Figs. 5.1-5.12), which are supplemented by the following descriptions.



L ..... 5m ..... R

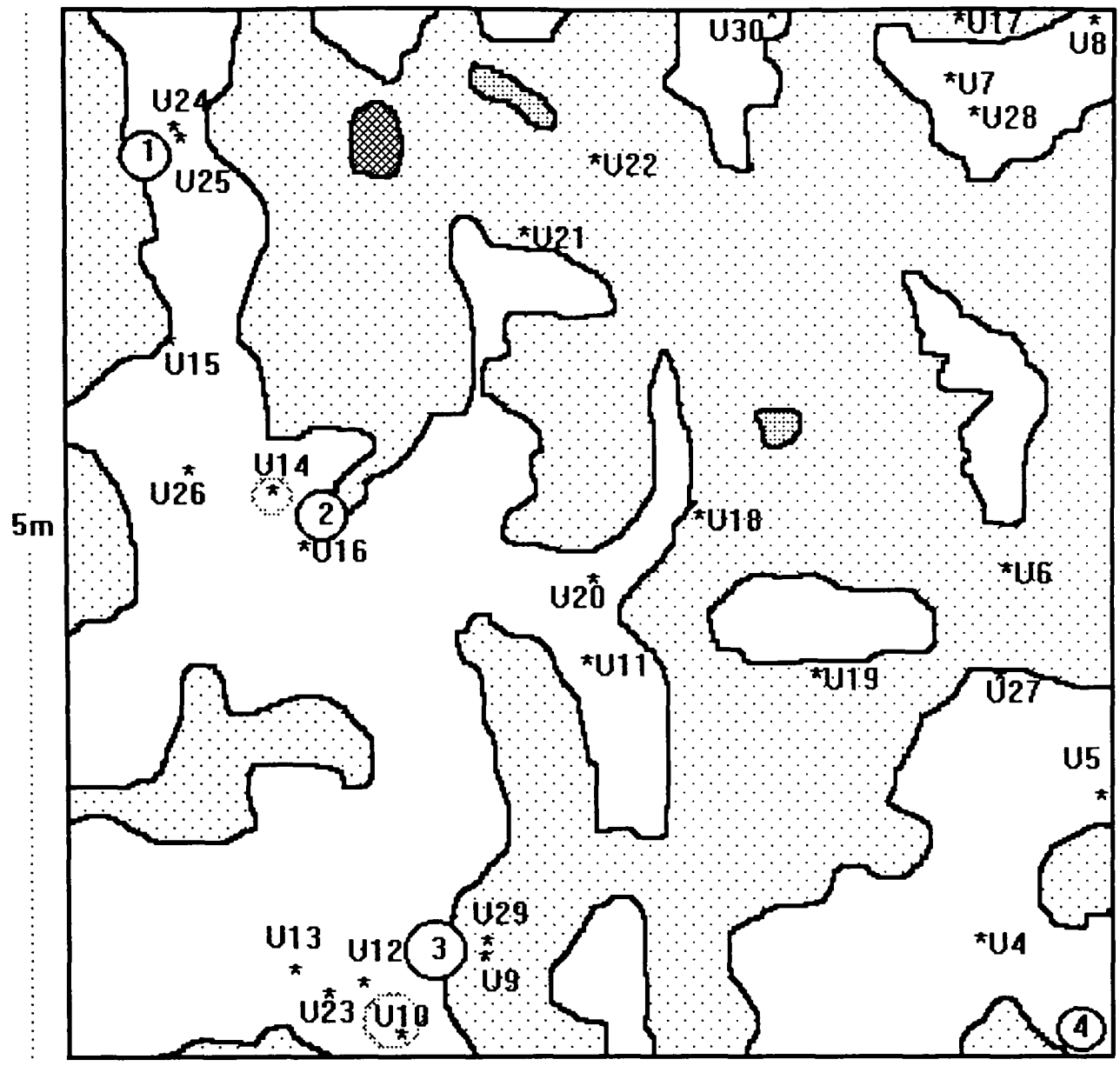
Nephrolepis biserrata

	No.	dbh (cm)
Acacia mangium (Stand height ca 30m)	1	15
	2	17
	3	7
	4	11
	5	9

Blank: Forest floor covered by dead leaves

U2 - U23 See Table 5.1

Fig. 5.1 *Acacia mangium* : Ground cover of understorey vegetation.
Year-long light-trap site, Brumas



Nephrolepis biserrata

Blechnum orientale

Paspalum conjugatum

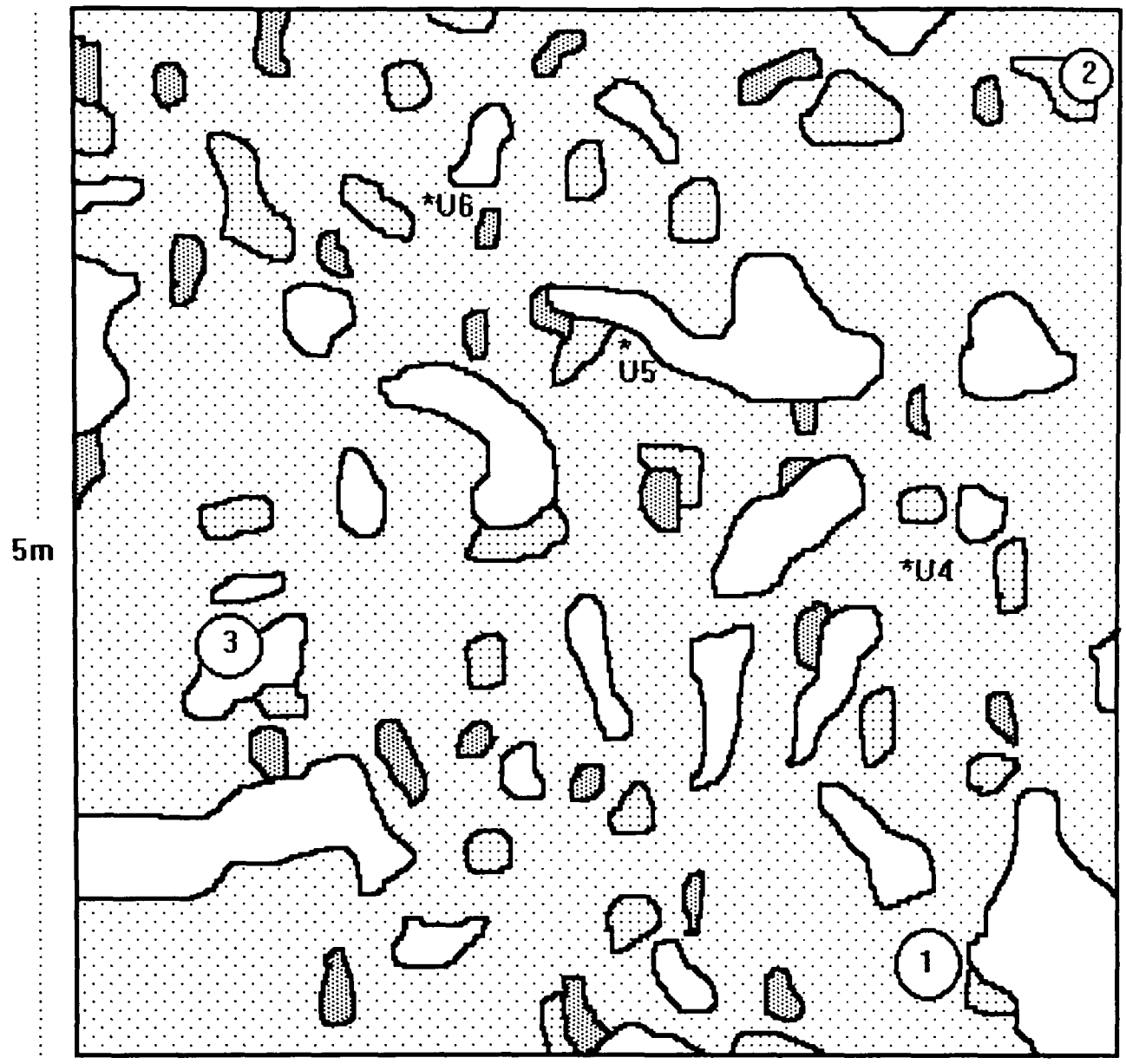
Eucalyptus deglupta (Stand height ca 25m)

No.	dbh (cm)
1	14
2	16
3	21
4	14

Blank: Forest floor covered by dead leaves

U4 - U30 See Table 5.2

Fig. 5.2 *Eucalyptus deglupta*: Ground cover of understorey vegetation. Year-long light-trap site, Brumas



Nephrolepis biserrata

Chromolaena odoratum

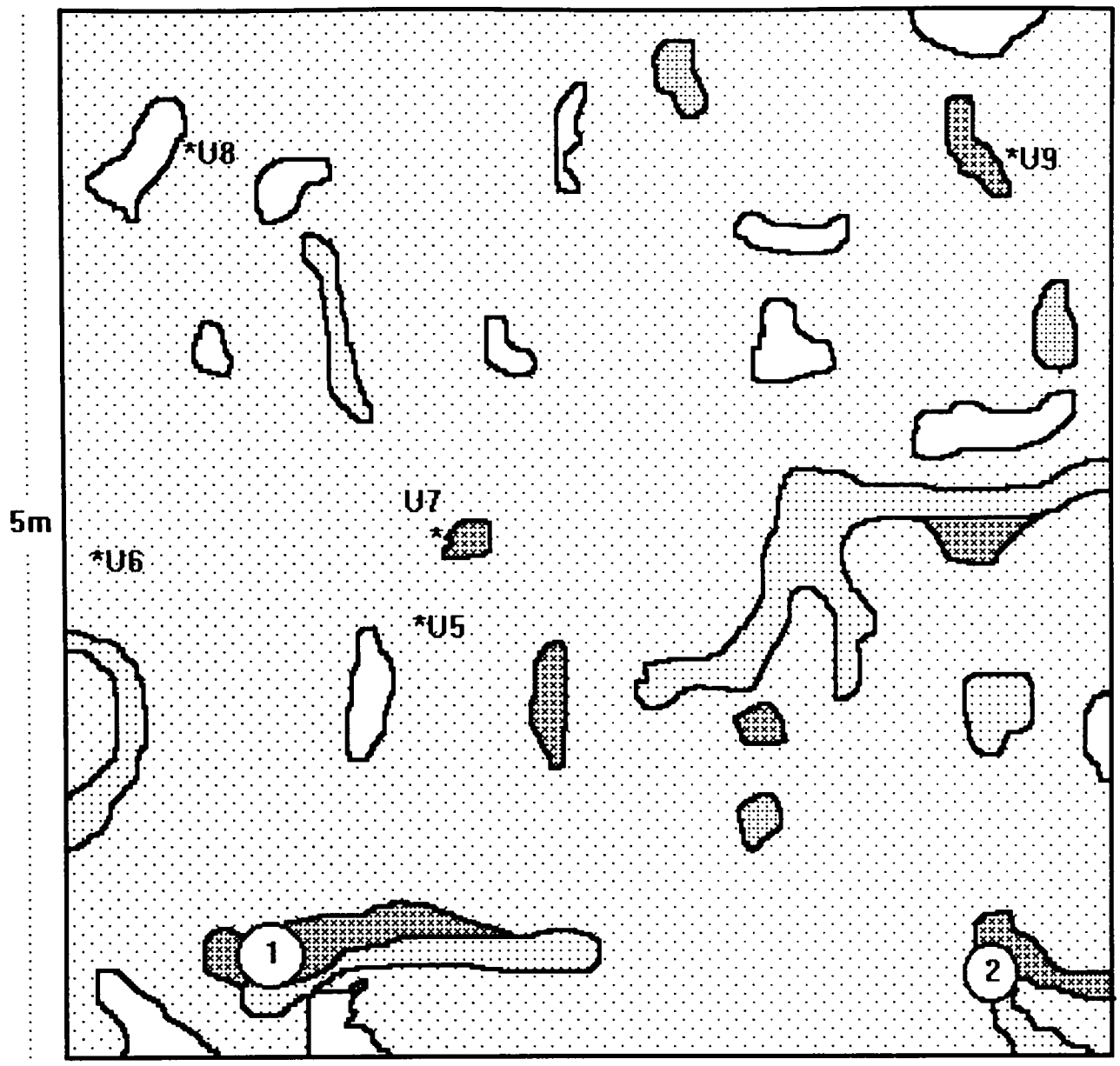
Fimbristylis dura

Gmelina arborea (Stand height ca 25m)	No.	dbh (cm)
	1	25
	2	18
	3	20

Blank: Forest floor covered by dead leaves

U4 -U6 See Table 5.3

Fig. 5.3 *Gmelina arborea* : Ground cover of understorey vegetation. Year-long light-trap site, Brumas



Nephrolepis biserrata

Chromolaena odoratum

Coscinium sp.

Paspalum conjugatum

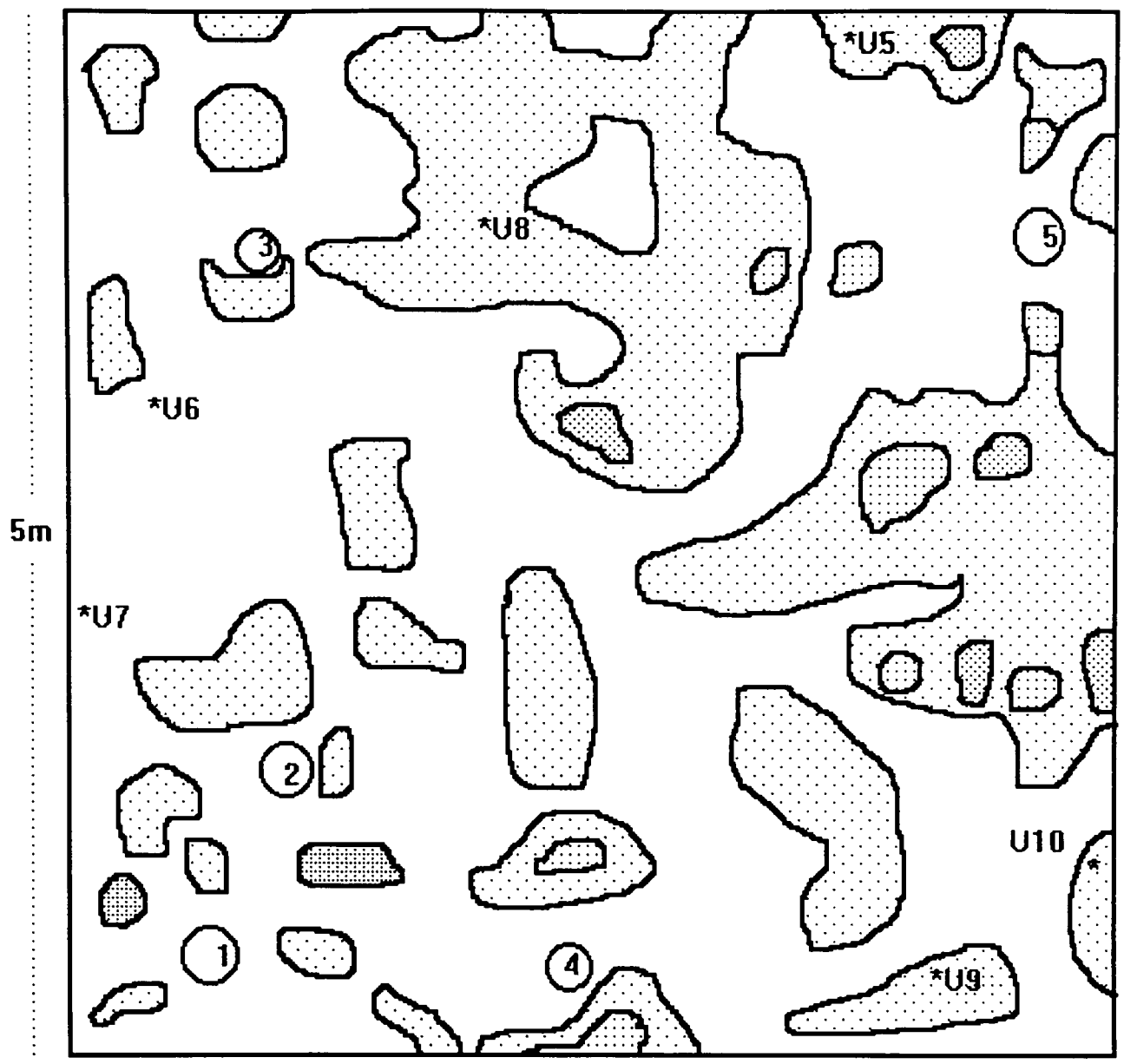
Paraserianthes falcataria (Stand height ca 30m)

No.	dbh (cm)
1	24
2	20

Blank: Uncovered forest floor

U5 - U9 See Table 5.4

Fig. 5.4 *Paraserianthes falcataria* : Ground cover of understorey vegetation. Year-long light-trap site, Brumas



L ..... 5m ..... R

Nephrolepis biserrata

Chromolaena odoratum

Mikania cordata

Paspalum conjugatum

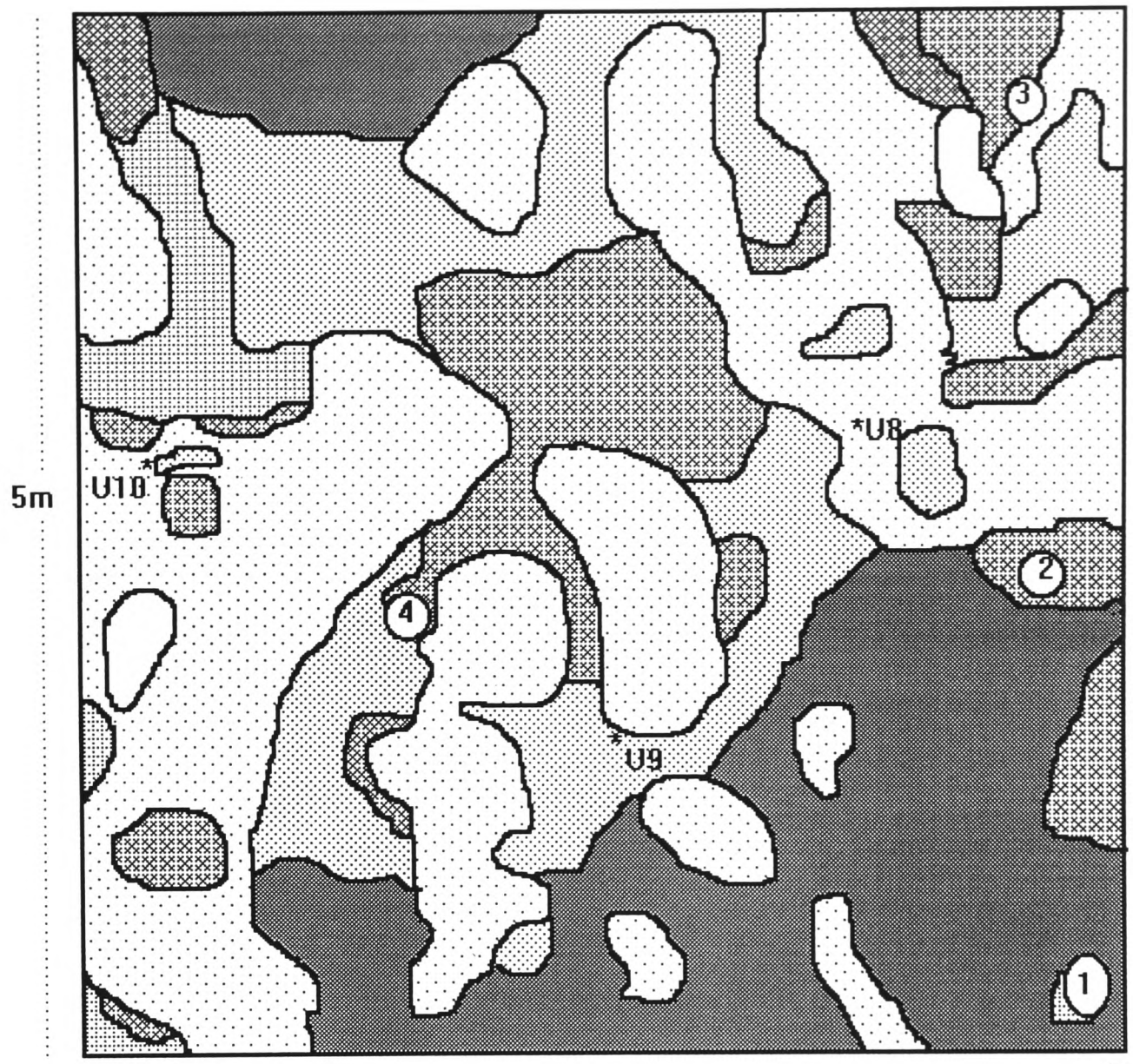
Pinus caribaea (Stand height ca 25m)

No.	dbh (cm)
1	24
2	22
3	19
4	19
5	20

Blank: Forest floor covered by dead leaf needles

U5 - U10 See Table 5.5

Fig. 5.5 *Pinus caribaea* : Ground cover of understorey vegetation. Year-long light-trap site, Brumas



L ..... 5m ..... R

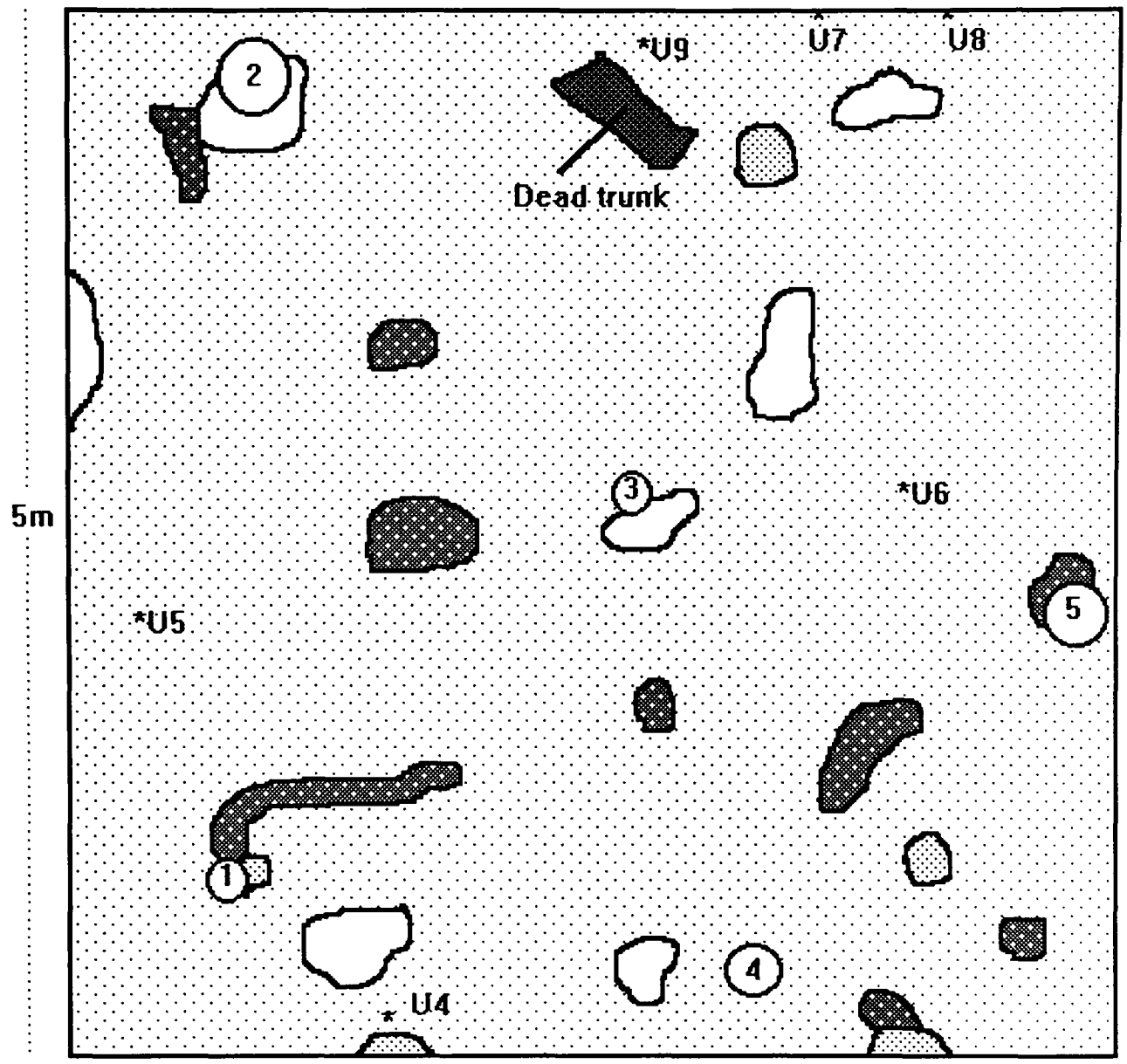
- *Nephrolepis biserrata*
- *Calopogonium mucunoides*
- *Bauhinia diptera*
- *Mikania cordata*
- *Passiflora foetida*
- *Piper* sp.
- *Paspalum conjugatum*
- *Acacia mangium* (Stand height ca 15m)

No.	dbh (cm)
1	18
2	13
3	11
4	6

- Blank: Forest floor covered by dead leaves

U8 - U10 See Table 5.6

Fig. 5.6 *Acacia mangium* : Ground cover of understorey vegetation. Transect plot, Brumas



L ..... 5m ..... R

Nephrolepis biserrata

Mikania cordata

Carex sp.

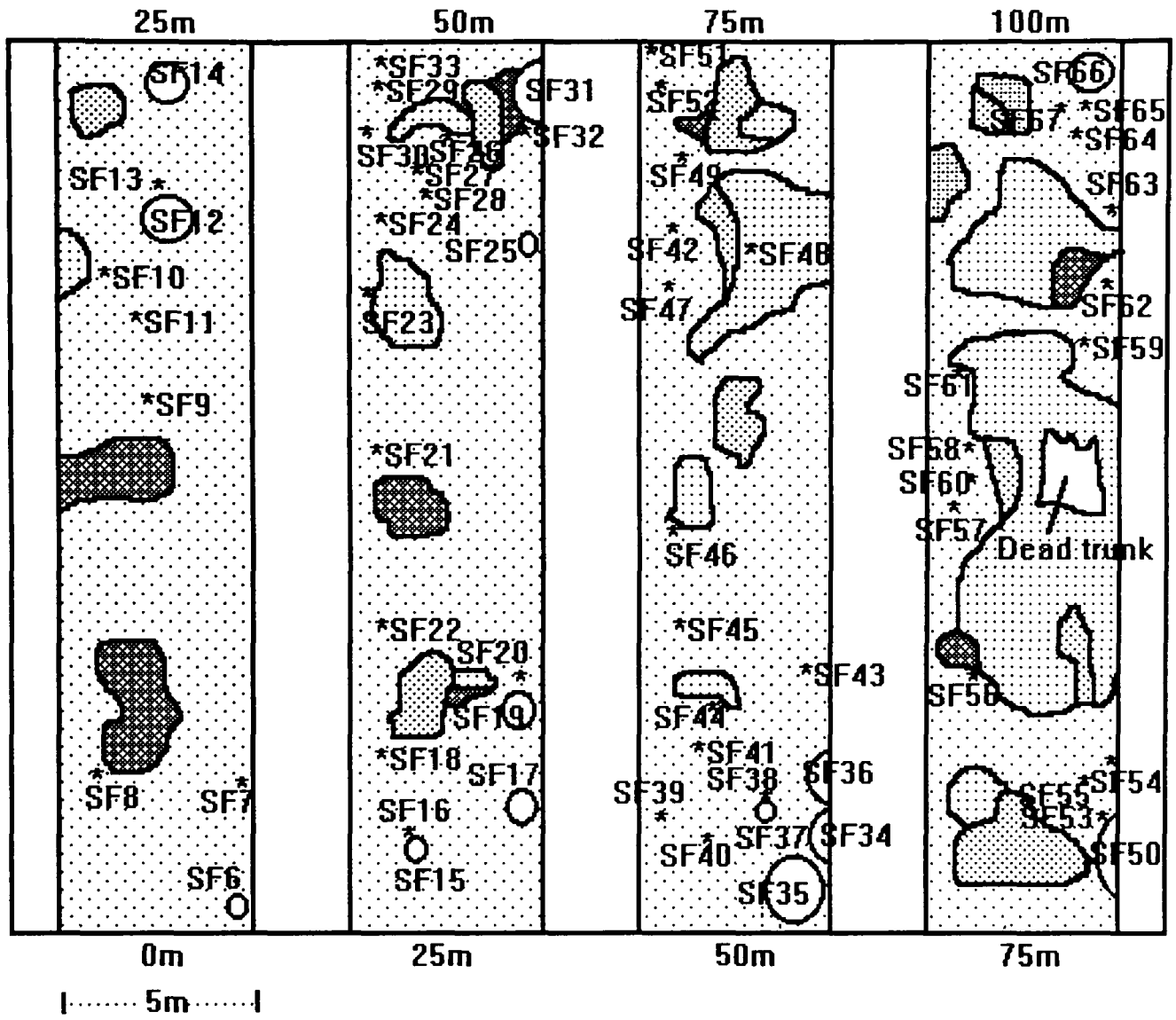
Gmelina arborea (Stand height ca 25m)

NO.	dbh (cm)
1	8
2	30
3	8
4	13
5	19

Blank: Forest floor covered by dead leaves

U4 - U9 See Table 5.7

Fig. 5.7 *Gmelina arborea* : Ground cover of understorey vegetation. Transect plot, Brumas



Nephrolepis biserrata

Merremia korthalsiana

Chromolaena odoratum

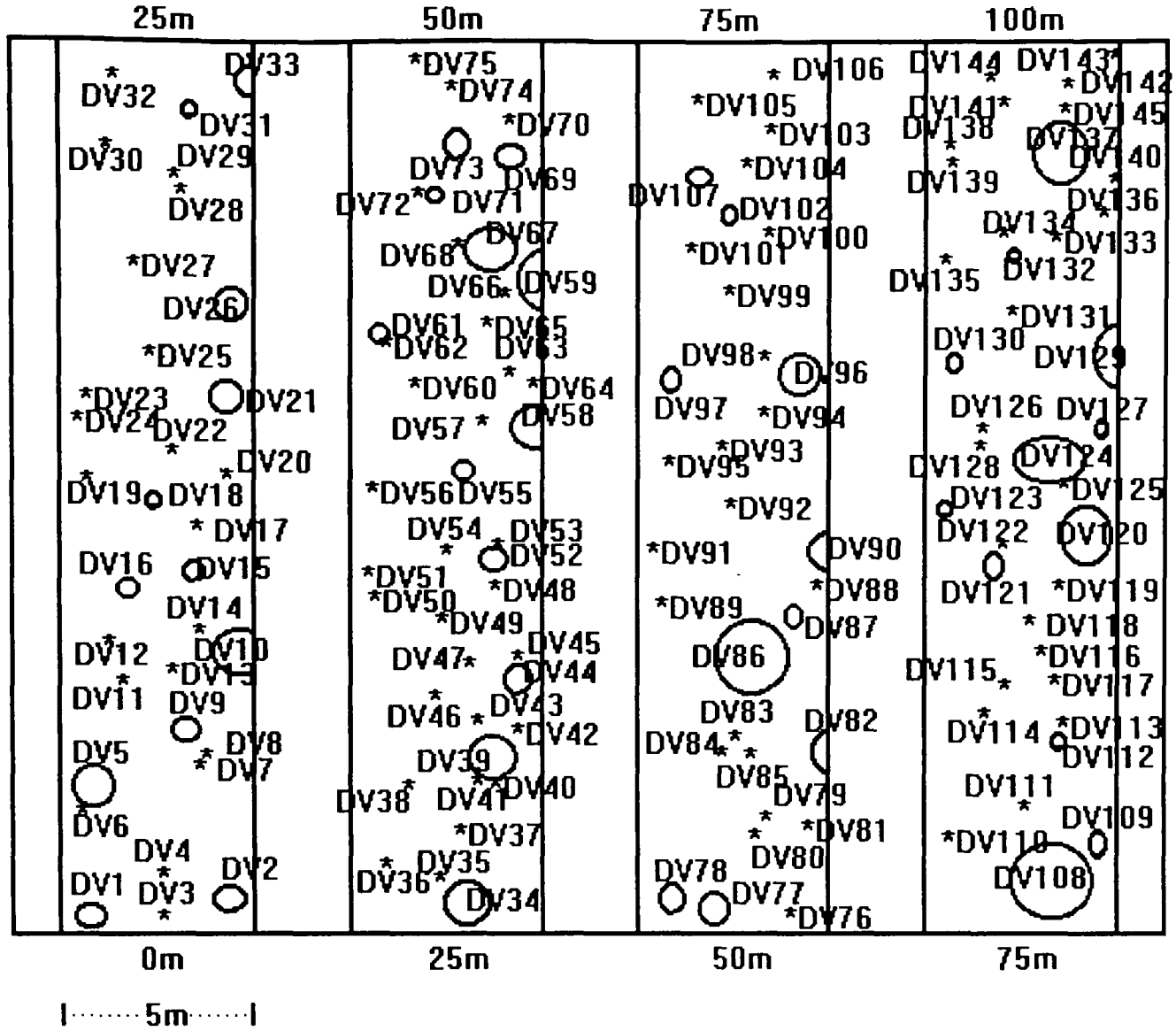
Mikania cordata

Paspalum conjugatum

Trees with dbh = or > 5cm

SF6 - SF67 See Table 5.8

Fig. 5.8 Secondary Forest : Ground cover of vegetation.
Plot 100m x 5m, Brumas



DV1 - DV145 See Table 5.9

Fig. 5.9 Primary forest : Ground cover of vegetation.
Plot 100m x 5m, Danum Valley

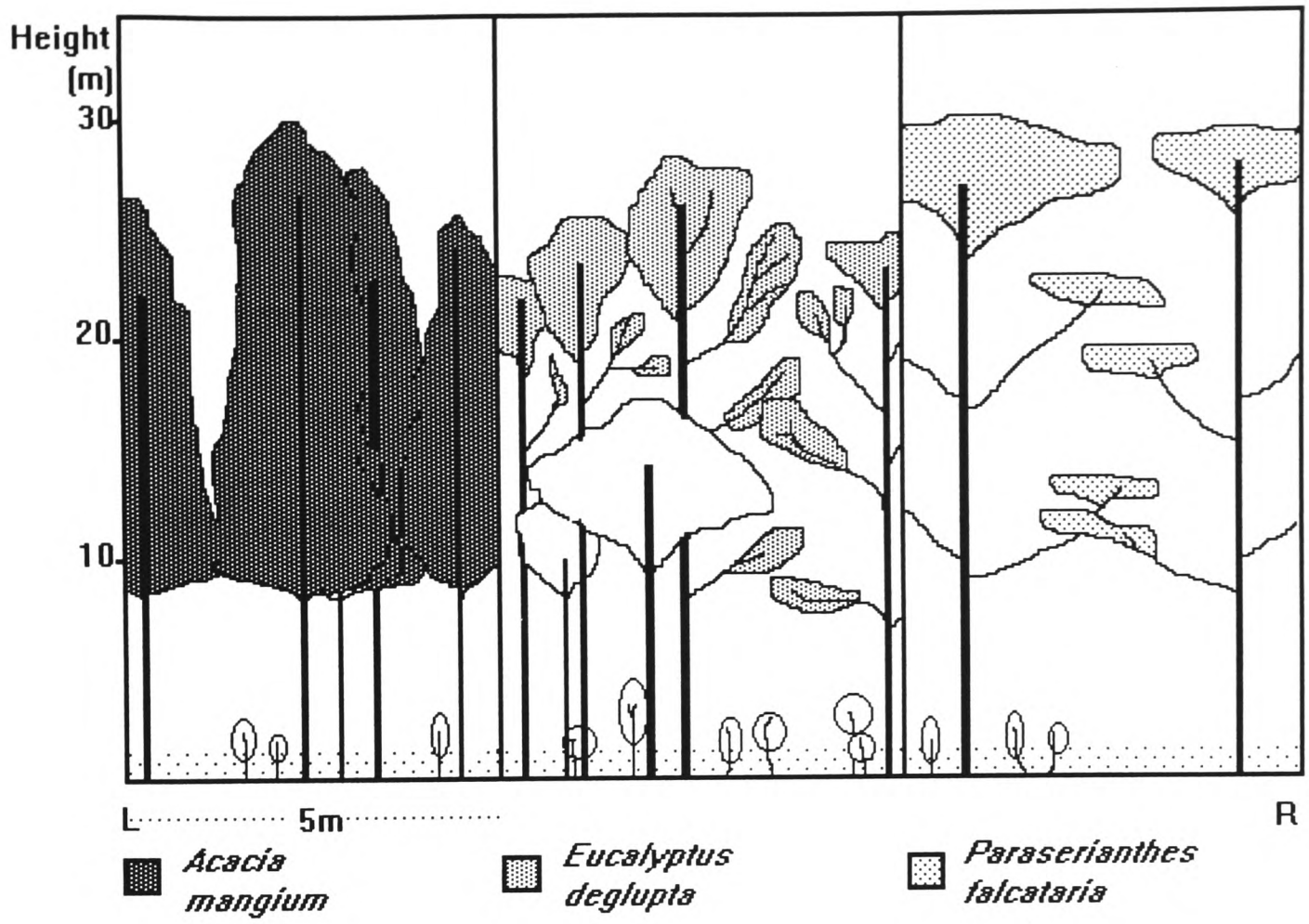


Fig. 5.10 Profile diagrams depicting forest plantation structures at moth-sampling sites, Brumas

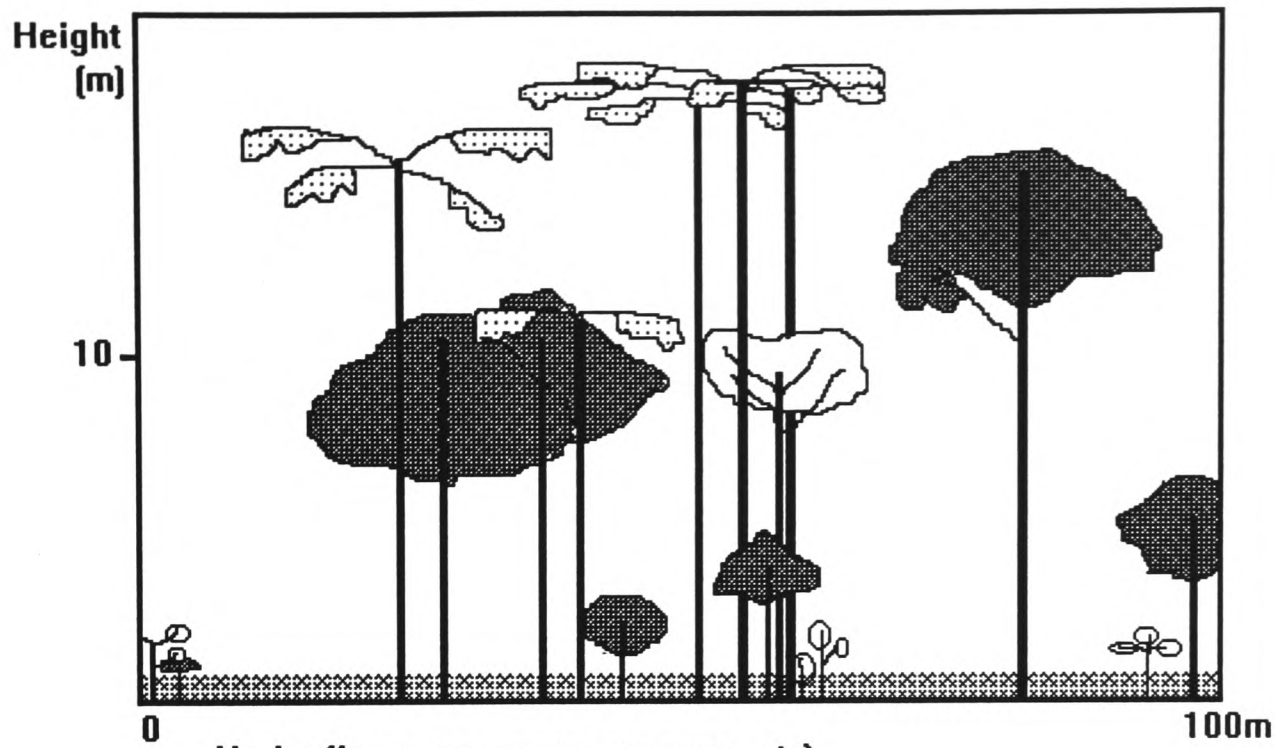


Fig. 5.11 Profile diagram depicting Secondary Forest structure at moth-sampling site, Brumas

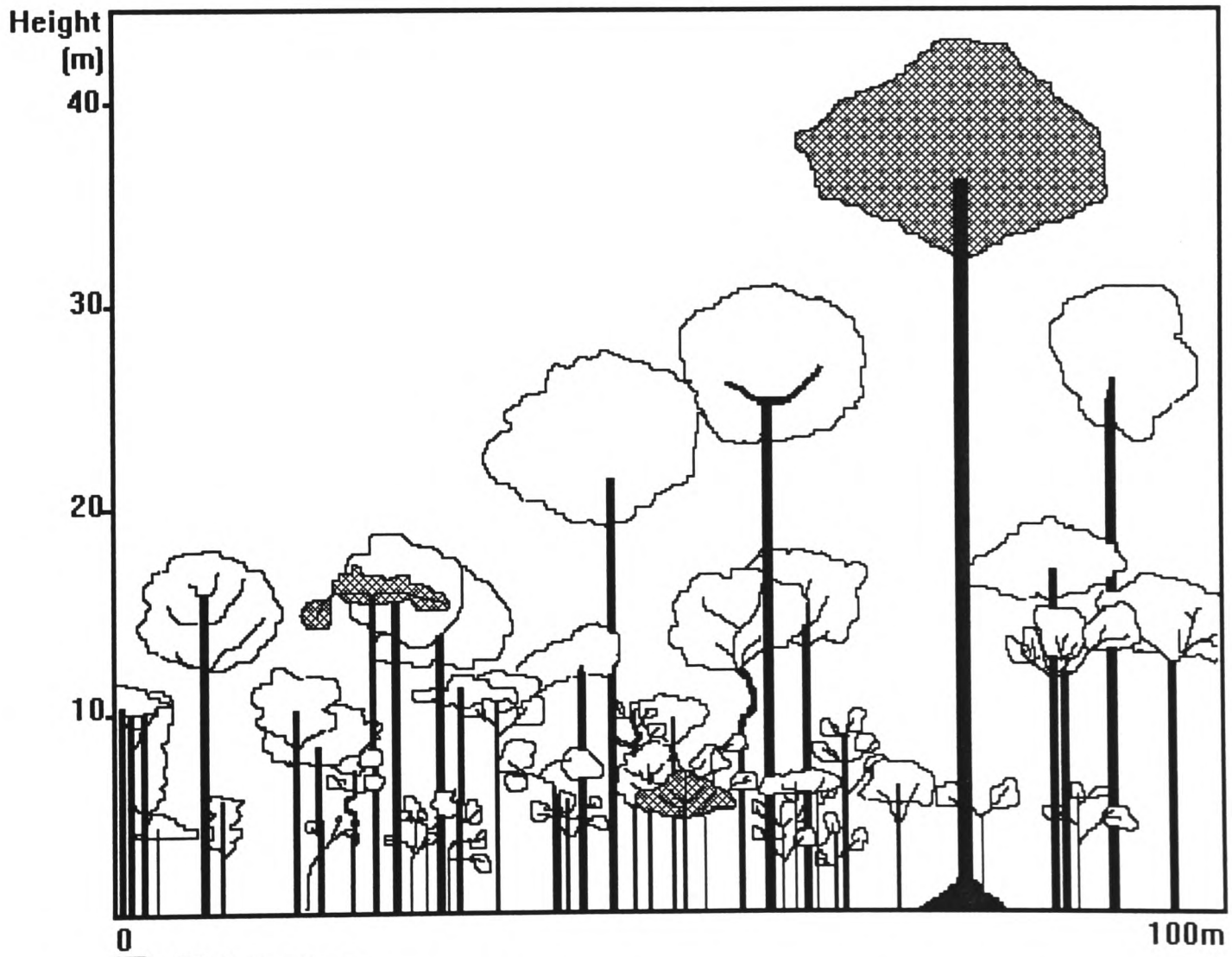


Fig. 5.12 Profile diagram of primary forest at moth-sampling site, Danum. Trees shown over 5m tall.

Table 5.1 Botanical survey :		*Acacia mangium*	
Forest plantation understorey vegetation, Brumas			
(1991 Year-long light-trap site. Plot sampled in front of light-trap site)			
5m x 5m plot - grids of 1m sq.*			
Date : 2 November 1992			
No.	Botanical name	Family	Remarks
U1	*Nephrolepis biserrata*	Davalliaceae	Fern - abundant ground cover
U2	*Momordica sp.*	Cucurbitaceae	Climbing herb
U3	*Ficus sp.*	Moraceae	
U4	*Momordica sp.*	Cucurbitaceae	Climbing herb
U5	*Clidemia hirta*	Melastomataceae	
U6	*Clidemia hirta*	Melastomataceae	
U7	*Clidemia hirta*	Melastomataceae	
U8	*Ficus midotis*	Moraceae	Ht < 1m
U9	Unidentified	Leguminosae	Ht < 2m
U10	*Mallotus miquelianus*	Euphorbiaceae	Ht < 1m
U11	*Glochidion calospermum*	Euphorbiaceae	Ht < 1m
U12	*Callicarpa longifolia*	Verbenaceae	Ht < 1m, straggling shrub
U13	*Dimocarpus sp.*	Sapindaceae	Ht 2m
U14	*Combretum sp.*	Combretaceae	Ht > 2m
U15	*Ficus sp. A*	Moraceae	Ht > 2m
U16	*Ficus sp. A*	Moraceae	Ht > 1m
U17	*Ficus sp.*	Moraceae	Ht < 1m
U18	*Mallotus miquelianus*	Euphorbiaceae	Ht < 1m
U19	*Ficus sp. A*	Moraceae	Ht < 2m
U20	*Ficus beccarii*	Moraceae	Ht < 1m
U21	*Callicarpa longifolia*	Verbenaceae	Ht < 1m, straggling shrub
U22	*Ficus sp. A*	Moraceae	Ht > 2m
U23	*Ficus megaleia*	Moraceae	Ht < 1m
	14 spp.		
*Refer to Figure 5.1			

Table 5.2 Botanical survey :		*Eucalyptus deglupta*	
Forest plantation understorey vegetation, Brumas			
(1991 Year-long light-trap site. Plot sampled in front of light-trap site)			
5m x 5m plot - grids of 1m sq.*			
Date : 6 November 1992			
No.	Botanical name	Family	Remarks
U1	*Nephrolepis biserrata*	Davalliaceae	Fern - abundant ground cover
U2	*Blechnum orientale*	Blechnaceae	Fern
U3	*Paspalum conjugatum*	Gramineae	
U4	Unidentified	Verbenaceae	
U5	*Spatholobus macropterus*	Leguminosae	
U6	*Glochidion rubrum*	Euphorbiaceae	Ht > 2m, dbh 1.5cm
U7	*Uncaria sp.*	Rubiaceae (Naucleaceae)	Ht 4m, dbh 3cm
U8	*Spatholobus macropterus*	Leguminosae	
U9	*Flacourtia rukam*	Flacourtiaceae	Ht 3m, dbh 1cm
U10	*Macaranga gigantifolia*	Euphorbiaceae	Ht 15m, dbh 21cm
U11	*Alseodaphne nigrescens*	Lauraceae	Ht > 2m, dbh 2cm
U12	*Nephelium ramboutan-ake*	Sapindaceae	Ht < 4m, dbh 3.5cm
U13	*Dimocarpus sp.*	Sapindaceae	Ht 3m, dbh 2cm
U14	*Ficus sp.*	Moraceae	Ht 12m, dbh 10cm
U15	*Mallotus miquelianus*	Euphorbiaceae	
U16	*Clerodendrum dispariifolium*	Verbenaceae	Ht < 2m, dbh 1cm
U17	*Clidemia hirta*	Melastomataceae	
U18	*Clidemia hirta*	Melastomataceae	
U19	*Clidemia hirta*	Melastomataceae	
U20	*Clidemia hirta*	Melastomataceae	
U21	*Clidemia hirta*	Melastomataceae	
U22	*Clidemia hirta*	Melastomataceae	
U23	*Phyllanthus sp.*	Euphorbiaceae	
U24	*Merremia gracilis*	Convolvulaceae	Climbing herb
U25	*Chromolaena odoratum*	Compositae	
U26	*Curculigo latifolia*	Liliaceae (Hypoxidaceae)	Monocot
U27	*Spatholobus macropterus*	Leguminosae	
U28	*Curculigo latifolia*	Liliaceae (Hypoxidaceae)	Monocot
U29	*Phyllanthus sp.*	Euphorbiaceae	
U30	*Spatholobus macropterus*	Leguminosae	
	20 spp.		
*Refer to Figure 5.2			

Table 5.3 Botanical survey :		*Gmelina arborea*	
Forest plantation understorey vegetation, Brumas			
(1991 Year-long light-trap site. Plot sampled in front of light-trap site)			
5m x 5m plot - grids of 1m sq.*			
Date : 4 November 1992			
No.	Botanical name	Family	Remarks
U1	*Nephrolepis biserrata*	Davalliaceae	Fern - most abundant ground cover
U2	*Chromolaena odoratum*	Compositae	
U3	*Fimbristylis dura*	Cyperaceae	Weed
U4	*Merremia gracilis*	Convolvulaceae	
U5	*Callicarpa longifolia*	Verbenaceae	Straggling shrub
U6	*Callicarpa longifolia*	Verbenaceae	Straggling shrub
	5 spp.		
*Refer to Figure 5.3			

Table 5.4 Botanical survey :		*Paraserianthes falcataria*	
Forest plantation understorey vegetation, Brumas			
(1991 Year-long light-trap site. Plot sampled in front of light-trap site)			
5m x 5m plot - grids of 1m sq.*			
Date : 5 November 1992			
No.	Botanical name	Family	Remarks
U1	*Nephrolepis biserrata*	Davalliaceae	Fern - abundant ground cover
U2	*Chromolaena odoratum*	Compositae	
U3	*Coscinium sp.*	Menispermaceae	Twining herb
U4	*Paspalum conjugatum*	Gramineae	
U5	*Ficus sp. A*	Moraceae	
U6	*Ficus sp. A*	Moraceae	
U7	*Ficus sp. A*	Moraceae	
U8	*Clidemia hirta*	Melastomataceae	
U9	*Callicarpa longifolia*	Verbenaceae	Straggling shrub
	7 spp.		
*Refer to Figure 5.4			

Table 5.5 Botanical survey :		*Pinus caribaea*	
Forest plantation understorey vegetation, Brumas			
(1991 Year-long light-trap site. Plot sampled in front of light-trap site)			
5m x 5m plot - grids of 1m sq.*			
Date : 1 November 1992			
No.	Botanical name	Family	Remarks
U1	*Nephrolepis biserrata*	Davalliaceae	Fern - rather abundant
U2	*Chromolaena odoratum*	Compositae	
U3	*Mikania cordata*	Compositae	Twining herb
U4	*Paspalum conjugatum*	Gramineae	
U5	*Clidemia hirta*	Melastomataceae	
U6	*Solanum sp.*	Solanaceae	
U7	*Leea indica*	Leeaceae	
U8	*Neonauclea cyrtopoda*	Rubiaceae	
U9	*Spatholobus macropterus*	Leguminosae	
U10	*Callicarpa longifolia*	Verbenaceae	Straggling shrub
	10 spp.		
*Refer to Figure 5.5			

Table 5.6 Botanical survey :	*Acacia mangium*		
Forest plantation understorey vegetation, Brumas			
(Plantation chosen for transect to adjacent secondary forest. Plot sampled in plantation near site T2)			
5m x 5m plot - grids of 1m sq.*			
Date : 7 November 1992			
No.	Botanical name	Family	Remarks
U1	*Nephrolepis biserrata*	Davalliaceae	Fern - ground cover
U2	*Calopogonium mucunoides*	Leguminosae	Climbing herb - ground cover
U3	*Bauhinia diptera*	Leguminosae	Climber
U4	*Mikania cordata*	Compositae	Twining herb
U5	*Passiflora foetida*	Passifloraceae	Climbing herb
U6	*Piper sp.*	Piperaceae	Climbing shrub
U7	*Paspalum conjugatum*	Gramineae	
U8	*Chromolaena odoratum*	Compositae	
U9	*Chromolaena odoratum*	Compositae	
U10	*Chromolaena odoratum*	Compositae	
	8 spp.		
*Refer to Figure 5.6			

Table 5.7 Botanical survey :	*Gmelina arborea*		
Forest plantation understorey vegetation, Brumas			
(Plantation chosen for transect to adjacent secondary forest. Plot sampled in plantation near site T2)			
5m x 5m plot - grids of 1m sq.*			
Date : 4 February 1993			
No.	Botanical name	Family	Remarks
U1	*Nephrolepis biserrata*	Davalliaceae	Fern - most abundant ground cover
U2	*Mikania cordata*	Compositae	Twining herb
U3	*Carex sp.*	Cyperaceae	
U4	*Alstonia spatulata*	Apocynaceae	
U5	*Alstonia spatulata*	Apocynaceae	
U6	*Clidemia hirta*	Melastomataceae	
U7	*Aglaia cordata*	Meliaceae	
U8	*Callicarpa longifolia*	Verbenaceae	Straggling shrub
U9	*Clidemia hirta*	Melastomataceae	
	7 spp.		
*Refer to Figure 5.7			

Table 5.8 Botanical survey :		Secondary Forest , Brumas	
(Plot near first 1991 light-trap site)			
100m x 5m plot - grids of 25m sq.*			
Date : 3 February 1993			
No.	Botanical name	Family	Remarks
SF1	*Nephrolepis biserrata*	Davalliaceae	Fern - abundant ground cover
SF2	*Merremia korthalsiana*	Convolvulaceae	Climber, ground cover
SF3	*Chromolaena odoratum*	Compositae	Ground cover
SF4	*Mikania cordata*	Compositae	Ground cover
SF5	*Paspalum conjugatum*	Gramineae	Ground cover
SF6	*Nauclea subdita*	Rubiaceae	Ht 4m, dbh 5cm
SF7	*Macaranga pruinosa*	Euphorbiaceae	Ht 3m, dbh 3cm
SF8	*Nauclea subdita*	Rubiaceae	Ht < 1m
SF9	*Leea aculeata*	Leeaceae	Ht < 2m, dbh 2cm
SF10	*Caesalpinia latisiliqua*	Leguminosae	Climber
SF11	*Leea aculeata*	Leeaceae	Ht < 2m, dbh 1.5cm
SF12	*Anthocephalus chinensis*	Rubiaceae	"Laran", ht 15m, dbh 17cm
SF13	*Poikilospermum tangaum*	Cecropiaceae (Urticaceae)	Climber
SF14	*Macaranga hypoleuca*	Euphorbiaceae	Ht 12m, dbh 12cm
SF15	*Trema orientalis*	Ulmaceae	Ht 2m, dbh 7cm
SF16	*Lygodium circinnatum*	Schizaeaceae	Climbing fern
SF17	*Macaranga hypoleuca*	Euphorbiaceae	Ht < 15m, dbh 12cm
SF18	*Leea aculeata*	Leeaceae	Ht 2m, dbh 4cm
SF19	*Anthocephalus chinensis*	Rubiaceae	"Laran", ht 12m, dbh 14cm
SF20	*Caesalpinia latisiliqua*	Leguminosae	Climber
SF21	*Flacourtia sp.*	Flacourtiaceae	Ht < 1m
SF22	*Clidemia hirta*	Melastomataceae	
SF23	*Clidemia hirta*	Melastomataceae	
SF24	*Cyperus sp.*	Cyperaceae	
SF25	*Macaranga gigantifolia*	Euphorbiaceae	Ht 3m, dbh 5cm
SF26	*Nauclea subdita*	Rubiaceae	Ht < 3m, dbh 3cm
SF27	*Caesalpinia latisiliqua*	Leguminosae	Climber
SF28	*Clidemia hirta*	Melastomataceae	
SF29	Unidentified	Polypodiaceae	
SF30	*Costus speciosus*	Zingiberaceae	
SF31	*Anthocephalus chinensis*	Rubiaceae	"Laran", ht 18m, dbh 20cm
SF32	*Caesalpinia latisiliqua*	Leguminosae	Climber
SF33	*Sphaerostephanos heterocarpus*	Thelypteridaceae	Fern
SF34	*Duabanga moluccana*	Sonneratiaceae	Ht 12m, dbh 12cm
SF35	*Anthocephalus chinensis*	Rubiaceae	"Laran", ht 18m, dbh 24cm
SF36	*Anthocephalus chinensis*	Rubiaceae	"Laran", ht 18m, dbh 22cm
SF37	*Macaranga gigantifolia*	Euphorbiaceae	Ht < 5m, dbh 5cm
SF38	*Smilax leucophylla*	Smilacaceae (Liliaceae)	Climber
SF39	*Vigna sinensis*	Leguminosae	
SF40	*Leea aculeata*	Leeaceae	Ht 1m
SF41	*Nauclea subdita*	Rubiaceae	Ht > 2m, dbh 3cm
SF42	*Carex sp.*	Cyperaceae	
SF43	*Leea aculeata*	Leeaceae	Ht 4m, dbh 4cm
SF44	*Benincasa sp.*	Cucurbitaceae	Climber
SF45	*Caesalpinia latisiliqua*	Leguminosae	Climber
SF46	*Uncaria cordata*	Rubiaceae	Climber
SF47	*Tetrastigma sp.*	Vitaceae	Climber
SF48	*Poikilospermum tangaum*	Cecropiaceae (Urticaceae)	Climber
SF49	*Benincasa sp.*	Cucurbitaceae	Climber
SF50	*Macaranga hypoleuca*	Euphorbiaceae	Ht 15m, dbh 26cm
SF51	*Tetrastigma sp.*	Vitaceae	Climber
SF52	*Cayratia geniculata*	Vitaceae	Climber
SF53	*Poikilospermum sp.*	Cecropiaceae (Urticaceae)	Climber
SF54	*Archidendron ellipticum*	Leguminosae	Climber
SF55	*Caesalpinia latisiliqua*	Leguminosae	Climber
SF56	*Cyperus sp.*	Cyperaceae	

No.	Botanical name	Family	Remarks
SF57	*Mimosa pudica*	Leguminosae	
SF58	*Benincasa sp.*	Cucurbitaceae	Climber
SF59	*Passiflora foetida*	Passifloraceae	
SF60	*Cyperus sp.*	Cyperaceae	
SF61	*Hyptis capitata*	Labiatae	
SF62	*Leea aculeata*	Leeaceae	Ht 2m, dbh 3cm
SF63	*Costus speciosus*	Zingiberaceae	
SF64	*Saurauia sp.*	Actinidiaceae	Ht 2m, dbh 1cm
SF65	*Leea aculeata*	Leeaceae	Ht 3m, dbh 3cm
SF66	*Macaranga hypoleuca*	Euphorbiaceae	Ht 6m, dbh 14cm
SF67	*Saurauia sp.*	Actinidiaceae	
	35 spp.		
*Refer to Figure 5.8			

Table 5.9 Botanical survey :		Primary forest, Danum Valley	
(Plot near light-trap site)			
100m x 5m plot - grids of 25m sq.*			
Date : 27 January 1993			
No.	Botanical name	Family	Remarks
DV1	*Archidendron microcarpum*	Leguminosae	Ht 12m, dbh 11cm
DV2	*Prunus arborea*	Rosaceae	Ht 12m, dbh 14cm
DV3	*Alpinia sp.*	Zingiberaceae	
DV4	*Baccaurea stipulata*	Euphorbiaceae	
DV5	*Aglaia leptantha*	Meliaceae	Ht 12m, dbh 22cm
DV6	*Litsea sp.*	Lauraceae	
DV7	*Aglaia cumingiana*	Meliaceae	Ht 6m, dbh 4cm
DV8	*Asplenium phyllitidis*	Aspleniaceae	Epiphyte
DV9	*Urophyllum griffithianum*	Rubiaceae	Ht 3m, dbh 10cm
DV10	*Knema cinerea*	Myristicaceae	Ht 18m, dbh 26cm
DV11	*Parashorea tomentella*	Dipterocarpaceae	Ht 1m
DV12	*Brownlowia peltata*	Tiliaceae	Ht > 2m, dbh 2cm
DV13	*Costus sp.*	Zingiberaceae	
DV14	*Engelhardtia serrata*	Juglandaceae	
DV15	*Urophyllum glabrum*	Rubiaceae	Ht 6m, dbh 7cm
DV16	*Diospyros sp.*	Ebenaceae	Ht < 5m, dbh 7cm
DV17	*Shorea agami*	Dipterocarpaceae	Ht > 2m, dbh 2cm
DV18	*Ryparosa hullettii*	Flacourtiaceae	Ht 4m, dbh 5cm
DV19	*Dillenia excelsa*	Dilleniaceae	Ht < 2m, dbh 1cm
DV20	*Lepisanthes multijuga*	Sapindaceae	Ht < 1m
DV21	*Archidendron microcarpum*	Leguminosae	Ht 12m, dbh 17cm
DV22	*Goniothalamus parallelovenius*	Annonaceae	Ht > 2m, dbh 1cm
DV23	*Leea indica*	Leeaceae	Ht 5m, dbh 3cm
DV24	*Strychnos ignatii*	Strychnaceae	Climber
DV25	*Parashorea tomentella*	Dipterocarpaceae	Ht 4m, dbh 4cm
DV26	*Enicosanthum erianthoides*	Annonaceae	Ht 12m, dbh 16cm
DV27	*Fagraea racemosa*	Loganiaceae	Ht 4m, dbh 2cm
DV28	*Parashorea tomentella*	Dipterocarpaceae	Ht < 2m, dbh 0.5cm
DV29	*Spatholobus viridis*	Leguminosae	Climber
DV30	*Dillenia excelsa*	Dilleniaceae	Ht 1m
DV31	*Ryparosa hullettii*	Flacourtiaceae	Ht 7m, dbh 5cm
DV32	*Zizyphus angustifolia*	Rhamnaceae	
DV33	*Shorea symingtonii*	Dipterocarpaceae	Ht 15m, dbh 12cm
DV34	*Canarium denticulatum*	Burseraceae	Ht 18m, dbh 26cm
DV35	*Litsea oppositifolia*	Lauraceae	Ht 3m, dbh 3cm
DV36	*Aglaia denticulata*	Meliaceae	Ht 5m, dbh 4cm
DV37	*Dillenia excelsa*	Dilleniaceae	Ht 1m
DV38	*Mallotus oblongifolius*	Euphorbiaceae	Ht > 5m, dbh 4cm
DV39	*Diospyros sp.*	Ebenaceae	Ht 18m, dbh 26cm
DV40	*?Lucinaea sp.*	Rubiaceae	Climber

No.	Botanical name	Family	Remarks
DV41	Unidentified	Cucurbitaceae	Climber
DV42	*Eugenia fastigiata*	Myrtaceae	Ht 6m, dbh 4cm
DV43	*Lepisanthes multijuga*	Sapindaceae	
DV44	*Aglaia odoratissima*	Meliaceae	Ht 13m, dbh 12cm
DV45	*Combretum sp.*	Combretaceae	Climber
DV46	*Meliosma sumatrana*	Sabiaceae	Ht 4m, dbh 3cm
DV47	*Aglaia palembanica*	Meliaceae	Ht 3m, dbh 2cm
DV48	*Dillenia excelsa*	Dilleniaceae	Ht < 2m, dbh 2cm
DV49	*Dracaena sp.*	Agavaceae	
DV50	Unidentified	Leguminosae	Ht 3m, dbh 4cm
DV51	*Archidendron microcarpum*	Leguminosae	
DV52	*Blumeodendron tokbrai*	Euphorbiaceae	Ht 12m, dbh 10cm
DV53	Unidentified	Unidentified	Mosses on DV52
DV54	*Polyalthia sp.*	Annonaceae	Ht 1m
DV55	*Lasianthus sp.*	Rubiaceae	Ht 4m, dbh 6cm
DV56	*Meliosma sp.*	Sabiaceae	Ht > 2m, dbh 2cm
DV57	*Parashorea tomentella*	Dipterocarpaceae	Ht < 2m, dbh 1cm
DV58	*Aporusa sp.*	Euphorbiaceae	Ht < 10m, dbh 24cm
DV59	*Dimorphocalyx muricatus*	Euphorbiaceae	Ht 14m, dbh 30 cm. Dying.
DV60	*Popowia pisocarpa*	Annonaceae	Ht 3m, dbh 3cm
DV61	*Urophyllum griffithianum*	Rubiaceae	Ht 6m, dbh 7cm
DV62	*Ficus sp.*	Moraceae	On DV61
DV63	*Leptaspis urceolata*	Gramineae	
DV64	*Costus sp.*	Zingiberaceae	
DV65	*Eugenia chrysantha*	Myrtaceae	Ht < 3m, dbh 2cm
DV66	*Xanthophyllum cordatum*	Xanthophyllaceae (Polygalaceae)	Ht > 2m, dbh 1cm
DV67	*Dillenia excelsa*	Dilleniaceae	Ht 25m, dbh 24cm
DV68	*Spatholobus viridis*	Leguminosae	Climber
DV69	*Aglaia affinis*	Meliaceae	Ht 12m, dbh 9cm
DV70	*Mallotus moritzianus*	Euphorbiaceae	Ht < 3m, dbh 2cm
DV71	*Antidesma neurocarpum*	Euphorbiaceae	Ht 3m, dbh 7cm
DV72	*Spatholobus viridis*	Leguminosae	Climber
DV73	*Ixora sp.*	Rubiaceae	Ht 9m, dbh 10cm
DV74	*Hypolytrum nemorum*	Cyperaceae	
DV75	*Lygodium circinnatum*	Schizaeaceae	Fern
DV76	*Vernonia arborea*	Compositae	Ht 4m, dbh 4cm
DV77	*Dillenia excelsa*	Dilleniaceae	Ht 12m, dbh 10cm
DV78	*Parashorea tomentella*	Dipterocarpaceae	Ht 6m, dbh 7cm
DV79	*Archidendron sp.*	Leguminosae	Ht 9m, dbh 4cm
DV80	*Xanthophyllum cordatum*	Xanthophyllaceae (Polygalaceae)	
DV81	*Zizyphus angustifolia*	Rhamnaceae	
DV82	*Diospyros elliptifolia*	Ebenaceae	Ht 18m, dbh 16cm
DV83	*Saurauia sp.*	Actinidiaceae	Ht 4m, dbh 3cm
DV84	*Spatholobus viridis*	Leguminosae	Climber
DV85	*Spatholobus viridis*	Leguminosae	Climber
DV86	*Nothaphoebe macrophylla*	Lauraceae	Ht > 30m, dbh 49cm
DV87	*Urophyllum griffithianum*	Rubiaceae	Ht 5m, dbh 5cm
DV88	*Buchanania sessilifolia*	Anacardiaceae	Ht < 2m, dbh 3cm
DV89	*Aglaia sp.*	Meliaceae	Ht > 5m, dbh 3cm
DV90	*Canarium denticulatum*	Burseraceae	Ht 18m, dbh 23cm
DV91	*Eugenia fastigiata*	Myrtaceae	Ht 6m, dbh 5cm
DV92	*Urophyllum griffithianum*	Rubiaceae	Ht 3m, dbh 2cm
DV93	*Canarium denticulatum*	Burseraceae	Ht < 2m, dbh 2cm
DV94	*Parashorea tomentella*	Dipterocarpaceae	Ht 1m
DV95	*Spatholobus viridis*	Leguminosae	Climber
DV96	*Baccaurea stipulata*	Euphorbiaceae	Ht 11m, dbh 12cm
DV97	*Aglaia elliptica*	Meliaceae	Ht > 5m, dbh 7cm
DV98	*Popowia pisocarpa*	Annonaceae	Ht < 3m, dbh 3cm
DV99	*Aporusa frutescens*	Euphorbiaceae	Ht 4m, dbh 2cm
DV100	*Mallotus moritzianus*	Euphorbiaceae	Ht < 3m, dbh 2cm
DV101	*Urophyllum griffithianum*	Rubiaceae	Ht 1m
DV102	*Aglaia cumingiana*	Meliaceae	Ht 4m, dbh 5cm
DV103	*Mallotus moritzianus*	Euphorbiaceae	Ht < 3m, dbh 2cm

No.	Botanical name	Family	Remarks
DV104	*Agelaea borneensis*	Connaraceae	Climber
DV105	*Diospyros elliptifolia*	Ebenaceae	Ht < 3m, dbh 2cm
DV106	*Xanthophyllum affine*	Xanthophyllaceae (Polygalaceae)	Ht 4m, dbh 3cm
DV107	*Luvunga sarmentosa*	Rutaceae	Ht 6m, dbh 7cm
DV108	*Parashorea malaanonan*	Dipterocarpaceae	Ht > 45m, dbh 97cm
DV109	*Urophyllum griffithianum*	Rubiaceae	Ht 5m, dbh 8cm
DV110	*Lepisanthes multijuga*	Sapindaceae	Ht < 3m, dbh 4cm
DV111	*Dillenia excelsa*	Dilleniaceae	Ht < 2m, dbh 1cm
DV112	*Lasianthus sp.*	Rubiaceae	Ht 4m, dbh 5cm
DV113	*Spatholobus viridis*	Leguminosae	Climber
DV114	*Popowia pisocarpa*	Annonaceae	Ht < 1m
DV115	*Luvunga sarmentosa*	Rutaceae	Ht > 2m
DV116	*Luvunga sarmentosa*	Rutaceae	Ht 2m, dbh 1cm
DV117	*Strychnos ignatii*	Strychnaceae	Climber
DV118	*Buchanania sessilifolia*	Anacardiaceae	Ht > 2m, dbh 2cm
DV119	*Ryparosa hullettii*	Flacourtiaceae	Ht 4m, dbh 3cm
DV120	*Dysoxylum undulatum*	Meliaceae	Ht > 20m, dbh 22cm
DV121	*Urophyllum griffithianum*	Rubiaceae	Ht > 3m, dbh 7cm
DV122	*Selaginella conferta*	Selaginellaceae	
DV123	*Parashorea malaanonan*	Dipterocarpaceae	Ht 4m, dbh 5cm
DV124	*Eugenia sandakanensis*	Myrtaceae	Ht 15m, dbh 25cm
DV125	*Piper sp.*	Piperaceae	Climber
DV126	*Xerospermum sp.*	Sapindaceae	Ht > 2m, dbh 2cm
DV127	*Chionanthus pachyphyllus*	Oleaceae	Ht 6m, dbh 5cm
DV128	*Selaginella conferta*	Selaginellaceae	
DV129	*Nothaphoebe umbelliflora*	Lauraceae	Ht 30m, dbh 35cm
DV130	*Ryparosa hullettii*	Flacourtiaceae	Ht 4m, dbh 5cm
DV131	*Urophyllum sp.*	Rubiaceae	Ht < 3m, dbh 2cm
DV132	*Aglaia sp.*	Meliaceae	Ht > 4m, dbh 5cm
DV133	*Selaginella conferta*	Selaginellaceae	
DV134	*Eugenia chrysantha*	Myrtaceae	Ht > 3m, dbh 3cm
DV135	*Urophyllum sp.*	Rubiaceae	Ht < 3m, dbh 2cm
DV136	*Popowia pisocarpa*	Annonaceae	Ht < 3m, dbh 2cm
DV137	*Blumeodendron tokbrai*	Euphorbiaceae	Ht 15m, dbh 25cm
DV138	*Urophyllum griffithianum*	Rubiaceae	Ht < 3m, dbh 3cm
DV139	*Spatholobus hirsutus*	Leguminosae	Climber
DV140	*Mastixia rostrata*	Cornaceae	Ht < 3m , dbh 2cm
DV141	*Litsea oppositifolia*	Lauraceae	Ht < 2m, dbh 2cm
DV142	*Popowia pisocarpa*	Annonaceae	Ht 4m, dbh 4cm
DV143	*Aglaia leptantha*	Meliaceae	Ht < 3m, dbh 2cm
DV144	*Xerospermum sp.*	Sapindaceae	Ht 3m, dbh 2cm
DV145	*Costus sp.*	Zingiberaceae	
	80 spp.		
*Refer to Figure 5.9			

Table 5.10 Botanical survey : *Acacia mangium*

Additional 20m x 20m plot (5m x 5m plot within its boundary) sampled for plantation with understorey saplings

(1991 Year-long light-trap site. Plot sampled in front of light-trap site , < 50m away.)

Date : 2 November 1992

No.*	Botanical name	Family	Ht.(m)**	Dbh(cm)***
S1	*Callicarpa longifolia*	Verbenaceae	< 3	1
S2	*Callicarpa longifolia*	Verbenaceae	3	1
S3	*Callicarpa longifolia*	Verbenaceae	3	1.5
S4	*Ficus sp.*	Moraceae	5	4
S5	*Callicarpa longifolia*	Verbenaceae	2	< 0.5
S6	*Barringtonia sp.*	Barringtoniaceae	> 1	n.a.+
S7	Unidentified	Leguminosae	5	1
S8	*Ficus beccarii*	Moraceae	6	3
S9	*Phaeanthus sp.*	Annonaceae	< 2	0.5
S10	*Xanthophyllum sp.*	Polygalaceae	3	1.5
S11	*Ficus fulva*	Moraceae	6	3
S12	*Alstonia angustiloba*	Apocynaceae	> 1	n.a.+
S13	*Callicarpa longifolia*	Verbenaceae	< 3	2
S14	*Urophyllum sp.*	Rubiaceae	> 2	1
S15	*Callicarpa longifolia*	Verbenaceae	> 2	1
S16	*Callicarpa longifolia*	Verbenaceae	> 1	n.a.+
S17	*Aglaia sp.*	Meliaceae	> 1	n.a.+
S18	*Barringtonia curranii*	Barringtoniaceae	3	2
S19	*Callicarpa longifolia*	Verbenaceae	< 1	n.a.+
S20	*Dichapetalum gelonioides*	Dichapetalaceae	< 2	1
S21	*Ficus sp. A*	Moraceae	> 2	0.5
S22	*Ficus lepicarpa*	Moraceae	> 2	1
S23	*Melastoma malabathricum*	Melastomataceae	< 2	0.5
S24	*Ficus beccarii*	Moraceae	> 2	1
S25	Unidentified	Leguminosae	< 1	n.a.+
S26	*Lepisanthes fruticosa*	Sapindaceae	< 3	1

*The numbers indicate the sequence in sampling and hence an idea of the proximity of plants to each other.

**Approximate height

***Approximate dbh (diameter at breast height)

n.a.+ = not applicable

Table 5.11 Botanical survey :		*Eucalyptus deglupta*		
Additional 20m x 20m plot (5m x 5m plot within its boundary) sampled for plantation with understorey saplings				
(1991 Year-long light-trap site. Plot sampled in front of light-trap site , < 50m away.)				
Date : 6 November 1992				
No.*	Botanical name	Family	Ht.(m)**	Dbh(cm)***
S1	*Neonauclea cyrtopoda*	Rubiaceae	5	2
S2	*Nephelium ramboutan-ake*	Sapindaceae	4	5
S3	*Macaranga gigantifolia*	Euphorbiaceae	6	10
S4	*Neo-uvaria sp.*	Annonaceae	< 1	n.a.+
S5	*Mallotus eucaustus*	Euphorbiaceae	< 1	n.a.+
S6	*Pleiocarpidia sp.*	Rubiaceae	2	< 0.5
S7	*Neo-uvaria sp.*	Annonaceae	2	1
S8	*Polyalthia rumphii*	Annonaceae	12	4
S9	*Mallotus eucaustus*	Euphorbiaceae	< 1	n.a.+
S10	*Polyalthia rumphii*	Annonaceae	< 1	n.a.+
S11	*Macaranga gigantifolia*	Euphorbiaceae	18	30
S12	*Ryparosa acuminata*	Flacourtiaceae	3	< 0.5
S13	*Mallotus leucodermis*	Euphorbiaceae	5	4
S14	*Fordia splendidissima*	Leguminosae	15	18
S15	*Actinodaphne glomerata*	Lauraceae	3	2
S16	*Actinodaphne glomerata*	Lauraceae	2	1
S17	*Polyalthia xanthopetala*	Annonaceae	2	1
S18	*Polyalthia rumphii*	Annonaceae	< 1	n.a.+
S19	*Dichapetalum gelonioides*	Dichapetalaceae	< 1	n.a.+
S20	*Macaranga gigantifolia*	Euphorbiaceae	16	20
S21	*Fahrenheitia pendula*	Euphorbiaceae	7	5
S22	*Dichapetalum gelonioides*	Dichapetalaceae	3	1
S23	*Eurycoma longifolia*	Simaroubaceae	2	< 0.5
S24	*Mallotus leucodermis*	Euphorbiaceae	2	< 0.5
S25	*Neonauclea cyrtopoda*	Rubiaceae	< 2	< 0.5
S26	*Chisocheton beccarianus*	Meliaceae	< 2	< 0.5
S27	*Mallotus leucodermis*	Euphorbiaceae	4	3
S28	*Phaeanthus sp.*	Annonaceae	> 1	n.a.+
S29	*Nephelium ramboutan-ake*	Sapindaceae	8	6
S30	*Phaeanthus sp.*	Annonaceae	> 1	n.a.+
S31	*Dillenia beccariana*	Dilleniaceae	> 2	5
S32	*Mallotus eucaustus*	Euphorbiaceae	< 1	n.a.+
*The numbers indicate the sequence in sampling and hence an idea of the proximity of plants to each other.				
**Approximate height				
***Approximate dbh (diameter at breast height)				
n.a.+ = not applicable				

Table 5.12 Botanical survey :		*Paraserianthes falcataria*		
Additional 20m x 20m plot (5m x 5m plot within its boundary) sampled for plantation with understorey saplings				
(1991 Year-long light-trap site. Plot sampled in front of light-trap site , < 50m away.)				
Date : 5 November 1992				
No.*	Botanical name	Family	Ht.(m)**	Dbh(cm)***
S1	*Ficus fulva*	Moraceae	< 1	n.a.+
S2	*Callicarpa longifolia*	Verbenaceae	< 2	1.5
S3	*Ficus hemsleyana*	Moraceae	> 1	n.a.+
S4	*Callicarpa longifolia*	Verbenaceae	< 1	n.a.+
S5	*Macaranga gigantifolia*	Euphorbiaceae	5	6
S6	*?Semecarpus sp.*	Anacardiaceae	> 1	n.a.+
S7	*Dillenia excelsa*	Dilleniaceae	> 2	2
S8	*Ficus hemsleyana*	Moraceae	< 2	3
S9	*Ficus hemsleyana*	Moraceae	> 1	n.a.+
S10	*Sterculia coccinea*	Sterculiaceae	6	7
S11	*Cratoxylum sumatranum*	Guttiferae	5	10
S12	*Ficus hemsleyana*	Moraceae	< 1	n.a.+
S13	*Ryparosa hullettii*	Flacourtiaceae	< 1	n.a.+
S14	*Ficus megaleia*	Moraceae	> 1	n.a.+
S15	*Ficus hemsleyana*	Moraceae	> 1	n.a.+
S16	*Ficus sp.*	Moraceae	< 2	1.5
S17	*Ryparosa acuminata*	Flacourtiaceae	5	2
S18	*Mallotus penangensis*	Euphorbiaceae	< 2	1.5
S19	*Ryparosa acuminata*	Flacourtiaceae	3	1.5
S20	*Nephelium ramboutan-ake*	Sapindaceae	> 1	n.a.+
S21	*Garcinia parvifolia*	Guttiferae	< 1	n.a.+
S22	*Ficus hemsleyana*	Moraceae	5	3
S23	*Mallotus papuanus*	Euphorbiaceae	< 1	n.a.+
S24	*Garcinia parvifolia*	Guttiferae	< 1	n.a.+
S25	*Ficus hemsleyana*	Moraceae	< 1	n.a.+
S26	*Ryparosa hullettii*	Flacourtiaceae	< 2	1
S27	*Mallotus miquelianus*	Euphorbiaceae	< 1	n.a.+
S28	*Ficus fulva*	Moraceae	> 2	2.5
S29	*Ficus hemsleyana*	Moraceae	> 1	n.a.+
S30	*Ficus sp.*	Moraceae	< 1	n.a.+
S31	*Ficus hemsleyana*	Moraceae	> 2	1
S32	*Ficus hemsleyana*	Moraceae	< 1	n.a.+
S33	*Ryparosa hullettii*	Flacourtiaceae	< 1	n.a.+
S34	*Ryparosa acuminata*	Flacourtiaceae	< 1	n.a.+
S35	*Callicarpa longifolia*	Verbenaceae	< 2	1.5
*The numbers indicate the sequence in sampling and hence an idea of the proximity of plants to each other.				
**Approximate height				
***Approximate dbh (diameter at breast height)				
n.a.+ = not applicable				

5.3.1 Plantation forest

5.3.1.1 *Acacia mangium*

See Table 5.1, Figures 5.1 and 5.10. Half of the forest floor was covered by the ubiquitous fern *Nephrolepis biserrata*, the other half was smothered with a rather thick layer of shed *Acacia mangium* leaves in varying degree of decay, which undoubtedly contributed to the bulk of the detritus. The forest structure was uniform with *A. mangium* trees of similar height and separated by similar planting distance (Fig. 5.10). The understorey shrubs and saplings as surveyed together with the 20m x 20m plot (Tables 5.1, 5.10) were dominated by *Callicarpa longifolia* (Verbenaceae), and *Ficus* spp. (Moraceae).

As for the plantation used in the transect plot, with it being of a different locality, the trees appeared rather stunted, the fact of it being 16 months younger than the year-long light-trap site above notwithstanding. Its understorey was devoid of noticeable saplings (Table 5.6, Fig. 5.6), and its forest floor was richer in herbaceous creepers which could be attributable to its somewhat thinner tree canopy.

5.3.1.2 *Eucalyptus deglupta*

See Table 5.2, Figures 5.2, 5.10. This plantation was characterized by its more abundant and diverse understorey saplings (see also Table 5.11). As evident from Figure 5.10, some of these saplings were rather big and tall (e.g. *Macaranga gigantifolia*, *Ficus* sp.) giving rise to a more heterogeneous forest structure compared to the other target plantation forests. Most of the *Eucalyptus deglupta* trees themselves had a sickly look, with their foliage not as dense as a more vigorous plantation. This could have promoted the rampant growth of its understorey, giving the place an air of abandonment and neglect.

5.3.1.3 *Gmelina arborea*

See Table 5.3, Figures 5.3, 5.10. *Nephrolepis biserrata* was the dominant ground cover, and its growth was actually encouraged by the forest managers (Chia, pers. comm.) as the fern helps retain moisture within the soil. The scarcity and absence of sapling species could have been due to their deliberate removal by weeding process, as *Gmelina arborea* is believed to be more site demanding. The forest was uniform with trees of similar height and structure (Fig. 5.10).

The other *G. arborea* plantation used for the transect (Table 5.7, Fig. 5.7) was similarly ground-covered by *Nephrolepis biserrata*, but with it being an older plantation (planted five years prior to the above-mentioned), it seemingly had a marginally more diverse understorey (Tables 5.7, 5.3).

5.3.1.4 *Paraserianthes falcataria*

See Table 5.4, Figures 5.4, 5.10. The forest floor was covered mainly by *Nephrolepis biserrata*. The understorey shrubs and saplings (Tables 5.4, 5.12) were very much dominated by *Ficus* spp., *Ryparosa* spp. (Flacourtiaceae), *Callicarpa longifolia*, *Mallotus* spp. (Euphorbiaceae) were also rather common. The structure of the plantation was homogenous with similarly planted trees.

5.3.1.5 *Pinus caribaea*

See Table 5.5, Figures 5.5, 5.10. The plantation was mostly either ground-covered by shed leaf needles or *Nephrolepis biserrata*. The forest floor had accumulated quite a thick carpet of those leaf needles which appeared to get decomposed rather slowly. The canopy was compact with densely packed needle foliage, and the amount of sunlight reaching the forest floor was hence not as great as the other plantations.

5.3.2 Natural forest

5.3.2.1 Logged-over Secondary Forest

See Table 5.8, Figures 5.8, 5.11. The logged-over Secondary Forest at Brumas was made up of a mixture of open habitat vegetation, light-demanding pioneer trees, and remnants of climax species. The regenerating forest surveyed was rich in a variety of floor creepers and climbers both herbaceous (e.g. *Mikania cordata*) and woody (e.g. *Tetrastigma* sp.), which at places formed a most bewildering entanglement among themselves and with their associated trees. The earlier extraction of giant dipterocarps had created a wounded forest with huge gaps, which gave rise to a whole new suite of light-demanding pioneer species, the most common of which were *Macaranga* spp. (Euphorbiaceae), and *Anthocephalus chinensis* (renamed *Neolamarckia cadamba*) (Rubiaceae) (Fig. 5.10). These pioneer species could germinate best in large forest gaps (Raich & Gong, 1990), and they grew profusely under direct and unrestricted sunlight. There was also a host of other secondary species (Table 5.8) some of which were also found in plantation forest understorey e.g. most weeds (Compositae e.g. *Chromolaena odoratum*), *Clidemia hirta* (Melastomataceae). In the plot surveyed, *Leea aculeata* (Leeaceae), a shrub of varying heights, and *Caesalpinia latisiliqua*, a legume climber, were quite abundant.

5.3.2.2 Virgin primary forest

See Table 5.9, Figures 5.9, 5.12. The stretch of primary lowland dipterocarp forest near the moth-sampling site at Danum Valley showed a wealth of primary species and a total absence of such light-demanding pioneers as *Macaranga* spp., and *Anthocephalus chinensis*. The forest canopy formed an almost continous layer, with a few giant emergents namely *Parashorea malaanonan* (Dipterocarpaceae), *Nothaphoebe* spp. (Lauraceae) towering over all

the rest (Fig. 5.12). This closed forest structure did not permit the growth of weedy vegetation (e.g. *Chromolaena odoratum*, *Mikania cordata*, *Nephrolepis biserrata*) which proliferated and spread like fire in many of the plantation forests at Brumas. The primary forest floor at Danum was not cluttered with such luxuriant weeds, in fact it was relatively bare save for the leaf litter which was scattered here and there. The vertical profile of that stretch of primary forest (Fig. 5.12) showed a site with trees which were more diverse in terms of both species and structure compared to the secondary forest as well as forest plantations at Brumas.

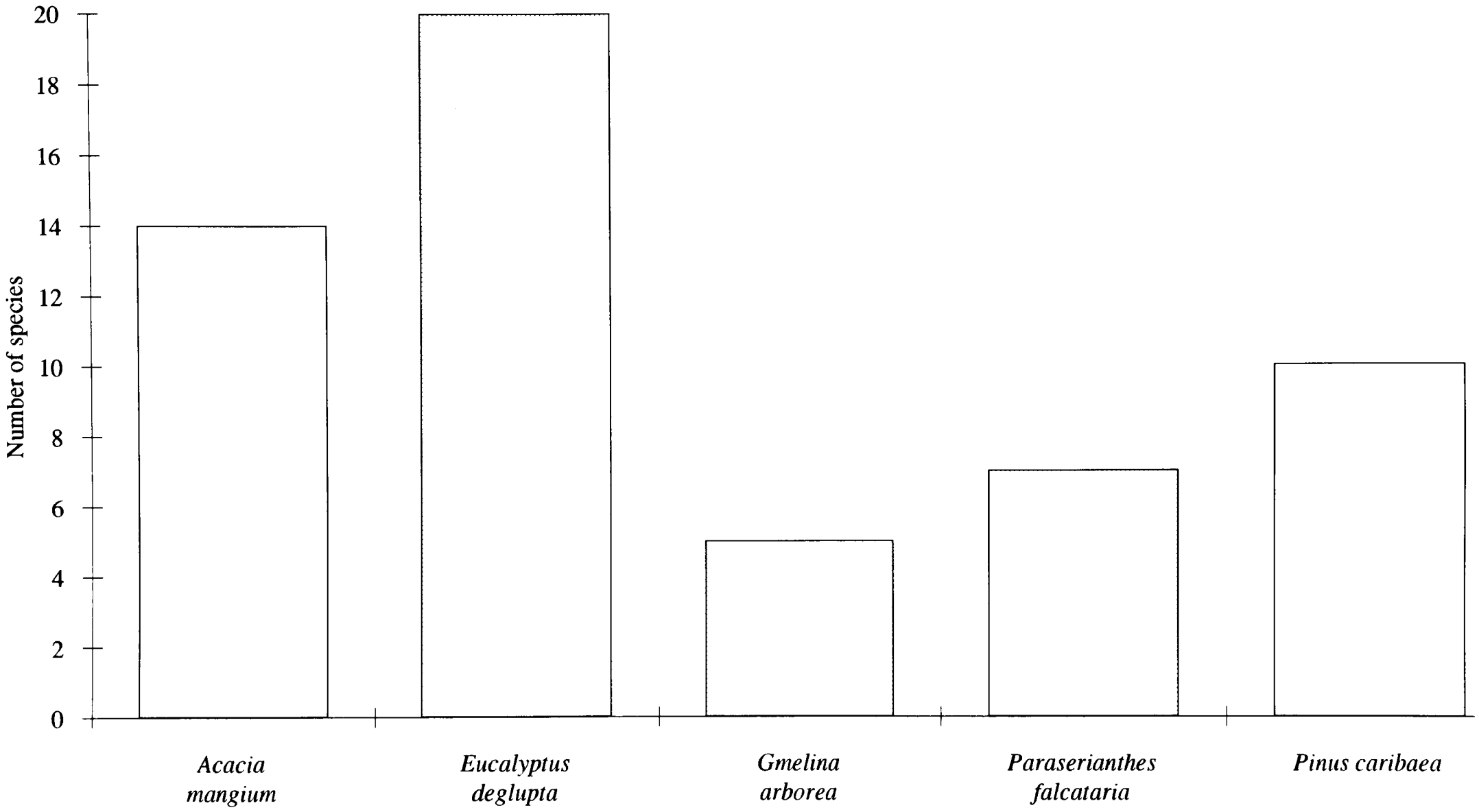
5.3.3 Relations between plants surveyed, moths sampled and host plant records

As can be seen from the data gathered above, the various plantation forests did house a number of understorey plant species in varying richness. It would be interesting to link the plant species surveyed with the host plant records (Appendix I) available for the various moths captured, particularly for the plantation forests.

Figure 5.13 shows that *Eucalyptus deglupta* was the plantation richest in understorey species, which could serve as a wider range of food plants for the moths compared to the other plantations. It was structurally more heterogenous (see Fig. 5.10) with understorey plants of larger stature. The other plantations were structurally simpler, most of their understorey plants were comparatively small in size. Southwood *et al.* (1979) found that insect diversity correlates positively with plant species diversity combined with architectural plus spatial complexity and not with plant species diversity alone. And Murdoch *et al.* (1972) also found that plant diversity as well as vegetation complexity in the form of foliage height diversity, correlate positively with insect diversity. The not so linear graphs in Figures 5.14 & 5.15 plotting the number of moth species sampled as well as the alpha values against the number of understorey plant species surveyed in Brumas seem to concur with those findings.

The amount of influence of the understorey as possible host plants could be estimated

Fig. 5.13 Number of understorey plant species surveyed in 5m x 5m plot



1991 Plantation light-trapping sites, Brumas

Fig. 5.14 Number of macromoth species sampled by light-trap against number of understorey plant species surveyed

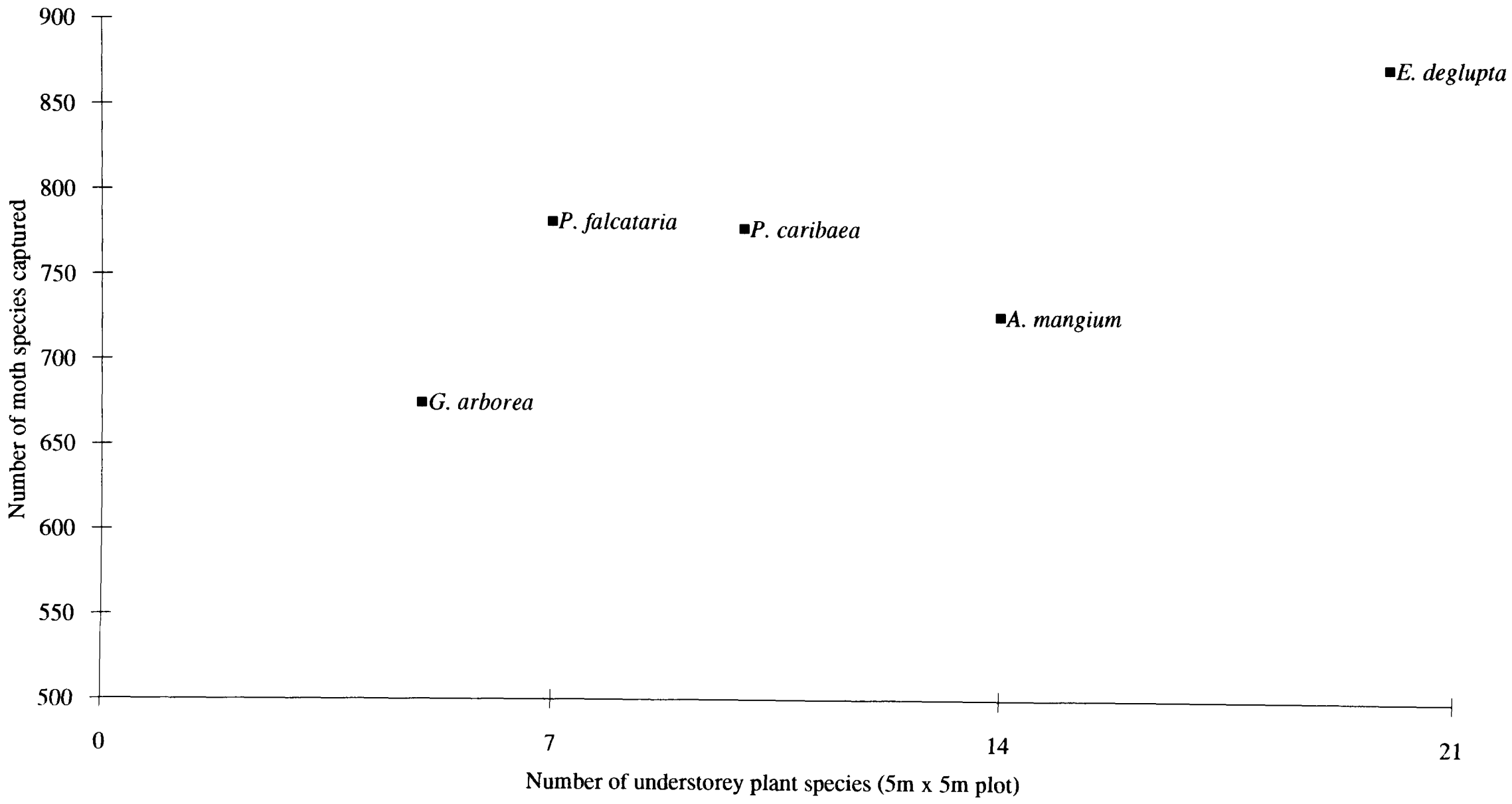
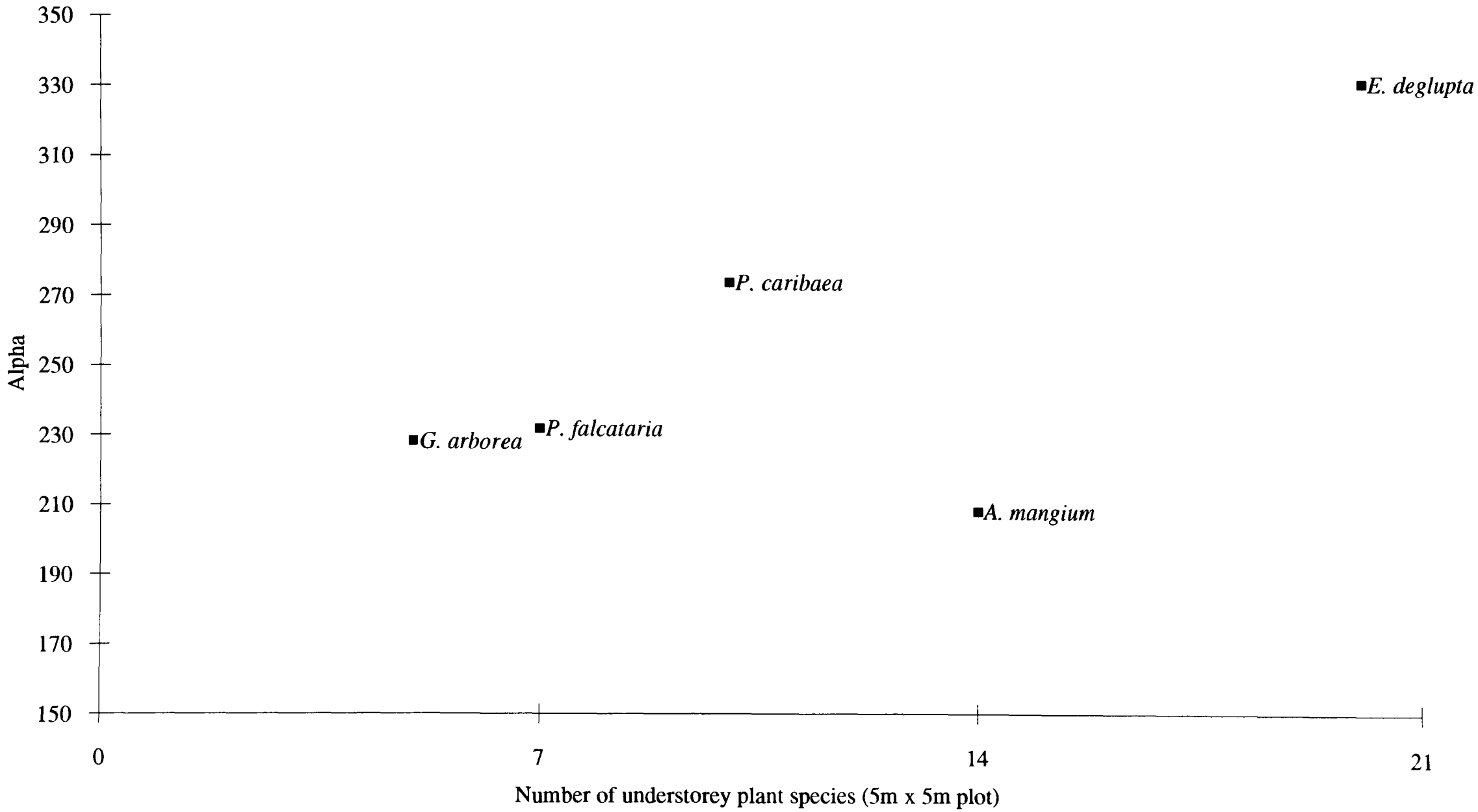


Fig. 5.15 Alpha values against number of understorey plant species surveyed



by checking the available host plant records of the moths captured. Taking the moths at their generic level and their host plants at family level (this has to suffice as many records available are on congeners with families of host plants), an attempt was made to estimate the possible proportions of moths feeding on the plantation tree itself or the plantation undergrowth (Table 5.13). The importance of the plantation understorey was beyond doubt as illustrated in Figure 5.16 where it can be seen to contribute towards more than half of the moth load, in *Eucalyptus* its contribution was as high as 75.34%, giving proof that *Eucalyptus* is a species not particularly rich in its moth fauna (see 4.3.2), the main bulk of the plantation's moths came from its wonderfully rich and diverse understorey. Comparatively the two legumes, *Acacia* and *Paraserianthes*, were faunistically richer in moths, a result which could be enhanced by the vast number of host records of moths feeding on Leguminosae, by far the most favoured family. From the author's observations in collecting trips, *Paraserianthes* appeared to be the plantation species with a most abundant assemblage of moth caterpillars, and probably most prone to defoliation.

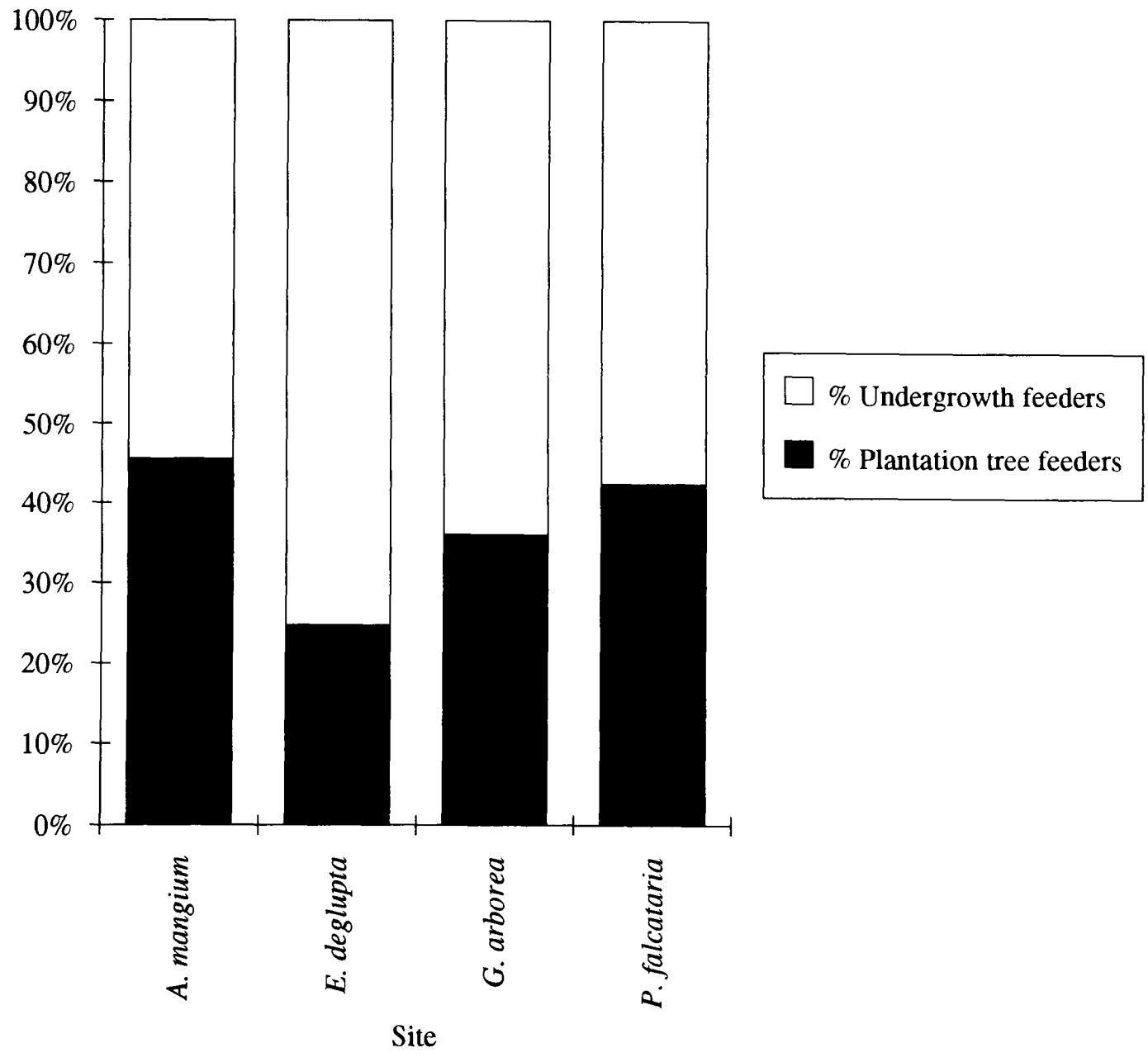
The natural Secondary Forest at Brumas had a richer and seemingly more diverse plant community than the plantations, and yielded the highest numbers of individuals as well as species of moths (see Fig. 2.3). The primary forest at Danum with an even more floristically diverse environment would be expected to house a richer moth community, but similar sampling efforts (it must be stressed here that the samples taken from Danum were far from exhaustive) at the secondary forest in Brumas (Chapter Three) revealed that the habitat was as good as, if not better, than the primary forest in Danum in terms of moth richness and abundance. Unlike most forest plantations of simple monoculture system, ecological parameters in the natural forest show complications which are not easily understood. Holloway (1984) while working on the moths of Sarawak's Mulu National Park discovered

Table 5.13 Estimated numbers of moth species ex plantation tree species and plantation undergrowth

	A. mangium	*E. deglupta*	*G. arborea*	*P. falcataria*	*P. caribaea*
Total species captured	726	872	675	782	778
Species with host records	542	618	511	594	558
Estimated site species	440	515	239	468	387
Possible plantation tree feeders	200	127	86	198	non-applicable*
% Plantation tree feeders	45.46	24.66	35.98	42.31	
% Undergrowth feeders	54.54	75.34	64.02	57.69	

* Host plant records pertaining to P. caribaea insufficient to form estimates

Fig. 5.16 Estimated proportions of moth species ex plantation tree/undergrowth



that the limestone forest with the lowest floristic diversity paradoxically gave rise to a greater moth diversity compared to other lowland forest types. Perhaps the Secondary Forest in Brumas could be likened to a mosaic of logged over natural forest (with its pioneer trees such as *Anthocephalus chinensis* and *Macaranga* spp.) as well as isolated pockets of primary forest, contributing to moth faunas which overlap and constitute a community of many secondary habitat specialists, as well as retaining some primary species.

A footnote on the estimation of site species in Table 5.13.
'Estimated site species' are moth species whose host plants (at the family level) were found to be present at the site. 'Possible plantation tree feeders' estimates were made with the assumption that all congeners feed on the plantation trees if of same family as the recorded host plant. Hence the estimates tend to be maximum values.

CHAPTER SIX

GENERAL DISCUSSION

The results and discussion obtained in the previous chapters, which though intimately linked, have been presented in a piecemeal fashion. In this final chapter, they are woven into a cohesive overview, in which questions posed at the beginning, and answers obtained at the end, are dealt with together in the form of a general discussion.

6.1 Conservation integrity of exotic forest plantations

The conservation value of the fast-growing exotic tree plantations in Sabah has been dubious to many Western conservationists, who more often than not question the propriety of such reforestation, and their concern, though well-meant, is often prejudiced by the absence of baseline information. Stamp & Casey (1993) commented on the generalizations about many agroecosystems which have been widely accepted as dogmas even though those ideas have not been rigorously tested, e.g. herbivore species diversity is commonly believed to be lower in agroecosystem than natural or unmanaged ecosystem, but examples of both relatively high and low species diversity can be found in both types of ecosystems, e.g. swamps and marshes are unmanaged ecosystems which are low in species diversity.

The Bornean rain forest, with its unique wealth of flora and fauna should ideally be 'sanctified', free from any form of man-induced deforestation. Practically this is far from possible, as timber still remains a major revenue earner, and in all its rawness is a precious and vital commodity, without which many rural poor would continue to live in poverty, disease, and misery. The realization of this fact may somewhat mitigate the amount of hostility aimed at plantation forestry, but still many are unconvinced about the merits of such

reforestation, for from a conservation viewpoint plantation forests are more or less worthless, there is no concrete evidence to prove otherwise, and anyone extolling the virtues of plantation forests is labelled "politically incorrect".

The actual impact on the forest ecosystem of replacing native Bornean dipterocarp forest with exotic tree plantation can best be gauged by comparing the biodiversity values between the two. In Brumas, where the most established exotic forest plantations are found, research on its conservation value has been hitherto limited to the vertebrates (Davies, 1981; Sheldon & Kennard, 1982; Duff *et al.*, 1984; Sheldon, 1986; Stuebing & Gasis, 1989). Although vertebrates such as birds and mammals are important part of the forest ecosystem, their scarcity and invisibility render them unsuitable as candidates for indicators of biodiversity. Moths, on the other hand, are numerous in species, easily sampled, and with the majority being phytophagous, are excellent biodiversity indicators (Holloway, 1983b).

6.2 Light-trapped moths as biodiversity indicators for plantation & natural forests

Even though moths are readily sampled using light-traps, critics of such trapping system are sceptical over its merits for environmental monitoring, as the mobility of moths may blur assessment of vegetation type, yielding 'resident' moths which are really 'tourists' in disguise. But no other sampling method can compare to the efficiency of the light-trap in attracting moths both qualitatively and quantitatively (Muirhead-Thomson, 1991), and in order to provide evidential support for its use in this project, canopy knockdown spraying in the form of mist-blowing was conducted in the various plantations as well as natural forest.

6.2.1 Knockdown spraying in support of light-trap sampling

The knockdown spraying yielded moth larvae the families of which showed similar

proportions with the light-trap adult moth samples (see 4.3.2), and even though the numbers brought down were low as in most other knockdown studies (Southwood *et al.*, Stork, 1991; Ozanne, 1991), the exercise nonetheless provided evidence that the introduced plantation trees were hosts to a range of macromoths, and that the plantation trees *per se* do not necessarily carry a poorer moth load compared to some native trees e.g. the relatively more abundant moth larvae knocked down from the canopy of the exotic *Paraserianthes falcataria* against the lower numbers from the native *Macaranga* spp.

6.2.2 Analyses of light-trapped moth samples

The various cluster analyses as seen in dendrograms and linkage diagrams have demonstrated the reliability of the light-trap in sampling moths for use as indicators of biodiversity. The R-mode approach of recognizing species associations, e.g. over a transect, helped mitigate the problem of mobility (lack of habitat fidelity) and 'tourists'. Moths occurring in substantial numbers at a particular site were clustered together, and some had been reared from the site's vegetation (see Appendix V), and they together were representative of the site, or known as the site's element. Certain moths were selected by TWINSPAN as indicator species, and similarly they were the ones predominant at the site.

Williams alpha, based on the log series, was considered the most suitable diversity measure for the light-trapped moth samples (see 2.2.5.1), and used throughout the project.

6.2.3 Plantation versus natural forest

For the main year-long survey conducted in 1991 at Brumas, the alpha values obtained for the moth samples from the plantation sites were not as poor as predicted. *Eucalyptus deglupta* even registered the highest alpha value of diversity (330.85+-16.37), better than the natural regenerating Secondary Forest (314.53+-11.99). Even though Secondary Forest

recorded the highest number of individuals as well as species, *Eucalyptus deglupta* with relatively more species from fewer individuals produced a better alpha value (which incorporates richness as well as evenness of species). The other plantation sites gave values between 200-300, which were unexpectedly good, considering the values from undisturbed lowland forest in Borneo were reported to be between 300 to 350 (Holloway & Barlow, 1992; Robinson & Tuck, 1993a). Table 6.1 lists a range of alpha values from different forest habitats, and it can be seen that the values from Brumas compared very favourably with other forest types in Borneo, where the lower montane zone (*ca.* 1000m in altitude) which sees an overlap between lowland and montane species, is found to be the best in macromoth diversity (Holloway, 1987a). When compared with other regions (particularly the Indo-Australian tropics), Borneo's supremacy is unsurpassed. It is of interest to note the relatively low values from temperate countries like New Zealand (only 5), and Great Britain (with a mean of 31).

For the subsidiary samples involving plantation to secondary forest transects in Brumas, as well as comparison with the primary forest in Danum, results obtained suggested the role of the secondary forest as a reservoir of the various moth species for the adjacent plantation. Moths of different levels of dispersal ability and predilection for plantation habitat seeped into the plantation with varying degree of success. A large area of open herb layer gave a very poor alpha value (42.97+-6.18), where the absence of a forest canopy reduced the structural complexity, and altered the microclimatic conditions significantly, resulting in greater insolation, lesser humidity, and decreased diversity. It was also of interest to note that the alpha values obtained from the primary dipterocarp forest in Danum (115.56+-20.21, 105.4+-22.65) were not necessarily higher than the disturbed forests in Brumas e.g. *Acacia mangium* (T2) with 124.68+-19.57, secondary forest (T5) with 135.15+-18.84. As these transect samples were comparatively small, it would not be sensible to read too much into

Table 6.1 Alpha values of macromoths from various types of forest habitats			
Site	Altitude(m)	Alpha	
Alluvial forest, Mulu, Borneo*	70	260	
Kerangas forest, Mulu, Borneo*	150	280	
Lowland dipterocarp, Mulu, Borneo*	150	309	
Lower montane, Mulu, Borneo*	1000	398	
Upper montane, Mulu, Borneo*	1790	118	
Dipterocarp on limestone, Mulu, Borneo*	250	321	
Lower montane on limestone, Mulu, Borneo*	900	289	
Upper montane on limestone, Mulu, Borneo*	1500	128	
Upper montane, Mt. Kinabalu, Borneo*	1930	172	
Primary forest, Danum, Borneo**	150	<200	
Logged forest, Danum, Borneo**	150	130	
Advanced secondary, Genting, P.Malaysia***	600	301	
Lowland forest, Sulawesi*	664	204	
Montane, Papua New Guinea****	>2000	<200	
Montane, Nandarivatu, Fiji*****	850	36	
Forest, Santo, Apouna, Vanuatu*****	300	27	
Forest & pasture, New Caledonia*	160	36	
New Zealand******		5	
Great Britain***		31	
Data sources:			
*Holloway (1987a)			
**Holloway et al. (1992)			
***Barlow & Woiwod (1989)			
****Hebert (1980)			
*****Robinson (1975)			
******Cumber (1951)			

them. What is worth mentioning is that dipterocarps in lowland forest were reported by Holloway (1987a) to have a relatively low incidence of lepidopteran defoliators, and thus the high proportion of green foliage biomass represented by lowland dipterocarps may in fact result in lower overall diversity of Macrolepidoptera.

6.2.4 Site floristics in relation to moths sampled

The floristics of the various moth sampling sites were surveyed, which helped to explain the unexpectedly high diversity values obtained from the plantation sites. *Eucalyptus deglupta* which gave the highest alpha value had the most diverse understorey in terms of both plant species and architecture, and it was estimated from available host plant records that a large proportion of its moth fauna (75%) were probable feeders on its understorey rather than the tree itself (see 5.3.3). In fact for all the plantation sites, their understorey seemed to contribute more than half of the moth species sampled. This also underlined the importance of the plantation understorey in producing a more diverse moth community, and the supposedly single species monoculture tree plantations sheltered under their canopies numerous plants, ranging from herbs (grasses, ferns, climbers), shrubs, to saplings of native tree species. These early successional stage ecosystems varied in complexity with silvicultural practices such as species choice, planting density and age of stand.

With the exception of *Eucalyptus deglupta*, whose diverse understorey rivalled the luxuriant growth in the natural Secondary Forest, the other plantation sites which were floristically simpler in terms of species and structure produced lower alpha values than the Secondary Forest.

6.2.5 Widespread and vulnerable moths

Moths can be classified as either widespread or vulnerable in terms of species conservation. Many biogeographically widespread or less vulnerable species are herbaceous

plant feeders characteristic of open habitats e.g. various trifine noctuids such as *Condica illecta* Walker (family specific on Compositae), *Athetis* spp., and predominantly arboreal feeding families such as Geometridae and Notodontidae as well as Lymantriidae are eliminated in open habitats (Holloway & Stork, 1991). The disturbed forest habitats in Brumas (both natural and plantation) were of course not as open as cultivated areas under agricultural crop e.g. paddy fields, and possessed more than just open habitat specialists. The scenario can be more readily appreciated by looking at the distribution of the various taxonomic groups. Table 6.2 shows the various macromoth groupings from the sampling sites at Brumas in 1991. The figures are better interpreted by ranking the sites according to the number of species sampled (Table 6.3). It is obvious that Secondary Forest (to a lesser extent *Eucalyptus deglupta*) heads the list for most groups, and considering that about half of the Secondary Forest moth species (total 1048 spp.) were shared with each of the plantation sites (503-653 spp.)(see Table 2.5), the importance of the Secondary Forest as a source area, particularly for the generalist species becomes even more apparent. Also worthy of note is the success shown by some plantation sites in recruiting species, e.g. Epiplemidae had the highest number of species in *Gmelina arborea*, which is the host plant for many *Epiplema* spp. (Appendix I). Larentiinae, with many montane species, was richest in species in *Pinus caribaea*, as the site was relatively high in altitude (see Table 2.1). *Pinus* also scored the highest numbers of species in various other groups: Arctiidae with many lichen feeders, which possibly thrived on the *Pinus* tree trunk which was typically scarred with deep cracks and crevices conducive for lichen growth; the site was also thick with shed leaf needles (see Fig. 5.5) which could serve as detritus food for comparatively more species of Herminiinae/Hypeninae; and Acontiinae, a member of which *Eublemma* sp. nr. *brachygonia* Hampson was reared by the

Table 6.2 Total numbers of individuals (N) and species (S) according to families and subfamilies sampled from the various sites at Brumas in 1991

Family	Number of individuals (N)						Number of species (S)					
Subfamily	Am	Ed	Ga	Pf	Pc	SF	Am	Ed	Ga	Pf	Pc	SF
Cossidae	12	37	21	23	7	174	4	9	6	6	5	16
Metarbelidae	0	1	1	0	0	1	0	1	1	0	0	1
Limacodidae	168	185	93	198	36	222	22	26	18	26	13	34
Lasiocampidae	11	32	20	18	15	80	5	8	5	11	9	12
Bombycidae	2	11	3	4	3	20	2	4	2	3	3	7
Saturniidae	0	1	0	0	0	2	0	1	0	0	0	1
Sphingidae	18	105	20	84	7	559	9	20	9	17	6	37
Drepanidae	11	76	23	31	23	119	5	16	10	13	11	16
Uraniidae	8	22	3	4	2	116	2	2	2	1	1	3
Epiplemidae	27	48	79	44	81	21	4	5	8	7	7	4
Geometridae	2326	962	651	1833	787	1686	126	165	118	147	137	190
Oenochrominae	21	27	30	46	33	92	6	6	4	6	7	7
Geometrinae	143	197	80	198	128	404	27	41	20	38	28	52
Sterrhinae	117	113	104	193	122	152	18	24	23	19	22	22
Larentiinae	4	9	6	13	17	11	2	5	2	3	6	4
Ennominae	2041	616	431	1383	487	1027	73	89	69	81	74	105
Notodontidae	17	46	17	42	15	96	13	21	9	24	13	28
Arctiidae	1048	554	965	919	744	614	81	81	76	71	91	73
Lithosiinae	876	409	653	723	659	239	74	71	67	60	79	58
Syntominae	22	103	90	42	31	125	2	3	2	2	4	2
Arctiinae	150	42	222	154	54	250	5	7	7	9	8	13
Lymantriidae	533	233	198	435	178	355	47	57	43	50	49	62
Noctuidae	2421	1972	2070	2888	2515	4425	406	456	368	406	433	564
Aganainae	27	24	9	47	12	116	5	4	3	6	5	8
Herminiinae	703	537	744	915	841	567	50	50	45	50	53	45
Hypeninae	16	40	32	37	57	67	8	11	14	14	18	14
Catocalinae	111	75	43	106	35	296	26	24	18	24	15	36
Ophiderinae	519	549	359	706	501	1436	122	160	119	135	143	199
Acontiinae	142	117	121	120	218	80	42	45	33	33	56	28
Plusiinae	6	6	26	23	6	53	5	5	3	7	4	9
Stictopterinae	238	89	241	100	288	422	30	23	25	26	33	45
Euteliinae	11	23	15	14	25	74	7	11	7	10	15	20
Nolinae	12	16	11	6	24	8	10	11	6	3	6	7
Sarrothripinae	122	71	125	115	74	188	26	21	25	21	19	31
Chloephorinae	135	247	79	92	142	409	30	49	26	31	30	62
Amphipyrinae	305	144	235	543	256	532	32	32	35	36	27	46
Acronictinae	1	3	1	4	1	4	1	2	1	2	1	2
Agaristinae	4	5	0	0	1	17	2	2	0	0	1	2
Hadeninae	69	26	29	60	34	156	10	6	8	8	7	10

Am = *Acacia mangium*
Ed = *Eucalyptus deglupta*
Ga = *Gmelina arborea*
Pf = *Paraserianthes falcataria*
Pc = *Pinus caribaea*
SF = Secondary Forest

Table 6.3 Sites ranked according to number of species (in brackets) sampled at Brumas, 1991

Family / Subfamily						
Cossidae	SF (16)	Ed (9)	Pf (6)	Ga (6)	Pc (5)	Am (4)
Metarbelidae	Ed (1)	SF (1)	Ga (1)	Pc (0)	Pf (0)	Am (0)
Limacodidae	SF (34)	Ed (26)	Pf (26)	Am (22)	Ga (18)	Pc (13)
Lasiocampidae	SF (12)	Pf (11)	Pc (9)	Ed (8)	Ga (5)	Am (5)
Bombycidae	SF (7)	Ed (4)	Pc (3)	Pf (3)	Ga (2)	Am (2)
Saturniidae	Ed (1)	SF (1)	Pc (0)	Pf (0)	Ga (0)	Am (0)
Sphingidae	SF (37)	Ed (20)	Pf (17)	Ga (9)	Am (9)	Pc (6)
Drepanidae	Ed (16)	SF (16)	Pf (13)	Pc (11)	Ga (10)	Am (5)
Uraniidae	SF (3)	Ed (2)	Ga (2)	Am (2)	Pc (1)	Pf (1)
Epiplemidae	Ga (8)	Pc (7)	Pf (7)	Ed (5)	SF (4)	Am (4)
Geometridae	SF (190)	Ed (165)	Pf (147)	Pc (137)	Am (126)	Ga (118)
Oenochrominae	SF (7)	Pc (7)	Ed (6)	Pf (6)	Am (6)	Ga (4)
Geometrinae	SF (52)	Ed (41)	Pf (38)	Pc (28)	Am (27)	Ga (20)
Sterrhinae	Ed (24)	Ga (23)	SF (22)	Pc (22)	Pf (19)	Am (18)
Larentiinae	Pc (6)	Ed (5)	SF (4)	Pf (3)	Ga (2)	Am (2)
Ennominae	SF (105)	Ed (89)	Pf (81)	Pc (74)	Am (73)	Ga (69)
Notodontidae	SF (28)	Pf (24)	Ed (21)	Pc (13)	Am (13)	Ga (9)
Arctiidae	Pc (91)	Ed (81)	Am (81)	Ga (76)	SF (73)	Pf (71)
Lithosiinae	Pc (79)	Am (74)	Ed (71)	Ga (67)	Pf (60)	SF (58)
Syntominae	Pc (4)	Ed (3)	SF (2)	Pf (2)	Ga (2)	Am (2)
Arctiinae	SF (13)	Pf (9)	Pc (8)	Ed (7)	Ga (7)	Am (5)
Lymantriidae	SF (62)	Ed (57)	Pf (50)	Pc (49)	Am (47)	Ga (43)
Noctuidae	SF (564)	Ed (456)	Pc (433)	Pf (406)	Am (406)	Ga (368)
Aganainae	SF (8)	Pf (6)	Pc (5)	Am (5)	Ed (4)	Ga (3)
Herminiinae	Pc (53)	Ed (50)	Pf (50)	Am (50)	SF (45)	Ga (45)
Hypeninae	Pc (18)	SF (14)	Pf (14)	Ga (14)	Ed (11)	Am (8)
Catocalinae	SF (36)	Am (26)	Ed (24)	Pf (24)	Ga (18)	Pc (15)
Ophiderinae	SF (199)	Ed (160)	Pc (143)	Pf (135)	Am (122)	Ga (119)
Acontiinae	Pc (56)	Ed (45)	Am (42)	Pf (33)	Ga (33)	SF (28)
Plusiinae	SF (9)	Pf (7)	Ed (5)	Am (5)	Pc (4)	Ga (3)
Stictopterinae	SF (45)	Pc (33)	Am (30)	Pf (26)	Ga (25)	Ed (23)
Euteliinae	SF (20)	Pc (15)	Ed (11)	Pf (10)	Ga (7)	Am (7)
Nolinae	Ed (11)	Am (10)	SF (7)	Pc (6)	Ga (6)	Pf (3)
Sarrothripinae	SF (31)	Am (26)	Ga (25)	Ed (21)	Pf (21)	Pc (19)
Chloephorinae	SF (62)	Ed (49)	Pf (31)	Pc (30)	Am (30)	Ga (26)
Amphipyrinae	SF (46)	Pf (36)	Ga (35)	Ed (32)	Am (32)	Pc (27)
Acronictinae	Ed (2)	SF (2)	Pf (2)	Pc (1)	Ga (1)	Am (1)
Agaristinae	Ed (2)	SF (2)	Am (2)	Pc (1)	Pf (0)	Ga (0)
Hadeninae	SF (10)	Am (10)	Ga (8)	Pf (8)	Pc (7)	Ed (6)

Am = *Acacia mangium*
Ed = *Eucalyptus deglupta*
Ga = *Gmelina arborea*
Pf = *Paraserianthes falcataria*
Pc = *Pinus caribaea*
SF = Secondary Forest

Table 6.4 Alpha values for the various groups of macromoths collected at Brumas in 1991

Family/Subfamily	N	S	Alpha
Cossidae	274	16	3.7+-0.95
Metarbelidae	3	1	0.52+-0.94
Limacodidae	902	49	11.11+-1.6
Lasiocampidae	176	18	5.02+-1.38
Bombycidae	43	7	2.37+-1.21
Saturniidae	3	1	0.52+-0.94
Sphingidae	793	42	9.45+-1.46
Drepanidae	283	31	8.87+-1.9
Uraniidae	155	3	0.52+-0.25
Epiplemidae	300	12	2.5+-0.69
Geometridae	8245	276	55.02+-3.05
Oenochrominae	249	11	2.35+-0.68
Geometrinae	1150	71	16.72+-2.06
Sterrhinae	801	40	8.85+-1.39
Larentiinae	60	12	4.51+-1.89
Ennominae	5985	142	26.1+-1.9
Notodontidae	233	50	19.53+-4.12
Arctiidae	4844	133	25.28+-1.95
Lithosiinae	3559	111	21.74+-1.88
Syntominae	413	5	0.8+-0.28
Arctiinae	872	17	2.99+-0.61
Lymantriidae	1932	93	20.38+-2.08
Noctuidae	16291	910	208.09+-7
Aganainae	235	9	1.85+-0.58
Herminiinae	4307	82	14.37+-1.34
Hypeninae	249	27	7.69+-1.76
Catocalinae	667	46	11.21+-1.75
Ophiderinae	4069	303	75.69+-4.7
Acontiinae	798	97	28.93+-3.61
Plusiinae	120	10	2.59+-0.91
Stictopterinae	1378	63	13.61+-1.67
Euteliinae	162	34	13.12+-3.33
Nolinae	77	19	8.06+-2.92
Sarrothripinae	695	59	15.39+-2.23
Chloephorinae	1104	79	19.48+-2.35
Amphipyrinae	2015	61	11.86+-1.37
Acronictinae	14	3	1.17+-1.01
Agaristinae	27	3	0.86+-0.59
Hadeninae	374	15	3.13+-0.77
Total	34477	1642	358.87+-8.7

author from *Pinus* flowers (see Appendix V). When the Brumas samples are considered as a whole, Noctuidae (with 16291 individuals and 910 species, alpha value of 208.09+-7) and Geometridae (8245 individuals and 276 species, alpha 55.02+-3.05) were the two most diverse families as shown in Table 6.4. This trend was also evident in samples from Genting (mature secondary rain forest not far from Kuala Lumpur) in Peninsular Malaysia (Barlow & Woiwod, 1989), except the samples in Brumas produced noctuids of higher diversity than geometrids while Genting had geometrids showing a marginally higher diversity. This could be partly attributable to Barlow & Woiwod using a Rothamsted light-trap, which is more efficient in sampling geometrids, and also because many common noctuids have a wide ecological range (more widespread), and tend to displace geometrids in more disturbed habitats (Holloway, 1987a).

In contrast, most of the species which were collected only at the primary forest in Danum (see Table 3.4, Appendices III & IV) appeared to be specialists of undisturbed lowland forest, e.g. *Naxa guttulata* Warren (Oenochrominae), whose congener feeds on Oleaceae, present in the botanical survey of Danum (see Table 5.9) but not Brumas. They were mostly singletons, stenotopic species with narrow niche breadth, probably most intolerant of environmental change or forest disturbance, and most prone to extinction. Many of the smaller taxonomic groups e.g. families of Bombycoidea, Cossoidea, Limacodidae, certain tribes of Geometridae, which have a high proportion of endemics or localized species of lowland forest are particularly vulnerable (Holloway *et al.*, 1992; Holloway, 1994), as lowland forest is most threatened by development, and most at risk of diversity erosion.

6.3 A note on landscape ecology in conservation

Extinction of species (in particular ultra-specialists) is a danger besetting many

developing countries shouldering the responsibility of rain forest conservation. As the rain forest becomes more and more fragmented, chances of species extinction will also increase. Samways (1994) gave a detailed account on the field of landscape ecology, in which landscape was defined as a heterogenous land area of a cluster of ecosystems, and has three basic structures namely matrix, patches, and corridors. When applied to the conditions in Borneo, the rain forest can be considered as a matrix of mostly dominant dipterocarp forest, exotic tree plantations are disturbance patches within the matrix, while corridors are movement pathways enabling migration. This leads to the controversial debate of SLOSS (single **l**arge **o**r several small) against SLOPP (single **l**arge **o**r **p**lentiful **p**atchy) concerning the size of areas designated specifically for conservation. Burkey (1989) is in favour of a single large rather than small remnant refuge patches for he believes that a species is more likely to survive in a continous tract of natural habitat than one that is divided into isolated patches, and that chance environmental impacts are less likely to induce extinction in large reserves than in smaller ones. Spellerberg (1991b) on the other hand thinks that it may be more appropriate to divide an area into very many small patches, each with many individuals, rather than a single large reserve. The difference in opinion regarding the above may each have its own merits, bearing in mind that different faunas have different requirements. What is evident from the results in the present project is the condition of the disturbance patch (here represented by the exotic tree plantations) rather than size alone which may affect the diversity of the macromoth fauna. The *Eucalyptus deglupta* plantation (30.41 ha) with a more diverse understorey produced alpha values of greater magnitude compared with bigger plantations each above 40 ha (*Acacia mangium*, *Gmelina arborea*, *Paraserianthes falcataria*) but with a less diverse understorey. The results obtained also highlighted the importance of conserving undisturbed primary forest to protect ultra-specialist species which are sensitive to

environment change, as even though plantation forest may conserve the more eurytopic or widespread species, it may not shelter the stenotopic or more restricted species.

6.4 Some recommendations for conservation of biodiversity in plantation forest

Based on the results obtained in the present project, the author has come up with the following suggestions for promoting biodiversity in forest plantations:

1. Choice of species. Different tree species vary in their ability to conserve diversity in their plantation sites as shown in this project, where *Eucalyptus deglupta* was found to be the best choice. Also Samways & Moore (1991) reported that in South Africa, exotic *Cupressus arizonica* tree patches increase orthopteran species richness and abundance, while exotic *Pinus roxburghii* and *P. ellioti* patches have a depressant effect. Forest managers should select tree species with a view to enrich the area's biodiversity, and native tree species should also not be overlooked.

2. Harvesting of commercial tree plantations should be staggered so that plantations of various ages and species are present if possible in a continous tract. This is to enable migration of species from a plantation that is being logged into the safe haven of a suitable nearby plantation.

3. Do not over-manage forest plantations. Unlike cash crops like cocoa or rubber, a forest plantation should best be left on its own after the initial planting stages. Various understorey plants such as legumes may even enrich the soil with nitrogen fixation.

4. Chemical control in the form of herbicides or pesticides should only be used with the utmost care. A richer understorey would encourage a more diverse community of arthropods including predators and parasitoids, which helps to stabilize the plantation ecosystem. The knockdown samples in this project produced numerous species of ant predators as well as

Table 6.5 Predators/parasitoids from knockdown samples, Brumas 1992/93

N = Number of individuals

S = Number of species

	A. mangium		*E. deglupta*		*E. d. Understorey*		*G. arborea*		*P. falcataria*		*P. caribaea*		Secondary Forest	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S
Formicidae (ants)	330	18	98	15	269	20	32	12	210	10	20	3	969	22
Chalcidoidea	7	5	2	2	6	6	3	3	1	1	2	2	110	10
Ichneumonoidea	6	6			1	1			3	3	7	3	7	6
Tachinidae			1	1			2	2						

Four sampling rounds at all sites except P. caribaea (only two).

parasitoids (Chalcidoidea, Ichneumonoidea, Tachinidae) (Table 6.5), which were particularly abundant on the vegetation sampled at Secondary Forest, and may have helped to explain its surprisingly low caterpillar load. These natural enemies are vital biocontrol agents which have a beneficial role in preventing the monoculture trees from unwanted pest outbreaks.

5. Allocate areas for permanent forest cover. Successive harvesting and planting of these plantation tree crops may exert undesirable effects on the seed bank, and weaken the potential for a diverse understorey. If permanent areas of tree plantations were available, succession in those areas would proceed unimpeded, and they would in time resemble natural forest, and increase the potential of valuable genetic material important for biodiversity conservation.

6.5 Epilogue

Plantation forests of introduced fast-growing tree species were by no means diversity deserts as evident in the findings of this project, which made comparison of biodiversity between plantation and natural forests in Sabah. This is indeed fortunate as plantation forestry seems to be the only way forward for many a developing country like Malaysia. Over the years economic pressures have wounded the Malaysian rain forest, which some regard as the price the country has to pay for progress. To many Westerners particularly those who have experienced the bewildering charms of the rain forest, and also those who have never been but nonetheless fascinated by the exciting tales brought back by enterprising explorers of days gone by, this cutting down of the rain forest for cash amounts to massacre, a bloodless murder of her tropical flora and fauna, which are defenceless when faced with the cruelty of man. Unscrupulous logging in many tropical countries in the past has produced a host of problems such as environment degradation, desertification, and a permanent loss in biodiversity. Hence the reforestation programmes undertaken by many third world countries like Malaysia are of

immense importance, but research on the impact of forest plantations towards conservation of biodiversity is strangely lacking, and this project has tried to fill in that void, but it would serve no purpose unless the information obtained could engender positive action in the form of constructive reaction.

As shown in the results of the present project, conversion of logged-over natural forest into fast-growing forest plantations has a major role to play in conservation of biodiversity. Plantation forest of introduced trees achieves this aim by helping the wounded forest to heal, to make the best of what is left, and empowering it with resilience to start anew. The various introduced plantation trees in Sabah are pioneer species which are light-demanding and capable of achieving rapid growth. Under their canopies a host of other plants, a lot of which herbaceous, but also many native tree species, managed to germinate and grow. The presence of a richer and more diverse understorey in turn attracted various faunas, the most numerous of which were undoubtedly arthropods including moths. Provided the plantations are not too heavily managed, in most cases they most often are left to grow on their own once above the age of the first couple of years, they can fulfill that conservation role more or less efficiently as seen in the relatively high diversity measures (alpha values) indicated by moths in this project.

Of course plantation forest on its own is not expected to support the whole realm of biodiversity which is enormous in any tropical rain forest. This project has pointed out the importance of keeping intact areas of pristine virgin rain forest, as indicated by the presence of moth species which were only collected from undisturbed forest, and more work should be done to further identify such seemingly threatened species, and to devise plans to prevent their extinction.

In conclusion the author can only reiterate the importance of the conservation potential

of tropical forest plantations, even though the plantation trees are introduced species which are more often than not unfairly dismissed as useless with regard to biodiversity conservation. The paucity of information on biodiversity research in forest plantations has created a state of deep misunderstanding, where prejudice is disguised as science. It is hoped that the reforestation efforts currently undertaken by third world countries such as Malaysia will receive support from the scientific community in the West, in particular those who love the rain forest, to carry out research in areas where they can be of tremendous help with their scientific knowhow and talents.

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Appendix I. Checklist of macromoths collected by light-trap at Brumas in 1991 and their recorded host plants/habitat preference^

		Am=	*Acacia mangium*					
		Ed=	*Eucalyptus deglupta*					
		Ga=	*Gmelina arborea*					
MACROLEPIDOPTERA		Pf=	*Paraserianthes falcataria*					
I. Superfamily : Cossoidea		Pc=	*Pinus caribaea*					
i. Family : Cossidae		SF=	Secondary Forest					
			Number of individuals					
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Cossus chloratoides	Holloway	2	1				2	Congener on Leguminosae: Intsia palembanica. Lowlands, hill dipterocarp forest
Cossus cinereus	Roepke			1			4	Lowland rainforest
Cossus javanus	Roepke	1				1	2	Lowland rainforest
Cossus rufipecten	Holloway	1	1				6	Lowland and lower montane forest
Cossus speideli	Holloway		2	1		2	1	Lower montane forest
Cossus telisai	Holloway		1				2	Lowland heath forest
Xyleutes adusta	Roepke						1	Alluvial, kerangas, lowland dipterocarp, mangrove and swamp forests
Xyleutes ceramica	Walker	8	18	15	9	2	68	Verbenaceae: Gmelina, Callicarpa. Tectona, Clerodendrum, Leguminosae, Bignoniaceae: Spathodea, Sonneratiaceae: Duabanga
Xyleutes malayica	Roepke				1		1	Mangrove, swamp, alluvial forest
Xyleutes mineus	Cramer		9	2	8		55	Lowland rainforest
Xyleutes quarlesi	Roepke		1	1	2		4	Lowland rainforest
Xyleutes stenoptera	Roepke						1	Lowland (limestone) and lower montane forest
Xyleutes strix	Linnaeus		3		2		18	Leguminosae: Sesbania grandiflora. Lowland alluvial forest
Zeuzera coffeae	Nietner						3	Wide range incl. Euphorbiaceae, Lauraceae, Leguminosae, Meliaceae, Myrtaceae, Rubiaceae, Flindersiaceae, Sapindaceae, Sterculiaceae, Verbenaceae
Zeuzera conferta	Walker		1	1	1	1	3	Myrtaceae: Eucalyptus, Sonneratiaceae: Sonneratia, Sterculiaceae: Theobroma, Bombacaceae: Ochroma, Barringtoniaceae: Barringtonia
Zeuzera indica	Herrich-Schaffer					1	3	Lauraceae: Phoebe, Litsea
	N	12	37	21	23	7	174	
	S	4	9	6	6	5	16	
ii. Family : Metarbelidae								
			Number of individuals					
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Squamura disciplaga	Swinhoe		1	1			1	Lauraceae: Persea (avocado), Rutaceae: Citrus
	N	0	1	1	0	0	1	
	S	0	1	1	0	0	1	
II. Superfamily : Zygaenoidea								
i. Family : Limacodidae								
			Number of individuals					
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Allothosea lola	Swinhoe	10	3	13	16	10	1	Theaceae: Camellia (tea). Lowland rainforest.
Atosia doenia	Moore		1		1	1		Leguminosae: Erythrina.
Atosia trusmadia	Holloway		2				1	
Birthama rubicunda	Walker	1	3				3	Congener on Rhizophoraceae: Rhizophora. Lowland, lower montane, hill dipterocarp, coastal forest
Birthamoides junctura	Walker						4	Anacardiaceae: Mangifera, Ebenaceae: Diospyros
Birthamula chara	Swinhoe	1	2		1		3	Palmae: Elaeis (oil palm). Alluvial, coastal, swamp, heath forest
Birthosea bisura	Moore					1		Palmae: Elaeis, Metroxylon, Rubiaceae: Coffea, Sapindaceae: Nephelium, Euphorbiaceae: Ricinus, Lythraceae: Lagerstroemia, Zingiberaceae (ginger)
Cania bandura	Moore	65	33	14	14	4	29	Ebenaceae: Diospyros discolor, Palmae. Lowland, lower montane forest
Cania guichardi	Holloway				1			Lowlands
Cania striola	Hering	5	2	1	1		1	Theaceae: Camellia (tea). Lowlands, alluvial, hill dipterocarp forest

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Cania styx	Holloway			1				
Chalcocelis albiguttatus	Snellen	4	2	10	9	2	3	Wide range incl. Leguminosae: Acacia mangium, Myrtaceae: Eugenia, Rubiaceae: Coffea, Euphorbiaceae, Flacourtiaceae, Palmae: Cocos
Darna bradleyi	Holloway	1						Palmae: Elaeis guineensis (oil palm)
Darna diducta	Snellen	1	1	1	1			Leguminosae: Acacia mangium, Palmae: Cocos, Elaeis, Pinanga, Myrtaceae: Eugenia, Sapindaceae, Sterculiaceae, Annonaceae, Musaceae
Darna metaleuca	Walker	26	7	14	72	2	2	Bombacaceae: Bombax. Lowland alluvial and hill dipterocarp forest
Darna trima ajavana	Holloway					1		Wide range incl. Leguminosae: Acacia mangium, Palmae: Elaeis, Cocos, Myrtaceae, Gramineae, Rutaceae, Sterculiaceae, Rubiaceae, tea, banana
Darna tuaranensis	Holloway	1						Sterculiaceae: Theobroma (cocoa)
Demonarosa diagonalis	Holloway				1		2	Lowland rainforest
Demonarosa mediodorsata	Hering						1	Lowland rainforest, occasionally montane
Flavinarosa holoxanthia	Hampson						1	Montane forest
Griseothosea cruda	Walker	2	1	2	4	5	1	Lowland rainforest, swamp, dry heath forest, occasionally montane
Hyphormides argentipunctata	Hering		2		1		1	Lowland rainforest
Idonauton apicalis	Walker		1	2	5		2	Palmae: Cocos
Limacosilla pirifera	Hering	12						Lowlands
Marsuplectra parasina	Hering	1	1	1			1	Wet heath forest (kerangas), occasionally lowland, lower montane, hill dipterocarp forest
Narosa concinna	Swinhoe	1	1				1	Lowlands, mangrove
Narosa nagani	Holloway				1			Hill dipterocarp forest
Narosa rosipuncta	Holloway			1				
Narosa velutina	Walker		1				1	Lowland rainforest
Nirmides ?basalis	Walker				1			
Nirmides basalis	Walker	4	13	1	1	3	10	Lowland, swamp, dry heath, hill dipterocarp, alluvial, lower montane forest
Nirmides flavissima	Holloway						1	Lowland forest
Nirmides purpurea	Holloway						1	Lowland rainforest
Parasa sundalepida	Holloway				1	1		Wide range incl. Palmae: Cocos, Rubiaceae: Coffea, Leguminosae: Acacia, Euphorbiaceae: Aleurites
Phocoderma velutina	Kollar		1				2	Anacardiaceae: Mangifera, Lannea, Euphorbiaceae: Sapium, Combretaceae: Terminalia, Bombacaceae: Bombax. Lowland rainforest
Pseudidonauton bhaga	Swinhoe	14		1			1	Congener on Leguminosae: Dalbergia. Lowland rainforest
Scopelodes albipalpalis	Hering		1		1		4	Lowland, wet heath (kerangas) forest
Scopelodes pallivittata	Snellen		9	2	17	1	21	Musaceae: Musa, Sterculiaceae: Theobroma cacao, Sapindaceae: Nephelium
Scopelodes unicolor	Westwood		7		3		9	Sterculiaceae: Theobroma, Myrtaceae: Eugenia, Euphorbiaceae: Ricinus, Sapindaceae: Nephelium and many fruit trees.
Setora cupreiplaga	Walker	1			3		3	Congener on wide range incl. Musaceae, Palmae, Sterculiaceae, Rubiaceae, Sapindaceae, Theaceae, Rutaceae, Solanaceae, Zingiberaceae
Setora cupreistriga	Walker	12	31	16	28	4	36	See S. cupreiplaga above
Setora tamsi	Hering			1			1	See S. cupreiplaga above
Setothosea asigna	van Eecke	3	56	10	10	1	69	Palmae: Elaeis, Cocos. Lowland, hill dipterocarp, lower montane, alluvial, kerangas forest
Susica heringi	Holloway	1	1				1	Palmae: Elaeis (oil palm). Lowland dipterocarp, heath, lower montane forest
Thosea borneensis	Hering	1	1				3	Wide range incl. Dipterocarpaceae: Shorea, Leguminosae, Musaceae, Theaceae, Rutaceae, Myrtaceae, Rubiaceae, Anacardiaceae, Punicaceae
Thosea rotundata	Holloway				1			Lowland heath forest (kerangas)
Thosea trifurca	Holloway		2					Lower montane forest
Thosea vetusinua	Holloway	1		2	3		1	Lowlands
Thosea vetusta	Walker				1		1	Palmae: Elaeis (oil palm), Musaceae: Musa, Theaceae: Camellia, Araceae: Acorus, Sterculiaceae: Theobroma (cocoa). Lowlands
	N	168	185	93	198	36	222	
	S	22	26	18	26	13	34	
III. Superfamily : Bombycoidea								
i. Family : Lasiocampidae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Euthrix laeta	Walker				1		1	Grass feeder, Leguminosae: Dalbergia

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Gastropacha leopoldi	Tams		2	5	2	2	4	Apocynaceae: Carissa. Congener on Leguminosae: Enterolobium, Pithecellobium, Euphorbiaceae: Baccaurea, Aporusa
Hallicarnia albipectus	Walker						3	Lowlands, dry heath, coastal, lower montane forest
Kunugia austroplacida	Holloway				1			Lowland, montane forest
Kunugia basimacula	Walker				1	4		Lowlands
Kunugia basinigra	Roepke					1		Upper montane forest
Kunugia ferox	Holloway		1					Lowland forest
Lebeda cognata	Grunberg						1	Ulmaceae: Trema orientalis, Rutaceae: Citrus, Rosaceae: Rosa (garden rose), Bombacaceae: Durio. Lowland rainforest
Metanastria gemella	Lajonquiere		1	1	1	1	1	Congener on wide range incl. Leguminosae: Acacia, Albizia, Verbenaceae: Gmelina, Myrtaceae: Eucalyptus, Dipterocarpaceae: Shorea, Sterculiaceae
Odonestis vita	Moore						1	Myrtaceae: Eugenia, Psidium, Lythraceae: Lagerstroemia. Lowlands.
Paralebeda lucifuga	Swinhoe	3	19	5	1	1	31	Melostomataceae: Melastoma malabathricum, Sapindaceae: Nephelium, Rubiaceae: Coffea
Paralebeda uniformis	Holloway	2				2		Verbenaceae: Gmelina arborea, Rutaceae: Citrus, Sapotaceae: Palaquium. Montane, lowland forest
Suana concolor	Walker	1		6	2	1	2	Wide range incl. Dipterocarpaceae: Shorea, Leguminosae: Acacia, Albizia, Myrtaceae: Eucalyptus, Verbenaceae, Sterculiaceae, Fagaceae, Theaceae
Suana riemsdyki	Heylaerts	3	2		2		5	Lowland, lower, upper montane forest
Takanea diehli	Lajonquiere	2	1		3	2	11	Lowland rainforest
Trabala ganesha	Roepke		5	3	3		18	Congener on Euphorbiaceae: Macaranga. Lowland rainforest
Trabala irrorata	Moore						2	Euphorbiaceae: Ricinus, Dipterocarpaceae: Shorea, Myrtaceae: Eugenia, Eucalyptus, Melastomataceae: Melastoma. Lowland, lower montane forest
Trabala pallida	Walker		1		1	1		Melastomataceae: Melastoma, Lythraceae: Lagerstroemia, Lauraceae: Persea, Myrtaceae: Psidium, Punicaceae, Sapindaceae, Combretaceae
	N	11	32	20	18	15	80	
	S	5	8	5	11	9	12	
ii. Family : Bombycidae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Ernolatia moorei	Hutton						2	Congener on wild fig Moraceae: Ficus elastica, F. benjaminiana, F. leucanthatoma. Upper montane forest
Gunda javanica	Moore	1	1	1	2	1	6	Congener on Moraceae: Ficus spp. Lowland rainforest
Mustilia dierli	Holloway						1	Lowlands to 2000m
Ocinara albicollis	Walker		2			1	1	Congener on Moraceae: Ficus, Artocarpus.
Penicillifera apicalis	Walker	1	7	2	1	1	5	Lowlands to upper montane
Prismosticta tiretta	Swinhoe		1		1		1	Lowlands
Trilocha friedeli	Dierl						4	Congener on Moraceae: Ficus, Streblus. Hill dipterocarp, lower montane forest
	N	2	11	3	4	3	20	
	S	2	4	2	3	3	7	
iii. Family : Saturniidae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Samia tetrica	Rebel		1				2	Congener on wide range incl. Lythraceae: Lagerstroemia indica, Euphorbiaceae: Ricinus communis (castor oil plant)
	N	0	1	0	0	0	2	
	S	0	1	0	0	0	1	
iv. Family : Sphingidae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Acherontia lachesis	Fabricius	1	6	1	2		26	Wide range incl. Solanaceae, Verbenaceae: Gmelina arborea, Leguminosae, Labiatae, Compositae, Convovulaceae: Merremia, Euphorbiaceae
Acosmeryx anceus	Stoll						1	Leeaceae: Leea, Vitaceae: Vitis, Cayratia, Cissus. Regenerating alluvial forest
Acosmeryx shervillii	Boisduval		2		6		32	Vitaceae: Cayratia, Cissus, Vitis, Leeaceae: Leea, Dilleniaceae: Dillenia, Actinidiaceae: Saurauia
Ambulyx canescens	Walker						3	Dipterocarpaceae: Shorea lepidota
Ambulyx clavata	Jordan						1	Lythraceae: Lagerstroemia. Lowlands

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Ambulyx obliterata	Rothschild		1				5	Lowland rainforest
Ambulyx pryeri	Distant						13	Apocynaceae: Plumeria (frangipani). Lowlands to 2600m
Ambulyx subocellata	Felder	1						Burseraceae: Canarium album, Anacardiaceae: Lannea (Odiner wodier), Buchanania latifolia
Ambulyx substrigilis	Westwood						1	Dipterocarpaceae: Dipterocarpus, Meliaceae: Aglaia, Lythraceae: Lagerstroemia
Ambulyx tattina	Jordan						1	Lowland forest to 2600m
Amplypterus panopus	Cramer	1						Anacardiaceae: Mangifera indica (mango), Dracontomelum, Rhus, Bombacaceae: Durio zibethinus (durian), Guttiferae: Calophyllum, Garcinia
Callambulyx rubricosa	Walker		1				2	Congener on elm in India. Lowland forest
Cechenena aegrota	Butler		2		3		20	Rubiaceae: Psychotria. Regenerating alluvial forest
Cechenena helops	Walker	1	1		2		15	Vitaceae: Tetrastigma.
Cypa decolor	Walker						2	Lowlands to 2600m
Daphnis hypothous	Cramer		2	1	2		31	Rubiaceae: Anthocephalus chinensis, Uncaria (gambier), Cinchona, Wendlandia paniculata, Ixora, Pavetta, Apocynaceae: Alstonia
Daphnis placida	Walker						1	Apocynaceae: Alstonia, Tabernaemontana. Upper montane forest
Daphnusa ocellaris	Walker	1	4		2		11	Bombacaceae: Durio zibethinus, Sapindaceae. Lowland forest
Degmaptera olivacea	Rothschild						1	Congener on Fagaceae: Quercus. Lower montane
Elibia dolichus	Westwood				1	1	19	Actinidiaceae: Saurauia, Leeaceae: Leea, Vitaceae: Cayratia, Tetrastigma. Lowlands
Enpinanga borneensis	Butler		6	2	1	1	47	Dilleniaceae: Dillenia (Wormia), Tetracera
Eurypteryx bhaga	Moore						2	Apocynaceae: Alstonia. Lowland forest
Gnathothlibus erotus	Cramer		1				1	Convolvulaceae, Dilleniaceae, Melastomataceae, Rubiaceae, Vitaceae: Cayratia, Cissus, Parthenocissus, Vitis, Escalloniaceae
Hippotion rosetta	Swinhoe						2	Rubiaceae: Borreria. Lowland open habitats
Macroglossum corythus	Walker						2	Rubiaceae: Morinda citisfolia, Paederia foetida, Guettarda, Strychnaceae: Strychnos nuxvomica. Upper montane forest
Megacorma obliqua	Walker						2	Disturbed forest habitats
Meganoton nyctiphanes	Walker						5	Verbenaceae: Symphorema
Panacra busiris	Walker		1			1	1	Araceae: Lasia, Pothos. Lowlands
Panacra dohertyi	Rothschild	3	5		6		33	Lowlands
Panacra malayana	Rothschild & Jordan		1		1			Hypoxidaceae: Curculigo. Lowlands
Panacra mydon	Walker		2			1		Araceae: Colocasia antiquorum, Amorphophallus, Caladium, Arisaema curvatum, Alocasia, Dieffenbachia, Homalonema, Vitaceae: Vitis
Panacra variolosa	Walker		1			2	3	Araceae: Scindapsus. Lowlands
Psilogramma menephron	Cramer		1	1	1		5	Wide range incl. Verbenaceae: Gmelina arborea, Callicarpa, Tectona, Bignoniaceae, Flacourtiaceae, Labiatae, Meliaceae, Oleaceae, Scrophulariaceae
Rhagastis rubetra	Rothschild & Jordan						6	Lowland forest
Rhyncholaba acteus	Cramer				1		1	Leeaceae: Leea, Vitaceae: Vitis, Begoniaceae, Commelinaceae, Araceae
Theretra alecto	Linnaeus			1			2	Leeaceae: Leea, Dilleniaceae: Dillenia, Tetracera, Vitaceae: Cissus, Vitis, Rubiaceae: Psychotria, Rubia, Actinidiaceae: Saurauia
Theretra boisduvali	Bugnion				3		3	Vitaceae: Cissus
Theretra clotho	Drury	4	5	3	10		22	Leeaceae: Leea, Dilleniaceae: Dillenia, Vitaceae: Cayratia, Cissus, Vitis, Malvaceae: Hibiscus, Araceae, Begoniaceae, Onagraceae, Urticaceae
Theretra latreillei	MacLeay	5	7	3	4		39	Actinidiaceae: Saurauia, Balsalminaceae: Impatiens, Vitaceae: Vitis, Tetrastigma, Cayratia, Cissus, Lythraceae, Begoniaceae, Dilleniaceae, Onagraceae
Theretra nessus	Drury		1		3		7	Barringtoniaceae, Convovulaceae, Dioscoreaceae, Araceae, Leguminosae, Rubiaceae, Theaceae, Amaranthaceae, Balsaminaceae, Cucurbitaceae
Theretra rhesus	Boisduval	1	55	6	36	1	191	250m to 1200m
Theretra suffusa	Walker			2				Melastomataceae: Melastoma
	N	18	105	20	84	7	559	
	S	9	20	9	17	6	37	
IV. Superfamily : Geometroidea								
i. Family : Drepanidae								
1. Subfamily : Drepaninae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Trotothyris sp.				1				
Albara hollowayi	Watson	2	4		1	2	2	Congener on Rosaceae: Rubus. Lowland to lower montane

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Albara reversaria	Walker		6	2	2		6	Lowland to lower montane
Callidrepana patrana	Moore		7	1	1	3	10	Congener on Rhizophoraceae: Bruguiera
Callidrepana praeusta	Warren						2	
Callidrepana pulcherrima	Hampson		1		1		1	
Callidrepana splendens	Warren	1	1					
Canucha specularis	Moore		2		1		14	Lowland to lower montane
Ectothyris trifenestrata	Swinhoe		1					?Lowland
Euphalacra nigridorsata	Warren						1	?Lowland
Hyalospectra pustularia	Walker			1		1		?Montane
Leucoblepsis neoma	Swinhoe						1	Lowland
Leucoblepsis renifera	Warren					1		
Macrauzata ?submontana	Holloway					1		?Lowland
Nordstroemia duplicata	Warren						2	?Montane
Strepsigonia ?placida	Swinhoe					1		Lower montane
Strepsigonia affinis	Warren		4	1	1			Lowland
Strepsigonia quadripunctata	Walker		1			1		Lowland, lower montane
Teldenia specca	Wilkinson	1	10	2	4	3	12	Congeners on Combretaceae: Terminalia, Tiliaceae: Grewia, Dipterocarpaceae: Hopea. Lowland to upper montane
Tridrepana albonotata	Moore		2	1			3	Lowland
Tridrepana flava contracta	Watson		1		1	1		Lowland, montane
Tridrepana fulvata	Snellen		2	1	3		6	Sapindaceae: Nephelium lappaceum. Lowland
Tridrepana microcrocea	Gaede	6	32	11	12	7	38	Lowland
Tridrepana sp.					1			Lowland, lower montane
Tridrepana subtusmaculata	Gaede	1						
Trotothyris abnormalis	Warren		1					Lowland, lower montane
	N	11	75	21	28	21	98	
	S	5	15	9	11	10	13	
2. Subfamily : Oretinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Oreta ?bicolor	Warren				1			Congener on Rubiaceae: Mussaenda, Randia, Pavetta. Lowland
Oreta carnea	Butler			2	2	2	18	Lowland
Oreta fulgens	Warren						1	Lowland
Oreta rubromarginata	Butler						2	Lowland
Oreta singapura	Swinhoe		1					?Montane
	N	0	1	2	3	2	21	
	S	0	1	1	2	1	3	
ii. Family : Uraniidae								
1. Subfamily : Uraniinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Lyssa menoetius	Hopffer	4	21	2	4		108	Congener on Euphorbiaceae: Endospermum malaccense. Lowland
	N	4	21	2	4	0	108	
	S	1	1	1	1	0	1	

2. Subfamily : Microniinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Micronia astheniata	Guenee	4	1			2	6	Myrtaceae: Eugenia malaccensis, Euphorbiaceae: Endospermum malaccense. Lowland
Strophidia fasciata	Cramer			1			2	
	N	4	1	1	0	2	8	
	S	1	1	1	0	1	2	
iii. Family : Epiplemidae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Gathynia sp.					1			
Dirades rufinervis	Holloway		2	1		1		Congeners on Rubiaceae: Morinda, Canthium/Plectronia, Vangueria, Randia, Adina. ?Lower montane
Dirades sp. nr. unicauda	Hampson			1		1	1	?Lowland
Epiplema conflictaria	Walker	2	4	2	2	15	3	Annonaceae: Cananga odorata, Artabotrys. Lowland
Epiplema instabilata	Walker	7	1	57	2	2		Verbenaceae: Premna. Congeners on Verbenaceae: Gmelina, Mussaenda, Oleaceae: Olea, Linociera. ?Lowland
Epiplema nivosaria	Walker			1				
Epiplema quadricaudata	Walker	13	36	12	30	26	11	Rubiaceae: Cinchona, Anthocephalus chinensis, Adina. Lowland
Epiplema sp.				1				
Gathynia mesilauensis	Holloway					1		Congener on Rubiaceae: Randia. Montane
Gathynia pernigrata	Warren				1			
Orudiza protheclaria	Walker				1			Bignoniaceae. Lowland, secondary forest
Phazaca erosioides	Walker	5	5	4	7	35	6	Lowland
	N	27	48	79	44	81	21	
	S	4	5	8	7	7	4	
iv. Family : Geometridae								
1. Subfamily : Oenochrominae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Alex palparia	Walker	1						Lowland, lower montane
Celerena signata	Warren	6	12	1	14		65	Lowland, disturbed forest
Derambila propages	Prout					1		
Derambila satelliata	Walker		5			1		
Eumelea rosalia	Stoll	1	2		3	2	5	Congener on Euphorbiaceae: Macaranga. ?Lowland
Heteralex rectilineata	Guenee		1	1	1	2	3	Lowland
Noreia sp.					1			Congener on Sapotaceae: Mimusops
Ozola ?basisparsata	Walker	8	5	8	24	22	11	Congener on Verbenaceae: Gmelina, Premna. ?Lowland
Ozola ?minor	Moore	3	2	20	3	4	1	Verbenaceae: Gmelina arborea, Premna
Ozola pannosa	Holloway	2				1	5	Lowland to montane
Sarcinodes restitutaria	Walker						2	Lowland, lower montane
	N	21	27	30	46	33	92	
	S	6	6	4	6	7	7	
2. Subfamily : Geometrinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Gelasma sp.			1	3	1		1	

Species	Authority	Number of individuals						Recorded host plants/habitat preference
		Am	Ed	Ga	Pf	Pc	SF	
?Idiochlora pudentifimbria	Prout	2	6		3	3		
Agathia eromena	Prout						1	Genus on Apocynaceae: Carissa spinarum, Nerium odorum, Tabernaemontana coronaria
Agathia exquisita	Warren				1		1	Congeners on Apocynaceae: Nerium, Tabernaemontana, Ichnocarpus, Rubiaceae: Gardenia, Guttiferae: Ochrocarpus, Asclepiadaceae. Lowland
Agathia hilarata	Guenee			1			1	Apocynaceae: Trachelospermum, Carissa. Lowland
Agathia obsoleta	Warren				1		1	Lowland
Agathia rubrilineata	Warren		1				2	Congener on Melastomataceae: Memecylon. Lowland to lower montane
Anisozyga ?textilis	Butler		1					Congener on unripe guava fruit (Myrtaceae). Lowland
Aporandria specularia	Guenee		3				1	Anacardiaceae: Mangifera indica (mango), Rhizophoraceae: Rhizophora, Sapindaceae: Litchi (longan), Loranthaceae: Loranthus. Lowland
Archaeobalbis subtepens	Walker		1					Congener on Araliaceae: Schefflera. Lowland
Archaeobalbis sundana	Holloway	2	2		2		3	Lowland
Archaeobalbis urapteraria	Walker		3				2	Montane
Berta ?zygophyxia	Prout					2		Sapindaceae: Nephelium lappaceum. Lowland
Berta annulifera	Warren		9	6	4	3	4	Lowland
Berta chrysolineata	Walker		1			2	1	Anacardiaceae: Mangifera, Sapotaceae: Chrysophyllum cainito (star-apple), Euphorbiaceae: Ricinus. Lowland
Chloromachia albisparsa	Walker		1		1		1	Lowland
Chloromachia rufimargo	Warren						1	Myrtaceae: Myrtus. Congeners on Myrtaceae: Eugenia jambolana. Lowland
Comibaena albicatena	Warren		1	1			2	Congeners on Leguminosae: Acacia, Anacardiaceae, Rhamnaceae: Zizyphus, Compositae: Tagetes, Myrtaceae: Myrtus, Rutaceae. Montane
Comibaena attenuata	Warren	9	10	5	15	9	7	Sapindaceae: Nephelium. Lowland
Comibaena biplaga	Walker	1	3				2	Lowland
Comibaena quadrinotata	Butler						3	Lowland
Comostola cedilla	Prout	1	2		4	2		Congeners on Viscaceae: Arceuthobium, Apocynaceae: Cerbera, Rhizophoraceae: Ceriops (inflorescence feeder). Lowland
Comostola demeritaria	Prout	1			2			Lowland
Dindica polyphaenaria	Guenee		1				2	Lauraceae: Litsea polyantha. Lowland
Dooabia ?lunifera	Moore		1					Montane
Dooabia puncticosta	Prout		1		1	1	3	Lowland
Dysphania transducta	Walker		2		2	1	4	Rhizophoraceae: Carallia eugenoides, congeners on Guttiferae: Garcinia. Lowland
Epipristis nelearia	Guenee	1			1	5	7	Lowland
Episothalma sp. nr. robustaria	Guenee						1	Lowland
Euxena albiguttata	Warren				1			?Lowland
Gelasma ?acutissima	Walker	2	1		3	2	1	Congeners on Combretaceae: Anogeissus, Terminalia, Myrtaceae: Eugenia, Syzygium, Dipterocarpaceae: Shorea, Euphorbiaceae: Phyllanthus
Gelasma ?chromatocrossa	Prout						1	Lowland
Gelasma ?magnipuncta	Prout	32	7	9	40	26	11	
Gelasma ?waterstradti	Prout				1		2	Lowland
Gelasma sp.		7			1	4		
*Gelasma sp. no. 10670**		1		1				
Gelasma thetydaria	Guenee		1					Montane
Idiochlora ?subtusumbrata	Fuchs	3	6	1	3	11	1	Congener on Compositae: Helianthus annuus (sunflower)
Lophomachia semialba	Walker		1	1	1	1	3	?Flower feeder. Lowland
Metallolophia vitticosta	Walker		3		1	1	3	Lowland
Mixochlora vittata	Moore		1					Lower montane
Neobalbis flavibasalis	Warren						2	Lowland, lower montane
Neohipparchus xeromeris	Prout						1	?Montane
Oenospila ?flavifusata	Walker		3		2	2		Anacardiaceae: Anacardium occidentale, Sapindaceae: Nephelium, Sapotaceae: Chrysophyllum, Melastomataceae: Memecylon, Myrtaceae. Lowland
Ornithospila esmeralda	Hampson						2	Genus from lowland to montane
Ornithospila submonstrans	Walker	11	14	5	13	11	14	Dipterocarpaceae: Shorea parvifolia
Ornithospila succincta	Prout	9	10	1	7	5	20	
Orthorisma netunaria	Guenee						3	

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Pachyodes erionoma	Swinhoe			1	1			Montane
Paramaxates polygrapharia	Walker		1		1			Lowland
Paramaxates vagata	Walker	1	1		1		4	Lowland, montane
Pingasa ?chlora	Stoll						1	Lauraceae: Litsea polyantha
Pingasa chlora	Stoll	3			2		1	Leguminosae: Xylia, Lauraceae: Litsea polyantha, ?Buchanania (Anacardiaceae). Lowland, ?disturbed habitats
Pingasa rubicunda	Warren	1	1	2	1	1	8	Lauraceae: Litsea polyantha, Dipterocarpaceae: Shorea acuminata (flower feeder). Lowland
Pingasa ruginaria	Guenee	17	21	5	31	3	98	Lauraceae: Litsea, Rubiaceae, Sterculiaceae, Sapindaceae: Nephelium, Rhamnaceae, Combretaceae, Leguminosae. Lowland, secondary forest
Pingasa subviridis	Warren				1			Lauraceae: Litsea polyantha. Lowland
Pingasa tapungkanana	Strand	8	1	4	3	1	4	Lauraceae: Litsea polyantha. Lowland
Pingasa venusta	Warren						3	Lauraceae: Litsea polyantha. Lowland
Prasinocyma floresaria	Walker	3	27	9	18	12	15	Congener on Combretaceae: Terminalia. Lowland
Pyrrhorachis pyrrhogona	Walker					1	1	Lowland
Rhomborista semipurpurea	Warren				1		1	Congener on Leguminosae: Bauhinia. Lowland
Spaniocentra ?megaspilaria	Guenee	1				3	1	Lowland
Spaniocentra apatella	West	2						Montane
Spaniocentra megaspilaria	Guenee	2					2	Lowland
Spaniocentra spicata	Holloway		1					Lowland
Tanaorhinus rafflesii	Moore	4	19	3	7	4	65	Fagaceae: Quercus. Lowland to montane
Thalassodes ?griseifimbria	Prout	6	17	11	13	5	69	Genus on Anacardiaceae: Mangifera indica (mango), Sapindaceae: Schleichera trijuga. Congener on Euphorbiaceae, Barringtoniaceae. Montane
Thalassodes ?semihyalina	Walker	3	2	2	1	3	9	Congeners on Rosaceae: Rosa, Lythraceae: Lagerstroemia, Ulmaceae: Trema, Connaraceae: Rourea, Guttiferae: Calophyllum, Annonaceae. Lowland
Timandromorpha energes	Prout		1					Lower montane
Uliocnemis biplagiata	Moore	10	8	9	6	4	5	Leguminosae: Acacia auriculiformis. Lowland
Uliocnemis partita	Walker						2	Verbenaceae: Avicennia alba, Anacardiaceae: Buchanania, Mangifera. Lowland
	N	143	197	80	198	128	404	
	S	27	41	20	38	28	52	
3. Subfamily : Sterrhinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Idaea sp.		1			1			
?Ptochophyle sp.			1	1			2	
Anisodes ?dithyma	Prout			1		1		Congeners on Myrtaceae: Myrtus, Syzygium, Compositae, Leguminosae: Dalbergia, Annonaceae: Uvaria, Anacardiaceae: Mangifera. ?Lowland
Anisodes ?illepidaria	Guenee			1				Congeners on Annonaceae: ?Polyalthia, Connaraceae: Rourea, Celastraceae: Salacia, Lauraceae: Alseodaphne, Cinnamomum. Montane
Anisodes ?monetaria	Guenee						1	
Anisodes ?thermosaria	Walker	2	8	3		5		
Anisodes argyromma	Warren						1	Lowland
Anisodes rotundata	Warren						1	Lowland
Anisodes sp.			1			1	1	
Antitrygodes divisaria	Walker	3	9	4	6	6	16	Verbenaceae, Rubiaceae: Hymenodictyon, Mussaenda, congener on Rubiaceae: Anthocephalus cadamba, Marantaceae: Maranta. Lowland
Apostegania rectilineata	Swinhoe			1	1	1		
Chrysocraspeda ?remutans	Prout		2					Congener on Myrtaceae: Eugenia. Lower montane, limestone
Chrysocraspeda comptaria	Swinhoe		3	2	3	3	1	Lowland
Chrysocraspeda sp.					1			
Erythrolophus ?fascicorpus	Swinhoe			1	1	3		
Gnamptoloma aventiaria	Guenee	13	2	6	54	10	1	Leguminosae: Paraserianthes falcataria, Acacia confusa, Gramineae. Congener on Myrtaceae: Eucalyptus deglupta, Umbelliferae: Oenanthe javanica
Idaea ?phaeocrossa	Prout	1		1				
Idaea ?purpurea	Hampson	1	2	1		2		Lowland

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Idaea craspedota	Prout	1	4	1		3	4	Lowland
Idaea egenaria	Walker					1		
Idaea sp. 1		4			1	4		
Idaea sp. 2		3		5	3	2		
Organopoda ?acmaea	Prout		1				2	
Organopoda carnearia	Walker						1	Lowland
Problepsis plenorbis	Prout		1				1	Oleaceae: Jasminum. Congener on Oleaceae: Olea. Lowland
Ptochophyle cf. tristicula	Swinhoe		1					Congeners on Combretaceae: Terminalia, Sonneratiaceae: Sonneratia, Myrtaceae: Eugenia
Ptochophyle ozophanes	Prout		1	2		1		Lowland
Ptochophyle sanguinipuncta	Swinhoe		2			1		Lowland
Ptochophyle sp.					1		1	
Scopula sp.			1			1	1	Congeners on Moraceae: Ficus, Gramineae: Oryza sativa, Cruciferae: Brassica chinensis (Chinese cabbage), Sapindaceae: Nephelium lappaceum
*Scopula sp. no. 10765**		50	6	48	52	27	2	Congeners on Cucurbitaceae: Cucumis sativus (cucumber), Oleaceae: Jasminum, Combretaceae: Lumnitzera, Amaranthaceae: Deeringia
Scopula tenuispersata	Fuchs	4	6	6	7	21	9	Congeners on grasses. Lowland
Scopula vacuata	Guenee	7	22	2	7	18	19	Lowland
Scopula vacuata ab. subdecorata	Warren		4	3	1		5	Lowland
Sterrhinae 1		17		10	36	2		
Sterrhinae 2		1	1	1			1	
Symmacra solidaria	Guenee	1	2	1	3			Lowland
Zythos obliterata	Warren	1	11		3		34	Lowland
Zythos strigata	Warren	3	14	1	9	7	32	Lowland
Zythos turbata	Walker	4	8	2	3	2	16	?Oleaceae or Rubiaceae. Lowland
	N	117	113	104	193	122	152	
	S	18	24	23	19	22	22	
4. Subfamily : Larentiinae								Mainly montane species
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Acolutha pictaria	Moore		1					Congener on Palmae: Calamus subinermis. Lowland
Chloroclystis ?dilatata	Walker			1				Euphorbiaceae: Glochidion. Congeners on Euphorbiaceae: Breynia, Actephila, Combretaceae: Terminalia. Montane
Eois memorata	Walker		1		1	1		Lowland
Eois phaneroscia	Prout		1			1		Lowland
Eois sp. 1					2			
Eois sp. 2		1				1	2	
Gymnoscelis confusata	Walker						1	Congeners on Leguminosae: Cassia, Anacardiaceae: Mangifera, Cucurbitaceae: Hodgsonia, Rutaceae: Citrus, Araliaceae: Schefflera. ?Lower montane
Gymnoscelis polyodonta	Swinhoe					1		Congener on Melastomataceae: Memecylon. ?Montane
Pomasia vernacularia	Guenee	3	5	5	10	12	7	Lowland to montane
Sauris interruptata	Moore		1					Congeners on Myrtaceae: Syzygium, Lauraceae: Cinnamomum, Euphorbiaceae: Excoecaria, Loranthaceae: Dendrophthoe, Sapindaceae, Lythraceae
Scotocyma sp.							1	
Ziridava xylinaria	Walker					1		Lowland
	N	4	9	6	13	17	11	
	S	2	5	2	3	6	4	
5. Subfamily : Ennominae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Abaciscus ?lutosus	Holloway	1						

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Abaciscus intractabilis	Walker		1				3	Secondary lowland forest
Abaciscus lutosus	Holloway				1			Lowland, lower montane forest
Achrosis calcicola	Holloway						6	Lowland, lower montane forest
Achrosis fulvifusa	Warren	1	32	4	2	2	13	Rubiaceae: Ixora. Lowland dipterocarp, alluvial forest
Achrosis multidentata	Warren	2		2	1		14	Lowland forest
Achrosis recitata	Holloway	2	5	2	2		11	Rubiaceae: Ixora. Upper montane
Achrosis spurca	Swinhoe	1	1	2			6	Lowland alluvial, dipterocarp forest
Amblychia hymenaria	Guenee					1		Lowlands, alluvial, kerangas forest
Aplochlora vivilaca	Walker		1		1			Flacourtiaceae: Casearia, Ulmaceae: Heloptelea. Alluvial, hill dipterocarp, lower montane forest
Astygisa circularia	Swinhoe	2		1	1	1	1	Genus on Rhamnaceae. Lowlands, lower montane forest
Astygisa metaspila	Walker	1	6		3		14	Lowland forest
Astygisa vexillaria	Guenee	1	2	1			3	Lowland forest
Auzeodes chalybeata	Walker	1	1		1		2	Lowland coastal, swamp, heath forest
Biston ?pustulata	Warren	1						
Biston pustulata	Warren	13	4	3	111	4	1	Leguminosae: Acacia mangium, Gliricidia
Boarmacaria herbuloti	Holloway	1			2		2	Lowland forest
Borbacha altipardaria	Holloway	2	3	3	6	4	8	Lower, upper montane forest
Bracca maculosa	Walker	3	11	4	8	5	18	Lowlands to upper montane
Bulonga schistacearia	Walker	1	2	3	8	3	9	Lowland heath, swamp, coastal, mangrove forest
Calletaera schistacea	Swinhoe		1					Limestone
Cassyma ?erythrodon	Sommerer & Stuning			1				
Cassyma erythrodon	Sommerer & Stuning		2		1		1	Lowland rainforest
Cassyma quadrinata	Guenee	3	2			3	2	Lowland rainforest
Catoria ?olivescens	Moore						1	Congener from lower to upper montane forest
Catoria sublavaria	Guenee		1			1		Lauraceae: Alseodaphne, Euphorbiaceae: Excoecaria. Wet heath (kerangas), lower montane forest
Celenna festivaria	Fabricius		2			1	2	Lowland dipterocarp, montane forest
Chorodna complicataria	Walker	6	1	2		1	5	Lowland dipterocarp forest
Cleora ?injectaria	Walker	1						
Cleora alienaria	Walker	1						Leguminosae: Paraserianthes falcataria, Lauraceae: Cinnamomum, Caprifoliaceae: Sambucus
Cleora decisaria	Walker	1261	11	79	154	74	10	Leguminosae: Paraserianthes falcataria. Lowlands
Cleora determinata	Walker	75	16	16	54	18	40	Lowland forest
Cleora injectaria	Walker	1						Rhizophoraceae: Rhizophora, Verbenaceae: Avicennia, Euphorbiaceae: Excoecaria, Meliaceae: Xylocarpus. Mangrove habitats
Cleora pupillata	Walker	1	4	6	3	1	5	Regenerating alluvial forest, cultivated lower montane area
Cleora repetita	Butler	16	4	9	1	3	2	Combretaceae: Terminalia, Verbenaceae: Premna, Lauraceae: Persea, Myrtaceae: Callistemon, Eucalyptus, Fenzlia, Rutaceae: Flindersia
Cleora tenebrata	Fletcher	2	2	1		1	5	Disturbed, forested habitats
Clepsimelea phryganeoides	Warren						1	Lower montane forest
Coremecis incursaria	Walker		2	1	2	1	5	Lowland, kerangas, hill dipterocarp forest
Coremecis maculata	Warren				1		1	Lowland, limestone forest
Corymica latimarginata	Swinhoe		2	2	1	2	11	Lowland forest
Craspedosis arycandata	Walker		3		1	2	9	Lowland, disturbed, lower montane forest
Curbia martiata	Guenee	54	40	39	17	78	50	Lowland forest
Cusiala boarmoides acutijuxta	Holloway	3			1		1	Leguminosae: Cassia, Xylia. Lowland, forested, cultivated area
Danala laxtaria	Walker	2		1	4	1	2	Secondary, hill dipterocarp, lower montane forest
Diplurodes indentata	Warren	2	9	4		2	1	Hill dipterocarp, lower montane forest
Diplurodes petras	Meyrick	1	1		1	2	5	Lowlands
Ectropidia fimbripedata	Warren	4	14	8	4	11	23	Congener on Dipterocarpaceae: Shorea robusta. Lowland, heath, lower montane forest
Ectropis bhurmitra	Walker	7	1	7	13	1		Wide range: Dipterocarpaceae, Euphorbiaceae, Leguminosae: P. falcataria, A. mangium, Myrtaceae, Rubiaceae, Verbenaceae: Gmelina, Compositae

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Ennominae no. 3**						1		
Ennominae no. 4**							1	
Eutoea heteroneurata	Guenee			2			1	Lowland, lower montane forest
Fascellina aurifera	Warren		1	1	2	2	5	Lowland rainforest
Fascellina castanea	Moore	1	2	2	2	2	9	Lauraceae: Cinnamomum. Alluvial forest
Fascellina clausaria	Walker	1	3	1	2	2	8	Lauraceae: Cinnamomum. Lowland, lower montane forest
Fascellina meligerys	Prout				1			Congeners on Lauraceae: Phoebe lanceolata, Machilus gamblei, Litsea polyantha. Lowland, alluvial, limestone forest
Fascellina punctata	Warren			1			2	Lowland, hilly rainforest
Fascellina quadrata	Holloway		1		1		1	Lowlands
Fascellina viridicosta	Holloway		1					Heath forest
Godonela ?translineata	Walker	26	2	20	76	13		
Godonela avitusaria	Walker	2	7		4	4	22	Leguminosae: Albizia procera. Lowlands to 1930m
Godonela bornusaria	Holloway			1	1	2	1	Lowland forest
Godonela mutabilis	Warren	1	1		3	1	2	Lowland forest
Godonela nora	Walker	2	7	3	22	3	21	Leguminosae: Acacia. Lowlands to 1930m
Godonela ozararia	Walker	115		2	2	1		Leguminosae: Acacia mangium. Lowland forest
Godonela translineata	Walker	100	40	47	374	77	12	Leguminosae: Paraserianthes falcataria, Delonix, Elaeagnaceae: Elaeagnus. Lowland, lower montane forest
Heterolocha ?falconaria	Walker		1					
Heterolocha pyreniata	Walker		29	4	1	1	6	Lowlands
Heterostegane insulata	Warren				1		1	Lowlands
Heterostegane subtessellata	Walker	1				1		Leguminosae: Acacia. Lowland dipterocarp forest
Heterostegane tritocampsis classeyi	Holloway	59	3	5	72			Leguminosae: Acacia, Mimosa. Lowland forest
Heterostegane urbica guichardi	Holloway					2		Leguminosae: Acacia.
Heterostegane warreni	Prout	1	3	1	1		3	Lowland, alluvial, lower montane forest
Hypephyra brunneiplaga	Swinhoe		2		1			Lowlands to 1600m
Hypochrosis binexata	Walker	39	135	42	66	8	326	Sterculiaceae: Theobroma cacao (cocoa). Lowland, secondary, lower montane forest, agricultural areas
Hypochrosis cryptopyrrhata	Walker		2	1				Leguminosae: Paraserianthes falcataria. Lowland, lower montane forest
Hypochrosis pyrrhophaeata	Walker	5	8	4	10		30	Lowland, lower montane forest
Hypomecis costaria	Guenee	3	14	2	8	3	13	Lowland, wet kerangas, lower montane forest
Hypomecis separata	Walker	3	10	3	3	9	19	Lowland forest
Hypomecis subdetractaria	Prout	1	2		1		6	Lowland, wet kerangas forest
Hypomecis tetragonata	Walker		4			1	8	Lowland, kerangas, lower montane forest
Hypomecis transcissa	Walker	52	10	3	73	9	18	Euphorbiaceae: Aleurites. Disturbed lowland forest
Hyposidra incomptaria	Walker			1			1	Guttiferae: Calophyllum, Anacardiaceae: Campnosperma, Myrtaceae: Eucalyptus, Convolvulaceae: Merremia, Combretaceae: Terminalia.
Hyposidra picaria	Walker	2				3		Leguminosae: Acacia mangium. Lowland forest
Hyposidra talaca	Walker	31	8	18	140	15	27	Wide range:Leguminosae: A. mangium, P. falcataria, Myrtaceae: Eucalyptus, Compositae, Euphorbiaceae, Moraceae, Verbenaceae
Hyposidra violescens	Hampson		5				2	Lowland, lower montane forest
Hypulia continua	Walker						3	Lowland forest
Hypulia eleuthera	Holloway	1					2	Lowland, kerangas, swampy forest
Iulotrichia decursaria	Walker	62	11	4	33	10	7	Lowland forest
Krananda lucidaria	Leech	2			1		1	Lower montane
Lomographa luciferata	Walker			1		4		Lowland to upper montane forest
Lomographa sectinota	Hampson					1	2	Lowland to lower montane forest
Luxiaria acutaria	Snellen						1	Congener on Melastomataceae: Melastoma. Lowlands to 1500m
Luxiaria emphatica	Prout		2	3	4	1	5	1000m to 2500m, upper montane
Luxiaria fictaria	Prout						1	Lowland, heath, alluvial forest
Luxiaria phyllosaria	Walker				1	1		Lowland forest

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Luxiaria submonstrata	Walker	6	8	4	8	2	10	Lowland, lower montane, upper montane forest
Luxiaria subrasata	Walker		3		3		4	Lowlands to upper montane
Macaria abydata	Guenee			1				Leguminosae: Acacia, Cassia, Sesbania, Parkinsonia, Glycine, Leucaena latisiliqua, Mimosa invisa, Sapindaceae: Nephelium litchi (flower feeder)
Mesaster albidiscata	Warren	1					1	Lowland, lower montane forest
Microcalicha delika	Swinhoe		1				1	Lowland, alluvial, mixed dipterocarp forest
Microplutodes hilaropa	Meyrick					1		Lowland, alluvial forest
Nigriblephara cheyi	Holloway					1		Lowland
Nigriblephara radula	Holloway			1				Lower montane
Nigriblephara semiparata	Walker	2	8	10	9	5	21	Lowland dipterocarp forest
Omiza lycoraria	Guenee	1	3		2		4	Lowland forest to 1800m
Ophthalmitis basiscripta	Holloway		1				1	Hill dipterocarp forest
Ophthalmitis cordularioides	Holloway						1	Lowlands, upper montane
Ourapteryx claretta	Holloway				2			Lower, upper montane forest
Ourapteryx picticaudata	Walker		1		2		3	Lower montane, dipterocarp, dry kerangas forest
Ourapteryx podaliriata	Guenee						1	Lowlands to lower montane
Parasynegia lineata	Warren	5	2	6	11	4	3	Lowland, alluvial, kerangas forest
Parasynegia sundastriaria	Holloway	4	4	2	4	4	16	Lowland forest
Pareumelea eugeniata	Guenee		1					Lowland, lower montane forest
Peratophyga trigonata	Walker		1	1			1	Lowlands to 1600m
Peratophyga venetia	Swinhoe	7	6	2	1	15	4	Lowland, heath, lower montane forest
Peratostega coctata	Warren				1	2		Lowland, alluvial, lower montane forest
Petelia delostigma	Prout	2	2		1	1	1	Lowland, lower montane forest
Petelia distracta	Walker						1	Lowland, lower montane forest
Petelia medardaria	Herrich-Schaffer	7	5	4	5	4	4	Rhamnaceae: Zizyphus, Hovenia, Gouania. Lowland, disturbed habitats
Petelia paroobathra	Prout	1	8	1	2	1	6	Lowland, hill dipterocarp, lower montane, kerangas forest
Petelia tuhana	Holloway		1					Lowland, lower montane cultivated area
Plutodes cyclaria	Guenee	5	22	7	1	12	14	Lowland, lower montane forest
Plutodes malaysiana	Holloway		10	6	1	2	4	Lowland dipterocarp, alluvial forest
Probithia exclusa	Walker	1		2	2	1	4	Myrtaceae: Eugenia. Lowland forest
Pseudalcis catoriata	Warren		1		1		1	Lowland, disturbed forest
Pseudalcis cinerascens	Warren	1	2	2	3		8	Lowland, disturbed forest
Pseudocassyma sundagraphoides	Holloway	1	1				2	Lowland forest
Psilalcis calcicola	Holloway					7		Lower montane, dipterocarp forest
Racotis inconclusa	Walker	2	4	1	3		5	Lauraceae: Alseodaphne, Annonaceae: Saccopetalum. Lowland to upper montane forest
Racotis quadripunctata	Holloway	3	2	1	2	3	9	Lowland to upper montane
Ruttellerona pseudocessaria	Holloway		1				1	Lowland, lower montane, upper montane forest
Serratophyga sterrhoticha	Prout	7	4	1	2	1	4	Mangrove, limestone, hill dipterocarp forest
Sundagrapha tenebrosa	Swinhoe	1	3		1		3	Alluvial forest
Synegia imitaria	Walker		2		1	2	2	Piperaceae: Piper. Lowland, lower montane forest
Syngonorthus subpunctatus	Butler					1	4	Lower montane, lowland, swamp, heath forest
Tasta micaceata	Walker		2	1	2	1	11	Lowland, lower montane forest
Yashmakia bigrisea	Holloway			1				Lowlands
Yashmakia loxozyga	Holloway					2		Lowland alluvial forest
Yashmakia veneris	Warren						1	Hill dipterocarp, kerangas forest
Zamarada denticulata	Fletcher	1	3	3	2	14	8	Alluvial forest
Zamarada eogenaria	Snellen		2			1	2	Sterculiaceae: Theobroma cacao (cocoa). Lowland forest

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Zeheba aureatoides	Holloway		1	1			1	Lowlands
	N	2041	616	431	1383	487	1027	
	S	73	89	69	81	74	105	
V. Superfamily : Noctuoidea								
i. Family : Notodontidae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Allata argentifera	Walker	1			2		2	Leguminosae: Desmodium (Ougeinia), Mucuna, Pongamia, Derris. Lowland rainforest, occasionally montane
Allata benderi	Dierl			2	1		1	Lowland, kerangas forest
Ambadra rafflesi	Moore	1		4	2			Palmae: Elaeis guineensis (oil palm), Cocos nucifera (coconut). Lowland, dry heath forest
Ambadra suriga	Schaus			1	3	1	2	Palmae: Cocos nucifera (coconut). Lowland dipterocarp forest
Archigargetta viridigrisea	Hampson					1	2	Myrtaceae: Careya arborea. Lowland dipterocarp forest
Benbowia kiriakoffi	Holloway		1					Lowland, kerangas, hill dipterocarp, montane forest
Benbowia virescens	Moore		3		3		4	Lowland, kerangas, hill dipterocarp, montane forest
Besida xylinata	Walker		1		1		5	Leguminosae: Erythrina. Lowland rainforest
Blakeia marmorata	Kiriakoff		1		1			Lowland, limestone, alluvial, hill dipterocarp forest.
Brykia horsfieldi	Moore		2	2	3	1	10	Lowland, dry kerangas, swamp forest.
Brykia samarinda	Kiriakoff		3	2	1	1	6	Dipterocarpaceae: Shorea macroptera. Lowland rainforest
Calyptronotum singapura	Gaede		1				1	Lower montane, lowland forest
Caschara punctifera	Walker	2	1				6	Lowland mixed dipterocarp, lower montane forest
Cerasana anceps	Walker	3	6	2	2	1	20	Lowland, alluvial, riverine, dipterocarp, secondary, coastal forest
Cerura malaysiana	Holloway	1			1		3	Congener on Salicaceae, Flacourtiaceae.
Chadisra luzonensis	Kiriakoff						1	Congeners on Bombacaceae: Bombax, Tiliaceae: Grewia, Sapotaceae, Ulmaceae, Leguminosae, Sterculiaceae, Malvaceae. Open secondary habitats
Clostera bramah	Roepke		4		3		6	Lowland forest
Clostera bramoides	Holloway		1			1		Mixed dipterocarp forest
Dudusa vethi	Snellen	1			1		1	Sapindaceae: Nephelium (rambutan). Lowland dipterocarp forest
Fentonia helena	Kiriakoff						1	Montane forest
Gangarides rosea	Walker		1				2	Lowland forest
Gangarides vardena	Swinhoe		4		3	3	4	Lowland dipterocarp forest
Gargetta hampsoni	Schintlmeister				2			Euphorbiaceae: Briedelia.
Ginshachia bronacha	Schaus				1			Montane, mixed dipterocarp forest
Hexafrenum nigricollaris	Holloway					1		Congener on Fagaceae: Castanea. Montane forest
Liparopsis sundana	Holloway						1	Lowland, montane forest
Medanella subterminalis	Kiriakoff	2	4		1	1		Lowland dipterocarp forest
Micromelalopha ?cornutijuxta	Holloway						1	Swamp forest
Micromelalopha ?melinau	Holloway		1					Congener on Salicaceae. Lowland forest
Micromelalopha sp.						1		
Neostauropus alternus	Walker	1						Wide range incl. tea, coffee, rambutan, mango, Euphorbiaceae: Ricinus, Myrtaceae: Careya, Leguminosae: Cajanus, Cassia, Ougeinia, Pithecellobium
Neostauropus major	van Eecke	1	7	2		1	6	Lowland dipterocarp, kerangas forest
Norraca sabulosa	Kiriakoff		1					Montane
Norraca sordida	Roepke				1			Secondary, cultivated area
Omichlis dimorpha	Kiriakoff				3	1	1	Lowland, lower montane forest
Oxoia smaragdiplena	Walker		1		2		4	Lowland rainforest
Parasinga cinerascens	Kiriakoff		1					Lowland, hill dipterocarp, kerangas, swamp forest
Phalera banksi	Holloway	1						Lower montane
Phalera sundana	Holloway	1		1	2			Lowland, alluvial, kerangas forest

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Plusiogramma aurosigna	Hampson	1						Swamp forest
Porsica punctifascia	Hampson				1			Euphorbiaceae: Aporusa chinensis. Lowland, hill dipterocarp forest
Pseudohoplitis vernalis	Gaede						1	Mixed dipterocarp, alluvial forest
Pseudostauropus plagosus	Gaede		1			1		Montane, hill dipterocarp forest
Quadricalcarifera charistera fraseriana	Kiriakoff		1					Lowland, lower montane forest
Quadricalcarifera eusebia	Kiriakoff				1		1	
Quadricalcarifera malayana	Nakamura			1			1	Montane, lowland forest
Sagamora indigofera	Holloway						2	Lowlands to upper montane
Somera virens	Dierl				1			Lowlands to 2000m
Somera viridifusca	Walker						1	Lowlands to 2000m
Vaneeckeia pallidifascia ovalis	van Eecke	1						Montane
	N	17	46	17	42	15	96	
	S	13	21	9	24	13	28	
ii. Family : Arctiidae								
1. Subfamily : Lithosiinae								Many members are lichen feeders
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Macaduma sp.						2		
?Meteugoa sp.						1		
Asura ?calamaria	Moore						1	Genus on lichens, congeners on Convolvulaceae: Ipomoea batatas (sweet potato), Xanthophyllaceae: Xanthophyllum, Santalaceae: Santalum
Asura ?nigripuncta	Wileman	125	22	35	54	16	6	
Asura ?peloa	Swinhoe	7	3	9	4	3	3	
Asura ?synestramena	Hampson		1					Lowland
Asura asaphes	Hampson	7	10	1	2	6	10	Lowland
Asura birivula	Hampson	1	11	5	3	11	2	Lowland, lower montane
Asura biseriata	Hampson	5	11	2	16	17	7	Rutaceae: Citrus reticulata
Asura bizonoides	Walker		13	4		2	4	
Asura calamaria	Moore			1				Nyctaginaceae: Bougainvillea, Malvaceae: Hibiscus
Asura crustata	Talbot	5	2			2	1	
Asura cuneifera	Walker	1		2	1	2	4	
Asura euprepioides	Walker	3	9	6	22	11	2	Lowland
Asura peloa	Swinhoe	8	1	17	21	4		
Asura pudibunda	Snellen	1				1	1	Lowland
Asura sp. 1		1				1		
Asura sp. 2		1						
*Asura sp. no. 2708**		7	4		1			
*Asura sp. no. 2712**						6	1	?Limestone, lowland
*Asura sp. no. 2713**		4	10	4		124	10	Lowland
*Asura sp. no. 2740**		37	3	49	17	16	1	
*Asura sp. no. 2787**			7					
Asura strigipennis	Herrich-Schaffer	4	8	3	12	10		
Asura subcruciata	Rothschild	170	34	164	236	13	3	Lowland, alluvial forest
Asura uniformeola	Hampson	3		2	1			
Chamaita trichopteroides	Walker	1	1					Lower montane
Cyana costifimbria	Walker	16	17	9	3	8	3	Genus on lichens. Congeners on Apocynaceae: Dyera, Anacardiaceae: Mangifera, Zingiberaceae: Elettaria, Meliaceae: Dysoxylum. Lowland
Cyana inconclusa	Walker	8	1	3	10	4		Congener on Leguminosae: Dalbergia sissoo, Dipterocarpaceae: Shorea robusta, Verbenaceae: Tectona grandis. Lowland

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Cyana indonesia	Roesler & Kuppers	46	3	15	4	2	2	
Cyana infantula	Hampson		2	13	5	2		
Cyana malayensis	Hampson	13	13	7	2	2	11	Lowland
Cyana perornata	Walker	21	11	12	16	8	28	Lowland
Cyana pudens	Walker		3	1	1	1	4	Lowland
Cyana ridleyi	Hampson	41	3	10	2	3	5	Lowland
Cyana selangorica	Hampson	6	4	2	6	2		Lowland
Eilema ?cretacea	Hampson	3	1	2	2	1	1	Congener on Euphorbiaceae: Hevea brasiliensis. ?Lower montane
Eilema ?pulvereola	Hampson	11	9	22	11	108	5	Lowland to lower montane
Eilema apicalis	Walker	5	4	6	2	3	3	Mosses, lichens, Leguminosae: Tamarindus, Myrtaceae: Eugenia. Lowland
Eilema biplagella	Butler	9	22	13	3	12	7	
Eilema cf. apicalis	Walker		1			1		
Eilema cf. pentaspila	Hampson			1				
Eilema chiloides	Walker	4	7	2		2	2	Lowland
Eilema fasciculosa	Walker		1					
Eilema griseadisca	Holloway	8	2	13	14	26	2	
Eilema pentaspila	Hampson	5	1			3		
Eilema sp.						1		
Eugoa aequalis	Walker	54	9	54	13	3	9	
Eugoa bipunctata	Walker	4		2	6			Lowland to lower montane
Eugoa crassa	Walker	8	7	6	1	4	2	
Eugoa similis	Rothschild	2						
Eugoa sp.		5	4	4	4	1	1	
*Eugoa sp. no. 2749**		19	3	20	16	3		
*Eugoa sp. no. 2754**		2		4	2	1		
*Eugoa sp. no. 2758**		7	3	2	1		1	
*Eugoa sp. no. 2765**		1	6	2	6	2	3	
*Eugoa sp. no. 2766**		2	1			1	1	
Eugoa vagigutta	Walker	1						Lowland, ?alluvial forest
Eutane nivea	Hampson						1	?Lowland
Garudinia latana	Walker	4				2		Lowland
Garudinia simulana	Walker	15	1	1	1	2	1	Lower montane
Hemonia ciliata	Hampson		1	2	2			
Lambula fuliginosa	Walker	4	1	1	1	1		
Lithosiinae 1						18	1	
Lithosiinae 10		1			1			
Lithosiinae 11							1	
Lithosiinae 2			2					
Lithosiinae 3		6	3	8	6	32		
Lithosiinae 4						1		
Lithosiinae 5		1		2				
Lithosiinae 6			2	1	1	1		
Lithosiinae 7			1			1		
Lithosiinae 8		3	1	4		1	1	
Lithosiinae 9				2	1	1		
Lithosiinae no. 2643*		2		6	6	6	2	
Lithosiinae no. 2655*		3	6	7	1	5	2	

		Number of individuals						
Species		Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Lithosiinae no. 2681*		2	2				1	
Lithosiinae no. 2744*			2		5	1		
Lithosiinae no. 2787*			7		1	1	3	
Macotasa nubeculoides	Holloway	6	5	5	5	17	2	Congener on Leguminosae: Albizia moluccana
Meteugoa ?obliquiata	Hampson	4						
Meteugoa obliquiata	Hampson	2			2	2		Euphorbiaceae: Hevea. ?Lowland
Miltochrista cf. complicata	Butler			1		1		Genus on lichens
Miltochrista cornicornutata	Holloway	12	16	13	2	3	11	
Miltochrista cruciata	Walker	11	3	1	13	3	7	Lowland
Miltochrista cuneonotatus	Walker	9	7	7	41	7	2	Lowland
Miltochrista hypoprepioides	Walker	1			1			
Miltochrista lineata	Walker		1			1	1	Lowland
Miltochrista roseororatus	Butler	21	17	24	89	37	12	Sterculiaceae: Theobroma cacao
Miltochrista rubricostata	Herrich-Schaffer	1	2	2	5	1	11	Lowland, lower montane
Miltochrista sp. nr. inflexa	Moore	3		1				
Miltochrista syntypica	Swinhoe	1					1	
Nishada nodicornis	Walker	5	20	8	6	6	18	Lowland
Nishada sambara	Moore		1		1	1	1	Lowland
Nishada sp.		1						
Nishada syntomoides	Walker	5	4		1	1		Lowland
Oeonistis entella	Cramer	8	1	2	7	3	9	Lichens, Convolvulaceae: Cuscuta, Flacourtiaceae: Flacourtia, Moraceae: Ficus. Lowland
Padenia duplicana	Walker	23	2	12	3	1		Lowland, lower montane
Parasiccia marginipuncta	Talbot				1			Upper montane
Philenora lauta	Swinhoe	2		1				Lowland, ?kerangas
Poliosia marginata	Hampson	5	4	5		4		
Poliosia muricolor	Walker	20	1	2		4	1	
Siccia sp. 1						23	1	?Lichens
Siccia sp. 2				1				
Siccia sp. 4						5		
Stictosia flexilisana	Walker						1	
Teulisna nigricauda	Holloway					1		
Tospitis nulliferana	Walker					1		
Trischalis ?absconditana	Walker		1	1			1	
*Trischalis sp. no. 2770**			2	1				
Trischalis subaurana	Walker	3	5	3		12	1	
	N	876	409	653	723	659	239	
	S	74	71	67	60	79	58	
2. Subfamily : Syntominae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Amata derivata	Walker					1		Congeners on mosses, lichens, rice, Convolvulaceae, Leguminosae, Compositae, Santalaceae, Cruciferae: Brassica
Amata egenaria	Walker	5	17	17	14	4	21	Lowland forest
Amata macroflavifer	Holloway		1					Lowlands to lower montane
Amata prepuncta	Holloway	17	85	73	28	25	104	Lowland rainforest
Trichaetoides separabilis	Walker					1		Lowland, alluvial, dipterocarp forest
	N	22	103	90	42	31	125	
	S	2	3	2	2	4	2	

3. Subfamily : Arctiinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Aethalida borneana	Holloway						1	Lowland rainforest, alluvial forest
Amerila astreus	Drury		1	1	3	2	5	Dioscoreaceae: Dioscorea, Smilacaceae: Smilax, Rubiaceae: Ixora, Asclepiadaceae, Apocynaceae: Beaumontia. Lowlands to 2000m
Amerila omissa	Rothschild	1	3	1	2	2	2	Lowlands, montane
Argina astrea	Drury						1	Leguminosae: Crotalaria. Open lowlands
Baroa siamica	Hampson						1	Lower montane, lowland dipterocarp forest
Creatonotos transiens	Walker	81	12	101	79	17	157	Wide range incl. Gramineae: Paspalum, Leguminosae, Vitaceae: Cayratia, Meliaceae, Dioscoreaceae, Musaceae, Salicaceae, Chenopodiaceae
Nyctemera adversata	Schaller				1			Compositae: Erechtites, Erigeron, Gynura, Picris, Senecio. Open, secondary forest
Nyctemera baulus	Boisduval				5	5	1	Compositae: Crassocephalum, Emilia, Cruciferae: Brassica. Secondary, disturbed, agricultural habitats
Nyctemera coleta	Stoll						1	Compositae: Gynura. Lowlands to 1200m
Nyctemera latistriga	Walker				1			Open habitats
Nyctemera muelleri	Vollenhoven		2			3	13	Lowlands to 2000m, disturbed habitats
Nyctemera sonticum	Swinhoe			1			1	
Pareuchaetes pseudoinsulata	Rego Barros	36	1	94	8		6	Compositae: Chromolaena odoratum. Weedy habitats
Spilosoma ?borneensis	Rothschild	1						
Spilosoma griseabrunnea	Holloway	31	14	21	52	16	29	Congeners on Compositae, Gramineae: Paspalum, Leguminosae, Convolvulaceae, Musaceae, Orchidaceae. Disturbed habitats
Spilosoma hosei	Rothschild		9	3	3	8	32	Lowland forest
Tinoliodes dehanna	Pagenstecher					1		Lowland forest to 1500m
	N	150	42	222	154	54	250	
	S	5	7	7	9	8	13	
iii. Family : Lymantriidae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Dasychira sp.		3	2	3	1	1	2	Leguminosae: A. mangium
Allotoma cornifrons	Roepke						2	
Calliteara ?lairdae	Holloway		1					Congeners on Rubiaceae: Coffea, Theaceae. Upper montane
Calliteara angulata	Hampson		1				1	Congeners on Rhizophoraceae: Rhizophora, Myrtaceae: Psidium, Pinaceae: Pinus, Salicaceae, Dipterocarpaceae: Hopea, Lauraceae: Persea. Lowland
Calliteara horsfieldii	Saunders	1						Tea, Leguminosae: Canavalia, Anacardiaceae: Anacardium occidentale, Cruciferae, Myrtaceae, Lythraceae, Rosaceae, Combretaceae. Lowland
Carriola ecnomoda	Swinhoe				1		5	Bombacaceae: Durio. Lowland
Cassidia peninsularis	Holloway	1	5				11	?Lowland
Cobanilla ?tortricoides	Walker		1					Congener on Ebenaceae: Diospyros
Cobanilla plumbacea	Swinhoe	2	4	2	2		1	
Cobanilla sp. nr. phaedra	Collenette			1	1		1	Lowland
Cobanilla tortricoides	Walker		1				4	?Lowland
Dasychira ?hypersceles	Collenette				1			Gramineae: Centotheca, genus on Palmae, Ebenaceae, Leguminosae, Melastomataceae, Sterculiaceae, Casuarinaceae, Myrtaceae, Dipterocarpaceae
Dasychira angulata	Hampson		4	1	1	1	2	Congeners on Oxalidaceae: Averrhoa carambola (shoots), Anacardiaceae: Mangifera, Gramineae: Oryza, Zea, Myrtaceae: Careya. Lowland
Dasychira chalana	Moore			1				Congeners on Combretaceae: Terminalia, Sapindaceae: Schleichera, Rhamnaceae: Zizyphus, Fagaceae: Quercus, Verbenaceae: Tectona. Lowland
Dasychira inclusa	Walker	7	2		1	2	1	Leguminosae: Acacia mangium, Annonaceae, Rubiaceae: Anthocephalus, Moraceae: Ficus, Dipterocarpaceae: Shorea leprosula, Musaceae
Dasychira sp.		1			1		1	
*Dasychira sp. no. 1759**		10	5	2	5	7	2	Leguminosae: Acacia mangium. Lowland
Dura alba	Moore						2	?Lowland
Euproctis ?atereta	Collenette	1	3	1	1		1	Genus on wide range incl. Sterculiaceae, Gramineae, Dipterocarpaceae: Shorea, Leguminosae: Acacia, Verbenaceae, Myrtaceae: Eucalyptus. Lowland
Euproctis ?azela	Collenette	2		2		3	8	Congeners on Rhizophoraceae, Anacardiaceae: Anacardium occidentale, Buchanania, Bombacaceae: Bombax, Theaceae, Myrtaceae. Lowland
Euproctis ?chirunda	Swinhoe		1					Congeners on Sonneratiaceae: Sonneratia, Lauraceae: Cinnamomum, Persea, Combretaceae: Terminalia, Leeaceae: Leea, Rosaceae: Rosa. Lowland
Euproctis ?epinephela	Collenette		2	2		1	2	Congeners on Polypodiaceae: Drynaria, Loranthaceae, Asclepiadaceae: Calotropis, Euphorbiaceae: Ricinus, Hevea, Fagaceae: Quercus. ?Lowland
Euproctis ?flavolimbata	Aurivillius	1	1	9	3	3	5	?Lowland

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Euproctis ?flavomarginata	Wileman	1						
Euproctis ?funeralis	Swinhoe						1	
Euproctis ?limbata	Butler	8	6	7	11	9	4	Leguminosae: Paraserianthes falcataria. ?Lowland
Euproctis atereta	Collenette						1	Lowland
Euproctis bipunctapex	Hampson		2	2	1		5	Dipterocarpaceae: Shorea robusta, Combretaceae: Terminalia, Myrtaceae: Eugenia, Euphorbiaceae: Sapium, Lecythidaceae. Lowland, lower montane
Euproctis catala postlutosa	Holloway					1		
Euproctis cf. olivata	Hampson	5			3	1	1	
Euproctis cincta	Swinhoe	7	15	18	5	2	6	
Euproctis civitta	Swinhoe	4	7	1	15	2	17	Leguminosae: Paraserianthes falcataria. Lowland
Euproctis coelebs	Collenette	24		3			1	Lowland
Euproctis cosmia	Collenette				1	1	3	
Euproctis eclipes	Collenette	22	9	18	52	16	10	
Euproctis flavomarginata	Wileman	1	2	1	4		1	
Euproctis fumosa	Snellen	2	9	2	3	8	24	Dipterocarpaceae: Shorea teysmanniana. Lowland
Euproctis guttulata	Snellen	2	3	3	4	2	12	Lowland
Euproctis javana	Aurivillius				1	3	1	?Lowland
Euproctis lodra	Moore						1	?Montane
Euproctis lyclene	Swinhoe						1	Lowland, kerangas
Euproctis ormea	Swinhoe			1	1			Lowland
Euproctis protea	Collenette		1					
Euproctis raratior	Collenette	1				2	1	Lowland
Euproctis sp. 1		2	5	3	3	18	8	
Euproctis sp. 2		2	6	5	5	4	5	
Euproctis sp. 3		4		2	6	18		
Euproctis sp. 4			1					
Euproctis sp. 5		2			1			
Euproctis sp. 6		2	2	2	2	1		
Euproctis sp. 7		1				1		
Euproctis sp. 8		3						
Euproctis sp. 9					1	1		
*Euproctis sp. no. 1674**						1		
*Euproctis sp. no. 1676**		18	3	1	9			
*Euproctis sp. no. 1691**			2					
*Euproctis sp. no. 1732**		1	2		1	1	1	
Euproctis sp. nr. tamsi	Collenette					1		?Lower montane
Euproctis waterstradti	Holloway	1	2	2		3		
Euproctis xanthomela	Walker		1					Lowland
Ilema chloroptera	Hampson	3	7	6	24	1	6	Congener on Gleicheniaceae: Dicranopteris. ?Lowland
Locharna limbata	Collenette						1	?Montane
Lymantria ?capnodes	Collenette	1						Congeners on Myrtaceae: Eucalyptus, Fagaceae: Quercus, Dipterocarpaceae: Shorea macroptera, Anacardiaceae, Sterculiaceae, Sonneratiaceae
Lymantria brunneiplaga	Swinhoe		3	2	2		9	Leguminosae: Paraserianthes falcataria. Lowland
Lymantria capnodes	Collenette		1					Congeners on Casuarinaceae: Casuarina equisetifolia, Rhizophoraceae: Ceriops, Rhizophora, Anacardiaceae: Mangifera, Combretaceae: Terminalia
Lymantria pendleburyi	Collenette		1		1		5	Congeners on Rosaceae, Palmae: Cocos, Punicaceae, Rubiaceae: Adina, Mussaenda. Lowland
Lymantria singapura	Swinhoe		2		1	2		Pinaceae: Pinus. Lowland
Lymantriidae no. 1767*		1		2	1			
Orgyia postica	Walker	69	12	17	213	5	11	Leguminosae: Acacia mangium, Albizia, Dipterocarpaceae: Shorea, Euphorbiaceae, Sterculiaceae, Anacardiaceae, Rubiaceae, Tiliaceae, Combretaceae
Redoa ?camurisquama	Collenette	3	16	7	8	9	22	Genus on Leguminosae, Dipterocarpaceae: Balanocarpus, Shorea, Elaeocarpaceae, Anacardiaceae, Gramineae, Theaceae, Combretaceae, Lauraceae

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Redoa ?egerina	Swinhoe	4	5	1	1		13	Congeners on Lauraceae: Litsea, Anacardiaceae: Anacardium occidentale (cashew), Mangifera, Sapindaceae: Nephelium, Bombacaceae: Durio
Redoa ?gigantea	Aurivillius	1						Genus majority lowland
Redoa cf. lactea	Moore						1	
Redoa cf. phasmatodes	Collenette					1	2	
Redoa discirufa	Swinhoe		2		3	1	4	
Redoa flora	Swinhoe		2	1		1	3	Bombacaceae: Durio zibethinus
Redoa gigantea	Aurivillius		5		1	2	7	
Redoa marginalis	Walker	6	10	9	5	11	54	
Redoa micacea	Walker		1				1	
Redoa niphobola	Collenette		1	1				
Redoa rhopica	Toxopeus		8	1	5	2	14	
Redoa sp.		1	1		1	1	5	
*Redoa sp. no. 1571**		1	13			1	1	
*Redoa sp. no. 1572**			12	1		4	6	
*Redoa sp. no. 1623**		3	5	2	2	3	14	
*Redoa sp. no. 1666**		3	6	2	4	6	8	
Rhypotoses adela	Collenette		1			1		Lowland
Rhypotoses brooksi	Collenette	12	2	4	4	2	2	Lowland
Rhypotoses glebula	Swinhoe	272	1	32	4	4	5	Lowland
Rhypotoses humida	Swinhoe					4		
Rhypotoses strigifimbria	Walker	10	4	13	6	1	4	Lowland
Scarpona ennomoides	Walker		1	2	2	2	1	Ebenaceae: Diospyros discolor. Lowland
Sitvia denudata	Walker	1					1	
	N	530	231	195	434	177	353	
	S	46	56	42	49	48	61	
iv. Family : Noctuidae								
1. Subfamily : Aganainae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Agape chloropyga	Walker		1				3	Lowlands
Asota caricae	Fabricius	6		2	2	4	9	Moraceae: Ficus, Broussonetia, Dipterocarpaceae: Shorea, Verbenaceae: Tectona, Guttiferae, Compositae: Blumea. Lowland forest, agricultural area
Asota egens	Walker			1	4	1	17	Moraceae: Ficus. Lowland, secondary forest
Asota heliconia	Linnaeus	16	21	6	35	3	75	Oxalidaceae: Averrhoa (star-fruit). Lowlands, disturbed forest
Asota paphos	Fabricius					1		Lowland, alluvial forest
Asota plana	Walker	2	1		3	3	6	Moraceae: Ficus. Lowlands to 1900m
Asota producta	Butler	2	1		2		3	Lowland, montane forest
Euplocia membliaria	Cramer						1	Lowlands
Neochera marmorea	Walker	1			1		2	Congener on Asclepiadaceae: Marsdenia. Lowlands
	N	27	24	9	47	12	116	
	S	5	4	3	6	5	8	
2. Subfamily : Herminiinae								Many are detritus feeders
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Hadennia sp.			2		15		1	
Adrapsa ?ereboides	Walker	8	9	4		16	5	

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Adrapsa angulilinea	Prout					1		
Adrapsa sp. 1		1	1	4	5	4	1	
Adrapsa sp. 2		3	6	2	7	4	2	
Amilaga geometroides	Walker	4	6	2	1	3	11	Lowland
Amilaga sp.		5		2				
Auchmophanes nothusalis	Walker	2	14	1	22	1	1	Lower montane
Bertula carta	Swinhoe				1			Congener on dry grass
Bertula crucialis	Felder		1		1		3	
Bertula depressalis	Snellen	68	35	61	141	28	9	Detritus. Lowland
Bertula erectilinea	Swinhoe	9	7	7	10	60		?Lowland
Bertula moloalis	Walker		2	1			1	
Bertula sp. nr. delosticha	Swinhoe				1			
Bertula tespisalis	Walker	4	21	4	14	1	1	Lower montane
Bocana manifestalis	Walker	2	5			1	1	Meliaceae: Dysoxylum. Detritus, ?grasses. Lowland to montane
Bocana silenusalis	Walker	2	1	2	1	3	5	?Lowland
Catada canaliferalis	Moore	2						Congener on Connaraceae: Rourea
Catada picta	Moore	1			1	4	1	?Lowland
Catada sp.		2	3	3	1		17	
Globosusa ?curiosa	Swinhoe	1			1		1	
Globosusa sp.					1			
Hadennia hisbonalis	Walker		1			1	1	?Lowland
Hadennia maculifascia	Hampson						1	Lowland
Hadennia prunosa	Moore	6	17	7	6	14	17	Lowland
Herminia ?clathrata	Holland	5	3	2	6		2	Congener on moss
Herminia ?mundiferalis	Walker		1		2			
Herminia diagramma	Prout	1	4	3	11	12	1	?Detritus. ?Lowland
Herminiinae 1		29	11	56	27	83	7	
Herminiinae 11						1		
Herminiinae 12							1	
Herminiinae 13			4			1		
Herminiinae 14			1					
Herminiinae 2					1	4		
Herminiinae 3				4	9	10		
Herminiinae 4		1			1	3	1	
Herminiinae 5				2				
Herminiinae 6					2			
Herminiinae 7						1		
Herminiinae 8			1					
Herminiinae G**		2	4	1		11	7	
Herminiinae J**						1		
Herminiinae S**			1					
Hipoepa biasalis	Walker	149	67	109	184	109	34	?Detritus. ?Lowland
Hipoepa fractalis	Guenee	143	28	80	158	160	7	Leguminosae: Paraserianthes falcataria, Dalbergia, Rubiaceae: Rubia (dry leaves)
Hipoepa sp.			1	1	2	1	1	
Hydrillodes ?lentalis	Guenee		1					Congener on dead coconut leaves, decaying grass, Dipterocarpaceae: Dryobalanops lanceolata (fruit)
Hydrillodes ?subflavalis	Hampson	1	1	3	1	2		
Hydrillodes gravatalis	Walker	4	4	1	2	13	3	Lowland to montane

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Hydrillodes repugnalis	Walker	7	6	16	31	24	3	
*Hydrillodes sp. no. 10817**		3	2	3	1	4		
*Hydrillodes sp. no. 10822**		5	10	4	3	4	6	
Hydrillodes toresalis	Walker	3	7	2	5	9	9	Lowland to montane
Lysimelia ?nigripes	Hampson	1	3	1	1	6		
Lysimelia neleusalis	Walker		2	10	2	3	2	
Mixomelia ?erecta	Moore	2		2		2	2	
Mixomelia ?relata	Hampson	1						
Mixomelia ?umbripars	Hampson	39	4	12	19	26		
Mixomelia sp.		12	2	7	3	3		
Mixomelia stidzeras	Hampson	1				1		
Naarda ?fuscicosta	Hampson					1		Congener on Dipterocarpaceae: Dryobalanops lanceolata (fruit)
Naarda ?nodariodes	Prout	1						
Naarda sp.		1				1		
Nodaria ?angulata	Wileman & West	2	1			1		Congener on dry leaves of Leguminosae: Dalbergia, grass
Nodaria ?cornicalis	Fabricius	5		3	2			
Nodaria ?discolor	Wileman & West	3			1			
Nodaria cornicalis	Fabricius	44	34	209	71	60	16	
Ophiuchidia ?rectivia	Hampson						1	
Ophiuchidia rectivia	Hampson		2			1	5	
Pancroides abnormalis	Swinhoe						2	
Progonia ?patronalis	Walker			2				Congeners on Rubiaceae: Rubia cordifolia, Rutaceae: Citrus
Progonia oileusalis	Walker	4			4	5		
Progonia sp. 1		26	14	44	29	19	2	
Progonia sp. 2				6				
Progonia sp. 3		1		2	3	1	1	
Progonia sp. 4			14	1				
Progonia sp. 5		10	5	7	14	10	1	
Simplicia ?macrotheca	Prout	31	59	20	33	35	54	Congeners on dry leaves incl. tea, grass, Musaceae: Musa, Dipterocarpaceae: Dipterocarpus, Palmae: Cocos
Simplicia caeneusalis	Walker	1	1		3	2	1	Palmae: Metroxylon, Gramineae: Sorghum, Solanaceae: Solanum tuberosum (potato), Urticaceae: Pipturus (stem-borer)
Simplicia circumscripta	Walker	9	37	13	12	15	32	Lowland
Simplicia renota	Swinhoe	19	6	8	25	11	24	Lowland
Simplicia rufa occidentalis	Holloway	17	65	10	18	44	263	Detritus
	N	703	537	744	915	841	567	
	S	50	50	45	50	53	45	
3. Subfamily : Hypeninae								Many detritus feeders
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Alelimma lignea	Swinhoe				1		1	Lowland, ?alluvial forest
Dichromia ?quinqualis	Walker						2	Congeners on Urticaceae: Boehmeria, Asclepiadaceae: Tylophora, Marsdenia
Echanella temperate	Prout	1	4			3	8	Detritus. Lowland to montane
Hypena ?disualis	Swinhoe	1	5	5	11	14	10	Congeners on Verbenaceae: Lantana, Lippia, Commelinaceae: Commelina, Leguminosae: Indigofera, Desmodium, Abrus, Combretaceae: Combretum
Hypena ?mandatalis	Walker	1	1	2		3	1	Congeners on Rutaceae: Citrus, Polygonaceae, Acanthaceae: Hemigraphis, Hygrophila
Hypena ?medioexcisa	Rothschild	7	5	3	5	5	4	
Hypena gonospilalis	Walker		2	4	5	2	4	
Hypena iconicalis	Walker	1		3	1	6	2	Leguminosae: Desmodium gangeticum, Butea frondosa, Millettia. Lowland
Hypena iconicalis similata	Moore	3	5	4	4	2	9	Lowland to montane

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Hypena jugalis	Walker		5	3	2	4	7	Lowland
Hypena kanshireiensis	Wileman				1			
Hypena sp. 1				1	1		6	
Hypena sp. 2			1					
*Hypena sp. D***					2	2		
Hypenagonia albiocellata	Wileman & West			1		2		
Hypenagonia cf. brachypalpia	Hampson					1		
Hypenagonia sp. 1		1		2		3	1	
Hypenagonia sp. 2						1		
Hypenagonia sp. 3					1			
Hypenagonia sp. 4						1		
Hypenagonia sp. 5			1					
Hypenagonia sp. 6				1		3		
Hypenagonia sp. 7				1		1	1	
Luceria opiliusalis	Walker				1	1		
Mosopia endoxessalis	Walker		5	1	1	3	11	
Mosopia megaspila	Walker	1						
Thysanognatha' alpheusalis	Walker		6	1	1			
	N	16	40	32	37	57	67	
	S	8	11	14	14	18	14	
4. Subfamily : Catocalinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Achaea janata	Linnaeus						1	Wide range incl. Leguminosae: Albizia, Acacia, Euphorbiaceae, Combretaceae, Theaceae, Sapotaceae, Lythraceae, Rosaceae, Myrtaceae. Lowland
Achaea serva	Fabricius	1	1		4		5	Euphorbiaceae: Ricinus, Celastraceae, Rubiaceae, Sapotaceae, Chenopodiaceae, Sapindaceae, Ebenaceae, Anacardiaceae, Convolvulaceae
Anisoneura aluco	Fabricius						1	Lowland to montane
Anisoneura salebrosa	Guenee	1						?Montane
Artena dotata	Fabricius	1	1		2	1	7	Combretaceae: Calycopteris, Terminalia, Quisqualis. Lowland
Artena inversa	Walker	11	12	1	11	1	41	Lowland to montane
Avatha discolor	Fabricius	2		1		2	1	Sapindaceae: Guioa, Allophylus, Schleichera. ?Montane
Avatha noctuoides	Guenee		1					
Avatha pulcherrima	Butler			1			6	Sapindaceae: Schleichera. Lowland to montane
Chalciope mygdon	Cramer	1	1		3	1	1	Genus on Leguminosae: Rhynchosia minima. Congeners on Gramineae: Oryza, Leguminosae: Indigofera
Daddala brevicauda	Wileman & South		1	1	2		9	Montane
Daddala quadrisignata	Walker	1			1		3	Lowland
Daddala sp.		1						
Ercheia cyllaria	Cramer	14	15	6	30	10	92	Grass, Leguminosae: Dalbergia, Tiliaceae: Grewia, Liliaceae: Asparagus. Lowland to montane
Erebus caprimulgus	Fabricius				2	2	10	Genus on Smilacaceae: Smilax macrophylla. Congener on Leguminosae: Acacia. Lowland
Erebus ephesperis ephesperis	Hubner	1	1			1	2	?Leguminosae. Lowland
Erebus hieroglyphica	Drury	1			2			
Grammodes samosira	Kobes	2		2			1	Congeners on Euphorbiaceae: Phyllanthus, Glochidion, Rhamnaceae: Zizyphus, Gramineae, Ebenaceae: Diospyros, Linaceae: Linum (linseed)
Hypopyra ?pudens	Walker						1	
Hypopyra pudens	Walker	46		2	17	6	1	Leguminosae: Paraserianthes falcataria. Lowland to montane
Lygniodes endoleucus	Guerin-Meneville	2			2	2	14	
Mocis frugalis	Fabricius			1				Gramineae (hill paddy, grass)
Mocis undata	Fabricius		1	2	1		2	Leguminosae: Pueraria, Desmodium, Vigna unguiculata (cow pea), Phaseolus, Butea

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Ophisma gravata	Guenee		1				1	Polygonaceae: Polygonum
Ophisma pallescens	Walker						1	Lowland to montane
Ophiusa coronata	Fabricius	1	1		1		5	Combretaceae: Quisqualis indica, Terminalia, Combretum, Leguminosae: Storckiella. Congener on Sapindaceae: Hemigyrosa/Guioa
Ophiusa trapezium	Guenee	1	1	3			4	Combretaceae: Terminalia. Congeners on Myrtaceae: Psidium, Eugenia, Dipterocarpaceae: Shorea, Combretaceae: Terminalia, Calycopteris
Parallelia arctotaenia	Guenee		1					Congeners on Myrtaceae: Eucalyptus, Myrtus, Euphorbiaceae: Ricinus, Acalypha, Phyllanthus, Coriariaceae: Coriaria
Parallelia arcuata	Moore	1	3	2	1	1	1	Euphorbiaceae: Glochidion, Phyllanthus, Rutaceae: Citrus
Parallelia circumsignata	Guenee		1			1	3	
Parallelia forceps	Kobes	1	1	2	3			
Parallelia fulvotaenia	Guenee	1	8	2	3	1	21	Lowland
Parallelia joviana	Stoll	1						Euphorbiaceae: Phyllanthus emblica, Breynia
Parallelia palumba	Snellen	2	5	2	2	1	8	Rutaceae: Citrus decumanus (pomelo, ?adult fruit piercing), Atalantia, Paramignya. Lowland
Parallelia rigidistria	Guenee	9	6	2	2		10	?Euphorbiaceae. Lowland to montane
Pericyma cruegeri	Butler	4	3		5	2	11	Leguminosae: Delonix regia, Acacia catechu, Peltophorum pterocarpum. Congener on Leguminosae: Albizia, Sesbania. Lowland to montane
Phyllodes eyndhovii	Vollenhoven						1	Congener on Menispermaceae: Anamirta, Cocculus
Pindara illibata	Fabricius		1		1		1	Lowland
Pseudathyrma bubo	Hubner	2	2		1		5	
Pseudathyrma complens	Walker				1		1	
Pseudathyrma rufiscripta	Hampson			1			1	
Pterocyclophora ridleyi	Hampson	1					6	
Sypna albilinea	Walker		1		1		4	Congener on Rosaceae: Rubus. Lowland to montane
Sypnoides gluta	Swinhoe		6	2	8	3	14	
Trigonodes disjuncta	Moore	2		10				Congeners on Leguminosae: Vigna, Moraceae: Ficus, Gramineae
	N	111	75	43	106	35	296	
	S	26	24	18	24	15	36	
5. Subfamily : Ophiderinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Blasticorhinus decernens	Walker		1				1	
?Calesia sp.		1			1		1	
?Condate sp.			3	5	2	5	2	
?Erygia sp.					2			
?Eubryopterella vaneeckei	Roepke						1	
?Hyperlopha sp.			1	1		1	3	
?Mecodina sp.						1	1	
?Olulis sp. 1			1					
?Olulis sp. 2			3				1	
?Pangrapta sp.				1				
?Papuacola sp.							1	
?Tamba sp.			1			1	1	
Acygnatha ?mesozona	Hampson					1		
Aedia leucomelas	Linnaeus		1		1			Convolvulaceae: Ipomoea, Argyreia
Amphigonia hepatizans	Guenee		2	1	1		10	Leguminosae: Moullava/Wagatea
Amphigonia motisigna	Prout					1	7	
Anachrostis ?fulvicilia	Hampson	2				1		
Anachrostis ?indistincta	Wileman & South					1		
Ananepa doda	Swinhoe	3	5	5	7	9	15	

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Anereuthina lilach	Guenee	1					1	
Anereuthina sp.			1					
Anereuthina venosa	Hubner		3	1			6	
Anoba ?columnaris	Warren			1			1	Congener on Leguminosae: Dalbergia, Abrus. Lowland, limestone
Anomis ?albipunctula	Hampson					1		Congeners on Sterculiaceae: Waltheria, Eriolaena, Sterculia, Pterospermum, Malvaceae: Hibiscus, Gossypium, Rosaceae. Lowland to montane
Anomis cf. albitibia	Walker		3		6		10	Congeners on Bombacaceae: Bombax, Menispermaceae: Cissampelos, Leguminosae: Dalbergia, Verbenaceae: Lantana, Rosaceae: Rosa, Rubus
Anomis cupienda	Swinhoe	2			1	2	2	Congeners on Tiliaceae: Grewia, Amaranthaceae: Digera, Rutaceae: Citrus, Combretaceae: Combretum, Convolvulaceae: Ipomoea
Anomis holortha	Hampson						1	
Anomis scitipennis	Walker		1	1	5	1	6	
Anomis sumatrana	Swinhoe	5	3	1	23	26	13	Lowland
Anticarsia creberrima	Walker	4	17	7	6	13	40	Leguminosae: Cajanus indicus. Congener on Leguminosae: Vigna, Derris, Cyamopsis. Lowland
Arthisma rectilinea	Roepke	10	8	5	10	3	13	Lowland to montane
Athyrma hieroglyphica	Swinhoe	1					3	Congener on Sapindaceae: Nephelium
Athyrma tepescens	Walker				1			
Athyrma sp.							1	
Attonda adspersa	Felder	6	1	2	3	4	1	Euphorbiaceae: Mallotus philippensis
Avitta ?fasciosa	Moore					2		Congener on Menispermaceae: Cyclea, Stephania
Avitta bracteola	Holloway			1		1	2	
Avitta guttulosa	Swinhoe	1					2	
Avitta lunifera	Druce				2			
Avitta quadrilinea	Walker	3	2	2	6	1	13	Lauraceae: Alseodaphne
Avitta rufifrons	Moore					1		
Batracharta chariessa	Prout						2	
Batracharta nigritogata	Prout				1			
Batracharta obliqua	Walker				1			
Belciana biformis	Walker		1		1		2	Sterculiaceae: Heritiera
Belciana prasina	Swinhoe		1					Congener on Tiliaceae: Grewia
Bematha extensa	Walker						1	Lowland
Blasticorhinus rivulosa	Walker		1		1			Leguminosae: Pueraria phaseoloides
Bocula divergens	Prout		1	3	2		6	Lowland, lower montane
Bocula microscala	Holloway	9	25	14	18	8	64	Congeners on Tiliaceae: Grewia tiliaefolia, Sterculiaceae: Sterculia villosa, Moraceae: Ficus. Lowland
Bocula tuhanensis	Holloway	2	7	4	15	3	20	Lowland, ?alluvial forest
Brontypena ochrocuprea	Pagenstecher	1						
Caduca albopunctata	Walker			2		1	4	Lowland
Calesia gastropachoides	Guenee				1			Congener on Acanthaceae: Justicia/Adhatoda, Thunbergia, Strobilanthes, Neuracanthus
Calymniops sp.		3	2				6	
Calyptra minuticornis	Guenee	1	1	1	1		4	Menispermaceae: Cocculus macrocarpus, Cissampelos pareira
Carsina cf. undulifera	Hampson	1					1	
Catephia ?longinquua	Swinhoe	1	1	1		3	4	Euphorbiaceae: Antidesma. Congener on Convolvulaceae: Ipomoea batatas, Merremia, Argyreia, Leguminosae: Cajanus
Chilkasa falcata	Swinhoe	8	7	1	9	1	36	Lowland to montane
Chrysopera combinans	Walker						1	Lowland
Claterna cydonia	Cramer	10	8	4	16	2	57	Lowland, alluvial forest
Codonodes papuana	Hampson				1			
Codonodes rectigramma	Hampson		3	1	4	11	3	Leguminosae: Millettia, Derris
Condate orsilla	Swinhoe		1		2		1	Limestone, lowland to montane
Conosema alfura	Felder			1		1		
Corsa ?lignicolora	Walker		1		2			

Species	Authority	Number of individuals						
		Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Corsa lignicolora	Walker	1						
Crithote horridipes	Walker	2	6	3	3	5	15	Leguminosae: Dalbergia
Cryptastria fuscomarginata	Bethune-Baker				1		1	
Cultripalpa partita	Guenee			1		1		
Diascia hayesi	Holloway	13	8	26	11	19	69	Lowland to montane
Dinumma ?combusta	Walker	20	5	18	93	3	8	Leguminosae: Paraserianthes falcataria. Congener on Verbenaceae: Tectona
Donda eurychlora	Walker	1					1	Bombacaceae: Bombax, Ulmaceae: Trema. Congener on Malvaceae: Ochroma lagopus (balsa wood)
Dordura aliena	Walker				3		5	Lowland
Drepanorhina shelfordi	Swinhoe						1	?Lowland
Dunira ?rubripunctalis	Walker		15		1	3		
Dunira obliquilinea	Hampson			1		1		
Dunira sarconia	Hampson					1		
Dunira sp. 1			3					
Eclipsea sp.			1					
Egnasia cf. conifer	Hampson	1				2		Congeners on Rubiaceae: Canthium/Plectronia
Egnasia mopsa	Swinhoe					1		
Egnasides rudmuna	Hampson			2				
Episparis costistriga	Walker	14	12	10	19	7	96	Congeners on Meliaceae: Chukrasia tabularis, Sapindaceae: Schleichera, Rubiaceae: Stephegyne, Adina, Magnoliaceae: Michelia. Lowland
Episparis sejunctata	Walker	1	1		2		5	Lowland: alluvial, secondary forest
Ericeia ?amanda	Walker	1	3	1	3	2	1	Congeners on Leguminosae: Acacia mangium, Mimosa rubicaulis, Dalbergia latifolia, Cassia, Xylia, Albizia
Ericeia ?inangulata	Guenee	4	3	9	21	3	12	Leguminosae: Cassia, Xylia, Albizia. Montane
Ericeia amanda	Walker	1	3	3	1	1	4	Lowland
Ericeia eriophora	Guenee		1		1		1	Lowland to montane
Ericeia fuscipuncta	Prout	9	2	6	39		9	
Ericeia pertendens	Walker	25	1	2	6		1	Leguminosae. Lowland to montane
Ericeia subcinerea	Snellen	4	6	3	7		8	Leguminosae. Lowland
Erygia apicalis	Guenee	6	13	4	7	3	38	Leguminosae: Desmodium/Ougeinia dalbergioides, Acacia, Albizia, Flemingia. Congener on Leguminosae: Xylia. Lowland to montane
Eucatephia muscosa	Hampson				2		3	
Falana sordida	Moore		1			2	1	Euphorbiaceae: Mallotus
Felinia precedens	Walker	2	1				1	Leguminosae: Calliandra
Felinia spissa	Guenee	1	1	1	2	1	4	Leguminosae: Paraserianthes falcataria
Focillistis salsoma	Swinhoe			1		1	1	
Gesonia obeditalis	Walker	1		1	8			Congener on Leguminosae: Glycine (soy bean), grass
Gespanna pectoralis	Walker	2	1				1	Lowland, lower montane
Goniocraspedon ?mistura	Swinhoe	1						
Goniophila excavata	Swinhoe		1				1	
Gonoglasa camptogramma	Hampson						3	
Gonoglasa nigripalpis	Walker	1	3			2	3	
Hamodes pendleburyi	Prout						1	Congeners on Leguminosae: Dalbergia, Pithecellobium, Anacardiaceae: Mangifera. Montane, lowland infrequent
Hamodes propitia	Guerin-Meneville	1	1				3	Leguminosae: Dalbergia sissoo
Heoeugorna flavicincta	Hampson				1			
Homodes ?vivida	Guenee	3	1	4	2		5	Congeners on Leguminosae: Erythrina subumbrans, Myrsinaceae: Embelia, Euphorbiaceae: Hevea
Homodes crocea	Guenee	1		2	1			Euphorbiaceae: Excoecaria
Homodes perlitha	Hampson			1				
Homodes vivida	Guenee	3	3	2	2	2	4	Rutaceae: Flindersia
Hulodes caranea	Cramer	3		2	4	2	1	Leguminosae: Paraserianthes falcataria, Acanthaceae, Apocynaceae: Dyera costulata (jelutong bukit)
Hulodes drylla	Guenee	1					4	Leguminosae: Xylia. Lowland

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Hyperlopha cristifera	Walker						1	Ebenaceae: Diospyros. Lowland
Hyperlopha discontenta	Walker				1			
Hypocala subsatura	Guenee	1						Genus on Ebenaceae: Diospyros, Sapotaceae: Planchonella, Fagaceae: Quercus, Barringtoniaceae: Barringtonia, Sapindaceae: Lepisanthes
Hypocala violacea	Butler	2	1		5		3	Ebenaceae: Diospyros. Congener on Euphorbiaceae: Glochidion, Solanaceae: Solanum, Anacardiaceae: Spondias. Lowland to montane
Hyposemansis lasiophora	Hampson				1			Lowland: kerangas
Hyposemansis singha	Guenee	2	1		2	10	8	Lowland
Idicara olivaceae	Walker	1		1	3		6	
Iontha rufiscripta	Swinhoe		1					Lowland
Ischyja ferrifracta	Walker	1						Congeners on Dipterocarpaceae: Shorea, Sapindaceae: Cupania anacardioides, Nephelium
Ischyja hageni	Snellen						2	
Ischyja hemiphaea	Hampson	6	15	2	1	3	22	
Ischyja inferna	Swinhoe	2	1	1		2	5	Combretaceae: Terminalia, Leguminosae: Xylia, Dalbergia, Meliaceae: Aglaia
Lacera noctilio	Fabricius	1	1	1	2		1	Nyctaginaceae: Pisonia, Rubiaceae: Canthium, Leguminosae: Caesalpinia. Congener on Leguminosae: Moullava
Leptotroga costalis	Moore		1					
Loxioda dilutalis	Snellen	2	7	8		1		
Maguda ?multifasciata	Swinhoe	1			1		3	
Malagonia cf. acypera	Hampson		2		1	3	1	
Marapana pulverata	Guenee	1		1		2		
Masca abactalis	Walker	12	3		11	1	27	Lowland to montane
Mecodina ?lanceola	Guenee	4	1		1	1		Congeners on Moraceae: Ficus, Rubiaceae: Hymenodictyon
Mecodina albodentata	Swinhoe		2	1	1		1	Apocynaceae: ?Ichnocarpus. Lowland
Mecodina bisignata	Walker			1		1		
Mecodina lanceola	Guenee	1	2	2	6	1	3	
Mecodina metagrapta	Hampson					1		
Mecodina praecipua	Walker		3		1		2	Apocynaceae: Ichnocarpus. Lowland
*Mecodina sp. no. 10781**		1						
Mecodina sumatrana	Kobes				1		2	
Mesosciera orientalis	Hampson		1					
Metaphoenia plagifera	Walker		1	1		6	5	Lowland, lower montane
Midea rectalis	Walker	1		2		2		Leguminosae: Dalbergia. Lower montane on limestone
Neogabara plagiola	Wileman & West	8	7	37	4	7	13	
Nicevillea epiplemoides	Hampson	1	1		1	1	1	Lowland
Oglasa closteroides	Walker	5	4	5	1	6	14	Congeners on Leguminosae: Dalbergia, Sterculiaceae: Sterculia, Tiliaceae: Grewia. Lowland, limestone
Oglasa costisignata	Hampson	2	6	4	4	4	9	
Oglasa lugusalis	Walker		1			4		Leguminosae: Derris
Oglasa sp. 1			1	1	1	2	1	
Oglasa sp. 2				1				
Oglasa sp. 3						1		
Olulodes cautiperas	Hampson		3	3	3	4	7	
Ommatophora luminosa	Cramer						2	Lowland to montane
Ophiderinae 1						1		
Ophiderinae 10		2	1					
Ophiderinae 11		1	2	2	3	2	2	
Ophiderinae 12							2	
Ophiderinae 13			1				1	
Ophiderinae 14			8		2	4	3	
Ophiderinae 15						1	1	

Species	Authority	Number of individuals						
		Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Ophiderinae 16							1	
Ophiderinae 17		2	3			1		
Ophiderinae 18					1	24	1	
Ophiderinae 19						1		
Ophiderinae 2			1					
Ophiderinae 20			1	1		1		
Ophiderinae 21						1		
Ophiderinae 22				1				
Ophiderinae 23						3		
Ophiderinae 24			1					
Ophiderinae 25						1		
Ophiderinae 27							2	
Ophiderinae 29				1		1		
Ophiderinae 3						2		
Ophiderinae 30			2		16	6	1	
Ophiderinae 31				1				
Ophiderinae 32						1		
Ophiderinae 33							1	
Ophiderinae 34		1			1			
Ophiderinae 35							1	
Ophiderinae 36		2						
Ophiderinae 4		5			1	1	4	
Ophiderinae 5		2			3	1		
Ophiderinae 6							1	
Ophiderinae 7			1			9		
Ophiderinae 8				1	1		1	
Ophiderinae 9			2	1			3	
Ophiderinae B**							1	
Ophiderinae F**			3				5	Lowland on limestone
Ophiderinae J**		1	10	4			6	Lowland
Ophiderinae K**		2	2	1		7	3	Lowland
Ophiderinae no. 10769*		1		3		2	9	
Oraesia emarginata	Fabricius			1				Menispermaceae: Cissampelos pareira
Ortopla iarbasalis	Walker		3		1		7	
Ortopla sp.		1	2				3	
Ossonoba torpida	Walker	2	2	1	2		4	
Othreis fullonia	Clerck				1	1	6	Menispermaceae: Tinospora cordifolia, Cocculus laurifolius, Stephania, Cyclea, Tiliacora, Anamirta, Leguminosae: Erythrina, Musaceae, Rubiaceae
Othreis homaena	Hubner		1		1		1	Menispermaceae, Rutaceae: Citrus. Congeners on Amaranthaceae: Achyranthes, Menispermaceae: Tinospora, Cocculus, Stephania
Oxyodes billeti	de Joannis	1	2			1	4	Lowland, lower montane
Oxyodes scrobiculata	Fabricius	145	50	11	75	1	185	Meliaceae: Amoora/Aglaia, Sapindaceae: Litchi/Euphoria, Nephelium. Lowland to montane
Pandesma anysa	Guenee		1	2	2		1	Leguminosae: Dalbergia. Congeners on Leguminosae: Acacia, Albizia, Xylia
Pangrapta albiseriata	Hampson	2	8	1	7	13	11	
Pangrapta aviusalis	Walker		3		1	1		Lowland
Pangrapta holophaea	Hampson	1	3			9	5	Lowland, lower montane
Pangrapta macariana	Hampson			1		1		Lowland, lower montane
Pangrapta metagona	Walker	10	11	3	4	3	31	Lowland, lower montane
Pangrapta pannosa	Moore			3		1	9	Montane

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Pangrapta parsimonalis	Walker		4	2		12	4	Lowland
Pangrapta shivula	Guenee		1					
Pangrapta sp.				1				
Panilla poliochroa	Hampson		1	2				
Pantydia metaspila	Walker			1				Leguminosae: Vigna
Papuacola sp.				1				
Parolulis olivescens	Hampson	4	7	3	4	4	6	
Parolulis sp.							1	
Phorica phasipennis	Walker						1	
Pilipectus cyclopis	Hampson		1				1	Lauraceae: Alseodaphne
Platyja ciacula	Swinhoe			1				
Platyja minutipuncta	Swinhoe	1						Lower montane
Platyja sumatrana magnimargo	Holloway						1	
Platyja umminea	Stoll		1		1		6	Lowland to montane
Plecoptera nebulilinea	Walker	2	2		1		4	Congener on Leguminosae: Dalbergia, Pterocarpus. Lowland
Plecoptera recta	Pagenstecher	1	1	1		1	3	Leguminosae: Dalbergia. Lowland to montane
Pleurona falcata	Walker		1		1		4	Rubiaceae: Hymenodictyon, Verbenaceae: Tectona. Lowland
Plusiodonta chalcytoides	Guenee	2	3	5	2		3	Congeners on Menispermaceae: Cissampelos pareira, Stephania, Cyclea, Cocculus, Sapindaceae: Lepisanthes, Guttiferae: Garcinia
Plusiodonta clavifera	Walker				1	1		
Plusiodonta sp.					1	1	1	
Poeta quadrinotata	Walker	2		3		8	6	
Poliofoca gebenna	Swinhoe					1	1	
Polydesma boarmoides	Guenee			1				Leguminosae: Albizia, Pithecellobium. Congeners on Leguminosae: Xylia, Salicaceae: Salix
Pseudogyrtona ?modesta	Moore	2	3	1	2	1	6	Lowland, ?limestone forest
Pseudogyrtona ?stipata	Walker		1	4	7	3		
Pseudogyrtona ?trichocera	Hampson	1	1	1	1	2		
Pseudogyrtona hemicyclopis	Hampson		3	1	1	1	1	
Pseudogyrtona octosema	Hampson	1	12	5	1	2	2	Lowland
Pseudosphetta fissisigna	Hampson	1	1		1		2	
Pseudosphetta moorei	Cotes & Swinhoe				2		4	
Psimada quadripennis	Walker					1		Moraceae: Ficus
Radara infudens	Walker		4					
Ramadasa fumipennis	Walker				1			
Ramadasa pavo	Walker	2	1		1		5	
Rema costimacula	Guenee	1	2		4		9	Lowland, ?alluvial forest
Rhesalides cf. cineribasis	de Joannis	5	1	1	15	8	1	Leguminosae: Paraserianthes falcataria
Rhytia cocalus	Cramer	1					1	Congeners on Anacardiaceae: Mangifera (mango), Menispermaceae: Tinospora
Rivula curvifera	Walker		1					Congeners on bamboo, grass, Verbenaceae: Avicennia, Marantaceae: Phrynium
Rivula ochracea	Moore		4		1	2	1	Gramineae: Bambusa
Rivula sp. nr. constellata	Hampson					1		
Saroba cf. silignia	Turner			1			1	
Saroba finipalpis	Walker	4	3		2		5	Lowland to montane
Saroba pansa	Swinhoe					1	1	
Saroba phoenicias	Hampson				1	1		
Saroba pustulifera	Walker		2				3	
Sarobides inconclusa	Walker				3	1	1	Cruciferae: Brassica. Lowland
Savara contraria	Walker	1	7		4	1	13	Congener on Sterculiaceae: Sterculia, Heritiera. Lowland to montane

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Savara sp.		2			2	3	7	
*Savara sp. no. 10767**		1	1				3	
Semiothisops macariata	Hampson	3	2	1	2		8	
Spectrophysa distorta	Swinhoe		1					
Stenocarsia sthenoptera	Swinhoe	7	1		3	1		
Sympis rufibasis	Guenee	6	6	3	8		21	Sapindaceae: Nephelium litchi. Lowland to montane
Talariga capacior	Walker	1		2			1	
Tamba basiscripta	Walker		1			1	2	Congener on Barringtoniaceae: Barringtonia
Tamba capatra	Swinhoe	1	1	2	1	1	2	
Tamba cf. rufipennis	Hampson		1		1	1	1	
Tamba cosmoloma	Prout	11	7	6	17	52	15	
Tamba delicata	Prout					1	2	
Tamba diaphora	Prout				1			
Tamba dichroma	Prout			3	1		9	
Tamba euryodia	Prout		1				1	
Tamba hemiionia	Hampson		1	1			1	
Tamba hieroglyphica malayana	Prout	1		1	3	4	11	
Tamba ionomera	Hampson						1	
Tamba lahera	Swinhoe						2	
Tamba lala	Swinhoe	1	2			2	4	
Tamba magniplaga	Swinhoe		2	1	2		3	
Tamba mnionomera	Hampson	5	4	3	5	3	3	Lowland
Tamba ochra	Prout		4			2	5	
Tamba sidonalis	Swinhoe		1			1	2	
Tamba sp. 1							1	
Tamba sp. 2				1				
Tamba sp. 3				1		1	1	
Tephriopis divulsa	Walker	2	2		2	1	2	Leguminosae: Dalbergia, Pterocarpus. Lowland
Throana callista	Prout					1	1	
Throana flavizonata	Hampson	1		2	1	1	1	
Throana lasiocera	Hampson		5	3	1	8	1	Lowland
Throana pectinifer	Hampson	1		1				
Tipasa eubapta	Hampson					1		
Tipasa nebulosella	Walker					8		
Tipasa renalis	Moore			1	1	5		
Tiruvaca sp.		2	1					
Tiruvaca subcostalis	Walker	2	11	7	29	5	31	Bombacaceae: Durio zibethinus, Sterculiaceae: Theobroma. ?Lowland
Tropidtamba lepraota	Hampson						3	
Ugia decisa	Walker	1	5				10	Lowland
Ugia disjungens	Walker	2	5		1		13	Lowland
Ugia monogramma	Hampson		1					
*Ugia sp. no. 10780**		1	3			1	7	
Ugia sundana	Hampson		2				5	
Ugia transversa	Moore		1		1		3	
Vestura minereusalis	Walker	2	2	3		9	7	?Lowland
Xanthanomis fuscifrons	Walker		2	1		2	7	Lowland, lower montane
*Xanthanomis sp. no. 10771**			1				2	

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Zigera diffusifascia	Swinhoe						2	
Zigera eupsema	Swinhoe	1	1			1		
Zigera sp.				1				
	N	519	549	359	706	501	1436	
	S	122	160	119	135	143	199	
6. Subfamily : Acontiinae								Some species feed on scale insects (Coccoidea)
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Acontia olivacea	Hampson		2		1	1		Congeners on Malvaceae: Urena lobata (jute), Hibuscus, Kydia, Sida, Abutilon, Gossypium, Althaea, Decaschistia, Thespesia, Solanaceae
Acontiinae 1		1			2			
Acontiinae 10						1		
Acontiinae 11		1						
Acontiinae 12						3		
Acontiinae 13		1						
Acontiinae 14							1	
Acontiinae 15		1			1	1		
Acontiinae 16							1	
Acontiinae 17		1		1	1	6		
Acontiinae 18						1		
Acontiinae 19			1		1			
Acontiinae 2		7		2		6		
Acontiinae 20						1		
Acontiinae 21							3	
Acontiinae 22			1					
Acontiinae 23						1		
Acontiinae 24			1					
Acontiinae 25						2		
Acontiinae 26						1		
Acontiinae 27						1		
Acontiinae 28			1					
Acontiinae 3		2		1	1	1		
Acontiinae 36						1		
Acontiinae 37						1		
Acontiinae 39						1		
Acontiinae 4						3		
Acontiinae 5			1					
Acontiinae 6		1	2					
Acontiinae 7				1				
Acontiinae 8			1			2		
Acontiinae 9		2	3	3	9	3	3	
Amyna octo	Guenee	1	1	1				Sapindaceae: Cardiospermum, Ulmaceae, Amaranthaceae, Chenopodiaceae, Compositae, Malvaceae, Convolvulaceae, Leguminosae. Lowland
Amyna punctum	Fabricius	12	7	10	8	6	17	Euphorbiaceae: Croton tiglium, C. aromaticum. Herb feeder. Lowland to montane (?hill topping)
Arasada ?albicosta	Hampson				2	1	1	Palmae: Elaeis guineensis
Aroana rubra	Bethune-Baker	2	3		1	2		Congener on Meliaceae: Dysoxylum
Carmara subcervina	Walker	13	10	3	7	1	2	
Cerynea ?contentaria	Walker	9	6	7	17	10		Myrtaceae: Syzygium (rose apple borer)

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Cerynea ?homala	Prout			6				Lower montane, lowland infrequent
Cerynea ?melanocephala	Wileman & West	1			1			
Cerynea ?omphisalis	Walker	3	1			2		
Cerynea flavipuncta	Hampson		3	1		2	1	
Cerynea indecisa	Walker					1		
Corgatha ?atrimargo	Hampson	1				2	1	
Corgatha ?binotata	Warren	6	1	4	1	7	1	
Corgatha ?minor	Moore		1		1	7		
Corgatha implexata	Walker	1	4	2	4	1	9	Lowland
Corgatha leucosticta	Hampson	12		9	1			
Corgatha sp. nr. zonalis	Walker		1				2	
Corgatha tornalis	Wileman		1					
Cretonia vegetus	Swinhoe				1			Lowland
*Enispa sp. A***						39		?Lower montane
*Enispa sp. B***			4	3			7	
Epigrypera eriogona	Hampson	1	1	2			2	
Eublemma ?abrupta	Walker	22	10	13	20	3	2	Genus on coccids. Congeners on Anacardiaceae: Mangifera, Rhus, Solanaceae, Nepenthaceae: Nepenthes, Convolvulaceae, Compositae, cocoa
Eublemma ?castanea	Hampson		2			1		Congeners on Leguminosae: Albizia, Myrtaceae: Syzygium jambos (rose apple), Verbenaceae: Avicennia (fruit, bud-borer), Chenopodiaceae: Suaeda
Eublemma abrupta	Walker		1					Leguminosae: Acacia mangium, Verbenaceae, Anacardiaceae: Mangifera, Euphorbiaceae, Sapindaceae, Moraceae: Ficus. Lowland, lower montane
Eublemma brachygonia	Hampson	1		1	1			Anacardiaceae: Mangifera (flowers), Sapindaceae: Erioglossum, Litchi, Nephelium
Eublemma cf. rubricilia	Hampson					1		
Eublemma commoda	Walker		1	1	1			Lowland, lower montane
Eublemma crassiuscula	Walker				2		2	Lower montane
Eublemma dimidialis	Fabricius						2	Leguminosae: Vigna (bean stem-borer), Solanaceae: Solanum
Eublemma glactea	Hampson		1					
Eublemma quadripunctata	Warren	2	3	1		1	4	Lowland
Eublemma rhodocraspis	Druce						2	
Eublemma rubricilia	Hampson	1	2		1	4		
Eublemma semirufa	Hampson						1	Anacardiaceae: Mangifera (mango shoot borer)
Eublemma sp. 1		2	1	3	5	6		
Eublemma sp. 2		1				1		
Eublemma sp. 3		1						
Eublemma sp. 4		1	15	7		4	4	
Eublemma sp. 5		1	2				1	
Eublemma sp. 6				1	3			
Eublemma sp. nr. brachygonia	Hampson	1	1			21		Pinaceae: Pinus caribaea
Eublemma versicolora	Walker	1						Anacardiaceae: Anacardium occidentale, Mangifera, Euphorbiaceae, Bombacaceae: Durio, Sterculiaceae, Leguminosae, Sapindaceae, Myrtaceae
Eugnathia diagonalis	Hampson		1			1		
Hyposada hydrocampata	Guenee	1			3			
Lithacodia marginalis	Walker	1	1			3		Gramineae
Lithacodia separata	Walker		1	5	5	7		
Lophoruza cithara	Swinhoe				1	1		Congener on Smilacaceae: Smilax
Lophoruza pulcherrima	Butler	1			1	5		
Lophoruza sp.						1		
Maliattha signifera	Walker	1		1			3	Gramineae
Metamaene atrigutta	Walker	2	7	12	8	3	2	Lowland
Oruza ?divisa	Walker			1		2		Dennstaedtiaceae: Pteridium. Congener on Leguminosae: Calliandra, Gramineae: Zea mays (tassel)

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Oruza ?particolor	Warren	2		1		4		
Oruza ?stragulata	Pagenstecher	1	1	6	4	9		
Oruza decorata	Swinhoe	5		1		2		
Oruza fissifascia	Hampson		2					
Oruza lacteicosta	Hampson		3					
Oruza rorata	Walker		1			5		
*Oruza sp. C***				1				
Perynea ruficeps	Walker		1				1	
Perynea viridicincta	Hampson						2	
Tadaxa lintona	Swinhoe					1		
Zurobata intractata	Walker	1	1	2	2	5	2	
Zurobata vacillans	Walker	14	2	8	3	9	1	Fungus, lichen
	N	142	117	121	120	218	80	
	S	42	45	33	33	56	28	
7. Subfamily : Plusiinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Argyrogramma signata	Fabricius		1	1			1	Myrtaceae: Eucalyptus. Disturbed forest
Chrysodeixis acuta	Walker						1	Compositae: Helianthus annuus (sunflower)
Chrysodeixis diehli	Dufay	1	2	23	14	2	23	Lowland, lower montane forest
Chrysodeixis eriosoma	Doubleday				2	1	3	Wide range incl. Leguminosae, Solanaceae, Cruciferae, Malvaceae. Agricultural, open habitats
Chrysodeixis illuminata	Robinson	1	1	2	2		13	
Chrysodeixis minutoides	Holloway	1	1		2	1	4	Lowland, lower montane forest
Ctenoplusia albostriata	Bremer & Grey				1		1	Compositae, Convolvulaceae, Boraginaceae. Lower montane
Ctenoplusia sigillata	Dufay				1			Congener on Compositae, Araliaceae. Montane
Plusia' nigriluna	Walker	1	1		1		3	Euphorbiaceae: Acalypha, Labiatae: Hyptis (mint), Ulmaceae: Trema. Lowlands
Plusiopalpa adrasta	Felder	2				2	4	Compositae: Mikania.
	N	6	6	26	23	6	53	
	S	5	5	3	7	4	9	
8. Subfamily : Stictopterinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Aegilia sundascribens	Holloway	2	3		1		3	Congener on Guttiferae: Mesua ferrea. Lowland to upper montane forest
Diascoides ferruginea	Hampson	6		12	1	1	6	Lowlands, montane forest
Diascoides metaphaea	Walker			1			3	Montane
Diascoides pallida	Holloway		1		2		5	Lowland, montane forest
Gyrtona niveivitta	Swinhooe	1			3	2		Lowlands
Gyrtona oxyptera	Hampson	1						Lowland, coastal, dry heath forest
Gyrtona proximalis	Walker		1				1	Montane, lowland, limestone, kerangas forest
Gyrtona semicarbonalis	Walker					1		Montane, lowland, alluvial, kerangas forest
Lophoptera acuda	Swinhoe	57	28	54	20	55	79	Lowland, alluvial forest to 2000m
Lophoptera astriata	Holloway					1		Montane
Lophoptera belli	Holloway					1		
Lophoptera brunnistis	Holloway	1				1		Montane
Lophoptera chalybea	Walker			1				Upper montane forest

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Lophoptera cinnamona	Holloway						1	Lowland, alluvial forest
Lophoptera coangulata	Warren	1	1	1		1	3	Montane, lowland forest
Lophoptera denticulata brunneostriata	Holloway						1	Montane, lowland forest
Lophoptera dialeuca	Hampson	1	1	2		3		
Lophoptera flavina	Warren				1			Lower montane forest, 250m to 1500m
Lophoptera gadirthoides	Holloway				1		1	Lowland rainforest
Lophoptera huma	Swinhoe	3		4		1		Montane, alluvial forest
Lophoptera illucida	Walker	2	1	9	7	1	10	Dipterocarpaceae: Shorea robusta, Hopea wightiana. Alluvial, montane forest
Lophoptera khasiana	Warren	3	3	1	5	1	7	Upper montane, lowland forest
Lophoptera leucostriga	Hampson	2	3	1	1	5	7	Lowlands to 2000m
Lophoptera lineigera	Holloway		1		1		2	Lower montane
Lophoptera nama	Swinhoe	1				1		Lowland, montane forest
Lophoptera obscurapex	Holloway	1						Lowland rainforest
Lophoptera olivascens	Moore	18	6	19	2	9	36	Agricultural area, lower montane forest
Lophoptera pallibasis	Holloway	86	10	85	22	159	95	Lowland, alluvial, hill dipterocarp, montane forest
Lophoptera parallelnotata	Holloway						1	Dipterocarpaceae: Shorea leprosula. Lowlands
Lophoptera paranthyala	Holland		1				1	Lowland, dry heath, coastal, alluvial, hill dipterocarp forest
Lophoptera partitistis	Holloway		2	1		1	5	Upper montane
Lophoptera phaeobasis	Hampson				1	2		Lower montane forest
Lophoptera polygrapha	Walker						1	Lowlands
Lophoptera punctapex	Holloway			4	1		3	Lowland, kerangas, montane forest
Lophoptera purpurascens occidentalis	Holloway	2			4	1	2	Lowland, hill dipterocarp, montane forest
Lophoptera purpuribasis	Holloway		1				1	Lowland rainforest
Lophoptera purpuriridis	Holloway	2		4		1	4	Upper montane
Lophoptera pustulifera	Walker	1	1	1		2		Lowlands to montane
Lophoptera quadrinotata	Walker			3	3	8	8	Lowlands to 2000m
Lophoptera smaragdivirgatus	Holloway			1		2	2	Lowland rainforest
Lophoptera sp.							1	
Lophoptera squammigera	Guenee			2		1		Euphorbiaceae: Mallotus, Briedelia, Dipterocarpaceae: Shorea, Tiliaceae: Grewia
Lophoptera squammilinea	Holloway	1				1	2	Agricultural area, lower montane forest
Lophoptera stipata	Walker			1		2		Montane, lowland, coastal forest
Lophoptera submarginata	Holloway	6		14	1	7	9	Montane, kerangas forest
Lophoptera trilobuncus	Holloway	1	2	3	6	6	24	Upper montane, lowland
Lophoptera tripartita	Swinhoe		1		1		3	Montane, lowland, alluvial forest
Lophoptera univalva	Holloway				1	1		All altitudes
Odontodes pallidifimbria	Warren						2	Lowlands to upper montane
Odontodes seranensis	Prout	26	12	9	10	5	54	Dipterocarpaceae: Shorea robusta. Lowlands to upper montane
Savoca xista	Swinhoe	4	1	7			3	Lowland, kerangas forest
Sigmuncus albigrisea	Warren					1	1	Upper montane forest
Sigmuncus arcuata	Walker						1	Lowland, montane forest
Stictoptera columba	Walker	1					1	Lowlands, upper montane
Stictoptera cucullioides	Guenee	1			1		1	Guttiferae: Garcinia. Montane, lowland, limestone, alluvial forest
Stictoptera esmeralda	Holloway						3	1500m to 2600m
Stictoptera ferrifera	Walker		1				1	Lowland, hill dipterocarp, montane forest
Stictoptera macromma	Snellen						2	Lowland, dipterocarp, coastal, montane forest
Stictoptera repleta	Walker	1				3	1	Lowland, dipterocarp, dry heath, montane forest
Stictoptera semialba	Walker	1			1			Montane, lowland forest

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Stictoptera signifera	Walker	4	6	1	2	1	16	Dipterocarpaceae: Anisoptera. Lowlands to upper montane
Stictoptera terribilis	Holloway						2	Montane forest
Stictoptera trajiciens	Walker	1	2		1		7	Guttiferae: Garcinia kandis, G. indica. Lowlands, secondary alluvial, dry heath, montane forest
	N	238	89	241	100	288	422	
	S	30	23	25	26	33	45	
9. Subfamily : Euteliinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Anigraea ?homochroa	Hampson						1	Congeners on Anacardiaceae: Anacardium, Burseraceae: Canarium, Fagaceae: Castanopsis
Anigraea ?mediopunctata	Pagenstecher					1		
Anigraea cinctipalpis	Walker	1		1		2		Hill dipterocarp forest, agricultural area
Anigraea homochroa	Hampson				1			Montane, hill dipterocarp, lowland forest
Anigraea mediifascia	Hampson					7	9	Montane forest
Anigraea rubida	Walker		3			1		Lower montane forest
Anigraea serratilinea	Warren	1	2				4	Lowland, dipterocarp, lower montane forest
Anuga canescens	Walker					1		Lowlands
Anuga constricta	Guenee					1	5	Dipterocarpaceae: Anisoptera, Anacardiaceae: Mangifera, Semecarpus, Compositae: Blumea, Cruciferae: Brassica. Lowland, montane forest
Anuga fida	Swinhoe						2	Lowland to montane forest
Anuga insuffusa	Warren	1	1					Lowlands
Anuga rotunda	Holloway		2	1	2		12	Lowland dipterocarp forest, cultivated area
Aplotelia diplographa	Hampson					1		Lowland, montane forest, agricultural area
Atacira angulata	Holloway		1	1		1		Congener on Moraceae: Ficus, Anacardiaceae: Odina. Lowlands
Atacira approximata	Walker						1	
Atacira caesia	Roepke					1		Alluvial forest
Atacira dimidiata	Walker	4	8	9	4	4	22	Lowland rainforest
Atacira rubrirena	Holloway		2				1	Lowland dipterocarp forest
Atacira waterstradti	Holloway		1					
Chlumetia cf. alternans	Moore						1	Congeners on Anacardiaceae: Mangifera (mango shoot borers)
Chlumetia postrubra	Holloway						1	
Paectes osseotrigona	Holloway				1			Congeners on Verbenaceae: Tectona, Dipterocarpaceae: Shorea, Sapindaceae: Pometia. Lower montane, kerangas, hill dipterocarp forest
Paectes poliotis	Hampson		1	1	1	1	4	Lowland dipterocarp, lower montane forest
Penicillaria dorsipuncta	Hampson	1	1				2	Anacardiaceae: Semecarpus. Montane forest
Penicillaria jocosatrix	Guenee	2		1		1		Wide range incl. Anacardiaceae: Mangifera (mango), Anacardium, Schinus, Combretaceae: Terminalia
Penicillaria plusioides	Walker				1		1	Upper montane forest
Penicillaria simplex	Walker		1		1			Montane, lowland, alluvial, kerangas, hill dipterocarp forest
Phalga sinuosa	Moore	1		1			2	Anacardiaceae: Spondias. Lowlands
Targalla apicifascia	Hampson						1	Lowland, montane forest
Targalla delatrix	Guenee					1	1	Myrtaceae: Eucalyptus, Eugenia, Myrtus, Syzygium. Lowland, disturbed habitats
Targalla palliatrix	Guenee						2	Myrtaceae: Eucalyptus, Eugenia, Myrtus, Syzygium. Montane, lowland, dipterocarp, heath forest
Targalla suffundens	Walker				1		1	Hill dipterocarp, dry heath forest
Targalla transversa	Candeze				1	1		Lower montane, lowland forest
Targallodes vittalba	Semper				1	1	1	Congeners on Rutaceae: Citrus, ?Leguminosae. Lowland, montane forest
	N	11	23	15	14	25	74	
	S	7	11	7	10	15	20	

10. Subfamily : Nolinae								Many montane species
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Nola sp.		1						
Aquita acontioides	Walker		2	1				
Celama ?melanota	Hampson	1				1	1	Congeners (incl. flower feeders) on Sapindaceae: Nephelium, Leguminosae: Acacia, Dipterocarpaceae: Dryobalanops, Verbenaceae: Lantana
Celama bifascialis	Walker	1	1				1	Congeners on Melastomataceae: Memecylon, Combretaceae: Terminalia. Lowland, lower montane
Celama fasciata	Walker	2	2	2			1	
Manoba ?implens	Walker	1	2					
Manoba ?rectilinea	Snellen		1	1		1		
Manoba implens	Walker		1					
Nola sp.		2		4		1	1	Congeners on Combretaceae: Terminalia, Dipterocarpaceae: Shorea leprosula (fruit), Rhizophoraceae, Verbenaceae: Avicennia, Moraceae: Ficus
Nolinae 1		1						
Nolinae 2		1	3		1	19	1	
Nolinae 3					1			
Nolinae 4		1		1	4			
Nolinae 5							1	
Nolinae 6			1			1		
Nolinae 8						1		
Roeselia cuneifera	Walker		1					Congener on Combretaceae: Terminalia
Roeselia triangulalis	Leech		1					Lower montane
Sarbena lignifera	Walker	1	1	2			2	
	N	12	16	11	6	24	8	
	S	10	11	6	3	6	7	
11. Subfamily : Sarrothripinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Aquis sp.		1				1		
?Parasena sp.		1					2	
?Risoba sp.							2	
?Selepa sp. 1		1		2				
Aquis albida	Walker		4	1		2		?Lowland
Aquis viridisquama	Walker		1	1				Lowland
Asinduma exscripta	Walker	46	10	56	55	14	73	Leguminosae: flowers of Saraca
Barasa acronyctoides	Walker		1		2	1	4	Myrtaceae: Eugenia jambolana, Syzygium jambos (rose apple), S. aromaticum (cloves). Congener on Combretaceae: Terminalia. Lowland
Beana terminigera	Walker	21	4	4	7	2	5	Combretaceae: Quisqualis, Calycopteris, Rhamnaceae: Ventilago. ?Montane
Blenina chlorophila	Hampson					1	1	Dipterocarpaceae: Shorea pauciflora. Lowland to montane
Blenina lichenosa	Moore	1			1		1	Leguminosae: Pterocarpus stenoptera, Ebenaceae: Diospyros. Mostly montane
Characoma ?albulalis	Walker	2	5	2	7		8	?Leguminosae - pod feeder. Congeners on Fagaceae, Malvaceae: Hibiscus (bud-borer), Juglandaceae: Juglans (fruit). Lowland to montane
Characoma cf. basisuffusa	Holloway					1		?Lower montane
Characoma metalophota	Hampson	3		1	5	3	16	Lowland, montane
Characoma nilotica	Rogenhofer	2		5				Tamaricaceae: Tamarix, Combretaceae: Terminalia, Sterculiaceae: Heritiera, Leguminosae: Cynometra
*Characoma sp. no. 10671**		1						
Dilophothripa alopha	Hampson		1					Congener on Leguminosae: Saraca. Lowland, especially on limestone
Etanna basalis	Walker						1	
Garella ?rotundipennis	Walker	2	3	3	1	18	10	Leguminosae: Erythrina, Sterculiaceae: Helicteres, Combretaceae: Terminalia, Guttiferae: Calophyllum. Lowland
Giaura lichenosa	Hampson				1			Congeners on Leguminosae: Butea frondosa, Glycine, Dolichos,Malvaceae: Ochroma lagopus, Ulmaceae: Trema orientalis, Sterculiaceae: Heritiera
Giaura multipunctata	Swinhoe				1	2	4	Congener on Tiliaceae: Grewia. ?Montane

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Giaura niveidisca	Hampson	1	1		2	2		Sterculiaceae: Pterospermum. Lowland, lower montane
Gyrtothripa pusilla	Moore			2				Myrtaceae: Melaleuca cajuputi, Sterculiaceae: Heritiera (flower feeder). Lowland, lower montane
Labanda ?saturalis	Walker	1	1				2	Congeners on Ebenaceae: Diospyros, Euphorbiaceae: Glochidion. Montane
Labanda ?umbrosa	Hampson						2	
Labanda attenuatalis	Walker			1			2	
Labanda sp.					1			
Labanda umbrosa	Hampson		2				2	
*Metallophota sp. no. 10664**		1					2	
Nanaguna ?basalis	Moore			1				Congener on pod of Leguminosae
Nanaguna ?breviuscula	Walker						2	Combretaceae: flowers of Terminalia
Nanaguna ?vittalis	Walker	1						
Nanaguna breviuscula	Walker	20	5	21	7	1		Leguminosae: Cajanus, Desmodium, Calliandra, Anacardiaceae: Mangifera, Anacardium occidentale, Ulmaceae, Combretaceae. Lowland to montane
Negritothripa hampsoni	Wileman					1		
Ptisciana seminivea	Walker	3	6	6	4	7	6	Euphorbiaceae: Macaranga. ?Lowland
Risoba ?repugnans	Walker	1		1	3		2	
Risoba calaina	Zerny						2	Congeners on Lythraceae: Lagerstroemia, Combretaceae: Quisqualis, Terminalia, Leguminosae: Xylia, Melastomataceae: Melastoma, Osbeckia
Risoba diversipennis	Walker						1	
Risoba glauca	Hampson				1	1		
Risoba jucunda	Walker			1				
Risoba prominens	Moore	2	2	1	3		7	Combretaceae: Quisqualis, Leguminosae: Pterocarpus stenoptera
Risoba repugnans	Walker	1						Melastomataceae: Melastoma
Risoba sp. 1				3	4	2	8	
Risoba sp. 2		1	16	4			10	
Risoba sp. 3			1				1	
Risoba sp. 4			1	1	2		2	
Risoba sp. 5				1				
Sarrothripinae 1		2		1				
Sarrothripinae 2							1	
Sarrothripinae 3			1	1				
Sarrothripinae 6			1					
Sarrothripinae 7						1		
Sarrothripinae no. 10684*		1	3	3		8		
Selepa ?molybdea	Hampson	3						Congeners on Leguminosae: Acacia nilotica, Albizia, Anacardiaceae, Lauraceae: Cinnamomum, Solanaceae: Solanum melongena, Lythraceae
Selepa acervata	Hulstaert				1			Congeners on Euphorbiaceae: Phyllanthus, Verbenaceae: Gmelina, Moraceae: Ficus, Dipterocarpaceae: Shorea
Selepa discigera	Walker						1	Combretaceae: Terminalia, Euphorbiaceae: Euphorbia, Loranthaceae: Loranthus, Anacardiaceae: Anacardium occidentale
Selepa nigralba	Hampson				5			Lowland
Tathothripa continua	Walker	2	2	2	2	6	6	Lowland to montane
Triorbis aureovitta	Hampson	1					2	Guttiferae: Garcinia
	N	122	71	125	115	74	188	
	S	26	21	25	21	19	31	

12. Subfamily : Chloephorinae

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
?Homophlebia sp.						1		
Aiteta angustipennis	Warren			2			1	Genus on Combretaceae: Terminalia tomentosa. Lowland
Aiteta damnipennis	Walker				1		1	

Species	Authority	Number of individuals						
		Am	Ed	Ga	Pf	Pc	SF	
Aiteta deminutiva	Warren		1			6		
Ariola coelisigna	Walker	3			1	1	3	Lowland to montane
Ariolica lineolata	Walker		1					
Ballatha tenuipalpis	Snellen		1					
Beara dilatata	Holloway		1		1	1	1	Congeners on Rhamnaceae: Zizyphus, Zeltus, Solanaceae: Solanum tuberosum, Verbenaceae: Tectona, Ulmaceae, Tiliaceae, Leguminosae. Lowland
Bessara quadratipennis	Walker	1						
Carea ?effusa	Swinhoe		13	1		1	2	Congeners on Myrtaceae: Cleistocalyx, Syzygium, Eugenia, Eucalyptus, Moraceae: Ficus, Melastomataceae: Memecylon, Bombacaceae: Bombax
Carea ?trichotmeta	Prout		8		2		11	?Montane
Carea annae	Swinhoe		3				3	Lowland
Carea argentiviridis	Holloway		1		2		5	?Lower montane
Carea balteata	Warren						1	
Carea biviata	Hampson	2	3		1		16	
Carea careoides	Warren		1				1	
Carea carneplagiata	Warren	1	1		1		6	
Carea chlorostigma	Hampson	2					4	Theaceae (tea defoliator), congeners on Myrtaceae: Eugenia jambolana, Syzygium, Melastomataceae: Memecylon
Carea costiplaga	Swinhoe	2	8		3	2	12	Lowland
Carea diplogramma	Hampson		1				1	
Carea endophaea	Hampson						2	Melastomataceae: Memecylon. ?Montane
Carea exesa	Warren		1		1	2	8	
Carea jacobsoni	Roepke	1			1		2	
Carea metaphaea	Hampson	7	25	5	8	4	56	Lowland, lower montane
Carea mixticolor	Warren		2		1		2	
Carea nexilla	Hampson		21	2	4	2	17	
Carea pryeri	Druce	2	4	1	2		13	Lowland
Carea purpurea	Hampson	1					2	
Carea sp. 1			1					
Carea sp. 2							1	
Carea sp. 3				1			1	
Carea sp. 4							1	
Carea sp. 5			1					
Carea sp. 6							1	
Carea tumida	Hampson	3	6	1	1		17	Lower montane
Carea varipes	Walker		2		2		5	Myrtaceae: Eugenia xanthocarpa. Lowland, lower montane
Chandica quadripennis	Moore	4	4	2	1	3	9	Lowland, lower montane
Chloephorinae 1			1					
Chloephorinae 2				1			1	
Chloroplaga nygmia	Swinhoe	3	19	6	3	5	21	Lowland to montane
Chloroplaga pallida	Warren	1	5	1	2	1	11	Lowland to montane
Chora rubricosa	Bethune-Baker						1	
Choriola gratissima	Walker		1			1		?Montane
Cossedia hyriodes	Hampson		1			1	1	
Didigua ?effusa	Swinhoe	4	2	1		5	5	Lowland
Didigua cineracea	Holloway	8	21	4	3	2	26	Lowland
*Didigua sp. no. 10716**			2	1	1	2	3	Lowland
Didigua vexilla	Swinhoe		4		2	1	8	?Lower montane
Didigua viridifascia	Swinhoe	1	2	1	2	1	5	
Earias mjobergi	Prout		1					Congeners on Malvaceae: Hibiscus esculentus (okra or Ladies' Fingers), Gossypium, Althaea, Sida, jute, Gramineae: Oryza sativa, Tiliaceae: Grewia

Species	Authority	Number of individuals						
		Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Erizada lichenaria	Walker	1	3	1	5		7	Bombacaceae: Durio zibethinus. Congener on Tiliaceae: Grewia. ?Lowland
Erizada semifervens	Walker					1		
Hylophilodes dubia	Prout						1	
Lasiolopha saturata	Walker			1				
Maceda mansueta	Walker	49	22	20	20	55	35	Sterculiaceae: Heritiera. Lowland to montane
Maurilia cervina	Walker	2		1				Congener on ?Melastomataceae: Memecylon
Maurilia fortis	Swinhoe		2					
Maurilia iconica	Walker	18	7	13	7	3	19	Dipterocarpaceae: Shorea robusta, S. leprosula, Verbenaceae: Tectona grandis, Combretaceae: Anogeissus latifolia, Terminalia. Lowland to montane
Negeta ?sublineata	Walker	5	5		3	7	4	
Negeta signata	Walker	6	14	7	8	26	9	Lowland
Negeta sp.		1						
Orthocraspis acypera	Hampson				1		1	
Paracrama dulcissima	Walker					1		Tiliaceae: Grewia
Pseudelydna xanthia	Hampson						2	Congener on Combretaceae: Terminalia. Lowland
Pterogonia aurigutta	Walker						1	Lowland
Pterogonia cardinalis	Holloway	1	5			1	7	?Myrtaceae: Eugenia
Pterogonia nerissa	Swinhoe	1	3				5	Lowland
Pterogonia striatura	Moore			1			2	Lowland
Ptyonota formosa	Hampson						2	
Siglophora bella	Butler	1	6	2		1	5	Lowland
Siglophora cymographa	Hampson	1					1	
Siglophora sp.			1				2	
Sinna floralis	Hampson		1	1			1	
Titulcia eximia	Walker		1					
Urbona dentilinealis	Moore						1	
Westermannia albiorbis	Hampson		2	1		2	7	Genus on Combretaceae: Terminalia belerica. Lowland
Westermannia pangolina	Holloway		4		1	1	6	Congener on Lythraceae: Lagerstroemia. Lowland
Westermannia rajata	Kobes	1	2			2	1	
Westermannia triangularis	Moore	2		1	1		3	
	N	135	247	79	92	142	409	
	S	30	49	26	31	30	62	

13. Subfamily : Amphipyrinae

Species	Authority	Number of individuals						
		Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Aeologramma picatum	Butler		1				1	Mixed dipterocarp, lower montane forest
Ancara obliterans	Walker	2	1		4	1	5	Lowlands to upper montane
Ancara replicans	Walker	2	3	1		1	20	Lowlands to upper montane
Apsarasa radians	Westwood			1	2			Lowland, lower montane forest
Athetis bipuncta	Snellen	14	17	6	8	25	52	Lowlands to montane, open habitats
Athetis nonagrica	Walker	18	1	12	8	5	49	Montane, lowlands, open habitats
Athetis reclusa	Walker	1		2	3	4	2	Cruciferae: Brassica. Lowlands to 1200m, open habitats
Athetis thoracica	Butler	13	7	23	11	10	33	Wide range incl. Gramineae, Leguminosae, Convolvulaceae: Ipomoea, Myrtaceae, Solanaceae, Theaceae, Portulacaceae, Commelinaceae
Bagada api	Holloway						1	Limestone forest
Bagada labi	Holloway	1	1	2	7	9	8	Lowland rainforest
Bagada lignigera	Walker	1			2	3	6	Lowland forest to 2000m
Bagada malayica	Snellen					1		Lowland rainforest

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Borbotana nivifascia	Walker	1	1	1	3	3	2	Lowland, open habitats, dry heath forest
Callopistria callopistrioides	Moore			1		1		Genus on ferns e.g. Davalliaceae: Nephrolepis, Dennstaedtiaceae: Pteridium. Lowland forest
Callopistria emiliusalis	Walker	20	6	11	15	9	14	Disturbed, open habitats
Callopistria maillardi	Guenee	55	20	41	114	53	62	Davalliaceae: Nephrolepis, Adiantaceae: Adiantum, Pellaea, Schizaeaceae: Lygodium, Piperaceae: Piper
Callopistria obliterata	Warren		1			2		Lowland, primary, disturbed, dry heath, mangrove forest
Callopistria placodoides	Guenee		4	7	6	6	1	Dennstaedtiaceae: Pteridium. Lowland, dry heath forest
Callopistria pulchrilinea	Walker	1	4	1	6			Fern frond. Lowland forest to 2000m
Callopistria rivularis	Walker		1		1		1	Cultivated area, lower montane, lowland forest
Callopistria thalpophiloides	Walker						2	Lowland, montane forest
Callopistria trilineata	Walker			1				Lowlands to 1200m, open, disturbed habitats
Callopistria wallacei	Felder	1						Lowlands
Callyna monoleuca	Walker						1	Boraginaceae: Cordia, Ehretia
Callyna semivitta	Moore					1	2	
Chasmina coremata	Holloway	1			1			Congeners on Tiliaceae: Grewia, Sterculiaceae: Helicteres, Malvaceae: Hibiscus. Lowlands
Chasmina sundana	Holloway			1			2	Upper montane to lowlands
Clethrorasa micropuncta	Holloway						1	Hill dipterocarp, lower montane forest
Condica albigutta	Wileman		1	2		13	1	Cultivated area, lower montane
Condica aroana	Bethune-Baker		2	1	1			Open habitats, lowlands to 1200m
Condica dolorosa	Walker	1		1	1	2	4	Compositae: Conyza, Elephantopus. Cultivated area, lower montane
Condica illecta	Walker	23	15	13	60	23	65	Compositae: Ageratum, Bidens, Carthamus, Coreopsis, Dahlia, Dichrocephala, Acanthaceae. Open habitats, up to 2000m
Corythurus nocturnus	Hampson	2	9	1	6	2	35	Lowland, montane forest
Dipterygina dorsipallens	Holloway	16		19	46	18	4	Congeners on Verbenaceae: Callicarpa. Lowland, montane forest
Dipterygina vagivitta	Walker	104	12	63	203	45	31	Lowlands to 1200m
Dyrzela boscoides	Holloway	4	3	1	5	4	9	Lowland, montane forest
Dyrzela incrassata	Walker	1			1		1	Lowlands to 2000m
Dyrzela increnulata	Warren	3	3	1		5	5	Lowland, montane forest
Dyrzela plagiata	Walker		2	1	2	5	5	Tiliaceae: Grewia. Lowlands to upper montane
Dyrzela tumidimacula	Warren		1				2	Lowland, montane forest
Iambia lyricalis	Holloway	1	14		5	2	19	Congener on Rhamnaceae: Zizyphus. Lowland forest
Iambia tessellata	Prout	1						Lowland, montane forest
Lignispalta diversisigna	Prout						1	Montane
Lignispalta incertissima	Bethune-Baker	2	2	4	1		25	Lowland forest to 2200m
Mudaria magniplaga	Walker				1			Bombacaceae: Durio zibethinus (durian). Lowlands
Mudaria major	Warren	2	2	3	7		3	Lowlands to montane, open, cultivated area
Mudaria minoroides	Holloway		1		1		5	Lowland, montane forest
Mudaria tayi	Holloway	1		1	2		3	Lowland, montane forest
Paradiopa albidisca	Holloway	1	1				1	Lower montane
Phlogophora discalis	Warren				1			Congener polyphagous on leaves and flowers. Montane
Prometopus albistigma	Swinhoe			1			1	Congener on conifer. Lowlands, dipterocarp, montane forest
Sasunaga interrupta	Warren	3	3	2	3		12	Congeners on Rhamnaceae
Sasunaga interrupta murudensis	Prout				1			Upper montane forest
Sasunaga leucorina	Hampson	5		1	1		3	Upper montane to lower altitudes
Sasunaga longiplaga	Warren	3	3	6	3	3	23	Lowlands to 2600m
Sasunaga tenebrosa	Moore		1				5	Rhamnaceae: Ventilago. Lowlands to 2600m
Spodoptera litura	Fabricius				1			Wide range incl. Gramineae, Solanaceae: Capsicum, Dipterocarpaceae: Shorea macroptera. Lowland, open, cultivated, disturbed areas
Spodoptera mauritia	Boisduval			1			1	Wide range incl. Gramineae (rice), Compositae. Lowland, open, cultivated, disturbed areas
Spodoptera pecten	Guenee	1		1			2	Gramineae, Dipterocarpaceae: Shorea curtisii. Lowland, open, cultivated, disturbed areas

		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Stenopterygia calida	Walker						1	Congener on Ochnaceae: Ochna. Lowland forest to 2000m
Yepcalphis dilectissima	Walker		1	1				Verbenaceae: Vitex. Lowland forest, disturbed area
	N	305	144	235	543	256	532	
	S	32	32	35	36	27	46	
14. Subfamily : Acronictinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Acronicta rubiginosa	Walker	1	2		3		1	Combretaceae: Terminalia. Montane, lowland forest
Platyprosopa nigrostrigata	Bethune-Baker			1	1		3	Cultivated area, lower montane
Thalathoides curtalis	Holloway		1			1		Congener on Oleaceae: Olea. Lowland, montane forest
	N	1	3	1	4	1	4	
	S	1	2	1	2	1	2	
15. Subfamily : Agaristinae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Mimeusemia perakana	Rothschild	1					3	Congeners on Vitaceae: Cayratia, Dilleniaceae: Dillenia. Lowland forest
Mimeusemia postica	Walker	3	4			1	14	Lowland forest
Mimeusemia vittata	Butler		1					Montane
	N	4	5	0	0	1	17	
	S	2	2	0	0	1	2	
16. Subfamily : Hadeninae								
		Number of individuals						
Species	Authority	Am	Ed	Ga	Pf	Pc	SF	Recorded host plants/habitat preference
Bornolis kamburonga	Holloway						1	Congener ?conifer feeder. Montane
Elusa ceneusalis	Walker	44	10	11	18	12	28	Dipterocarpaceae: Shorea johorensis (fruit). Lowland, undisturbed, secondary forest
Elusa cyathicornis	Walker	4						Disturbed forest
Elusa penanorum	Holloway	4			2	2	1	Lowland, swamp, alluvial, hill dipterocarp forest
Elusa simplex	Warren	2		6	1			
Elusa temburong	Holloway	3						Lowland rainforest
Elusa ustula	Hampson				3			Lowland, alluvial forest
Mythimna calorai	Holloway	1	3				7	Cultivated area
Mythimna decississima	Walker	6	6	3	9	5	25	Lowland, open, secondary vegetation
Mythimna exsanguis	Guenee			1			1	Gramineae: Saccharum. Lowlands
Mythimna nabalua	Holloway			2		4		Disturbed habitats
Mythimna simillima	Walker				2		1	
Mythimna yu	Guenee	1	1	1		2	7	Gramineae: Paspalum, Saccharum. Cultivated area, swamp, coastal forest
Tiracola aureata	Holloway	1	1	1	4	1	15	Wide range. See T. plagiata. Lowlands to 2600m
Tiracola plagiata	Walker	3	5	4	21	8	70	Wide range incl. Euphorbiaceae (cassava), Leguminosae, Verbenaceae, Compositae, Rubiaceae, Sterculiaceae, Zingiberaceae, Piperaceae
	N	69	26	29	60	34	156	
	S	10	6	8	8	7	10	
	Total N	6602	4285	4164	6523	4413	8490	
	Total S	726	872	675	782	778	1048	

* Refers to slide number in the Natural History Museum in London prepared by J.D.Holloway
** Refers to series in J.D.Holloway's collection in the Natural History Museum
^ Sources of host plant records and habitat preference: Barlow (1982), Holloway (1983a, 1985, 1986, 1987b, 1988, 1989,1993), Robinson (1975), Murphy (1990), Browne (1968), Gardner (1943, 1946-8), Mathur (1942), Mathur et al. (1958),
Singh (1953, 1957), Sevastopulo (1946, 1947a, 1947b), & unpublished records of T.R.Bell (India), Y.P.Tho (Malaysia), and host records ex Commonwealth Institute of Entomology (CIE) index.
Numerous data for habitat preference not covered by Holloway in his Moths of Borneo series but provided by him based mainly on observations made during the Mulu survey (Holloway, 1984).
Some species reared by the author (see Appendix V).

Appendix II. Rainfall data for light-trapping sites at Brumas in 1991

Month	Rainfall (mm)
January	108
February	126.3
March	211.9
April	170.2
May	236.1
June	171.1
July	85.3
August	186.4
September	70.6
October	232
November	218.2
December	186.6

Appendix III. Light-trap transect samples of macromoths and their recorded host plants/habitat preference: Acacia transect

Transect from plantation forest to adjacent secondary natural forest in Brumas
With similar sampling at herb layer (area cleared for replanting) in Brumas &
primary natural forest in Danum Valley for comparison.

Plantation :
Acacia mangium
Sites :
T1 = Middle of plantation
T2 = Plantation site near secondary forest
T3 = Plantation-Secondary forest border
T4 = Secondary forest site near plantation
T5 = Middle of secondary forest
HL = Herb layer
DV = Primary natural forest in Danum Valley

Date :
October/November 1992

MACROLEPIDOPTERA
I. Superfamily : Cossoidea
i. Family : Cossidae

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Xyleutes ceramica	Walker	2	0	0	1	0	0	0	Verbenaceae: Gmelina, Callicarpa, Tectona, Clerodendrum, Leguminosae, Bignoniaceae: Spathodea, Sonneratiaceae: Duabanga
Xyleutes malayica	Roepke	0	1	0	0	0	0	0	Mangrove, swamp, alluvial forest
Xyleutes mineus	Cramer	0	2	0	0	1	0	0	Lowland rainforest
	sum	2	3	0	1	1	0	0	

ii. Family : Metarbelidae

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Squamura disciplaga	Swinhoe	1	0	0	0	0	1	0	Lauraceae: Persea (avocado), Rutaceae: Citrus

II. Superfamily : Zygaenoidea
i. Family : Limacodidae

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Cania bandura	Moore	0	0	1	1	4	0	0	Ebenaceae: Diospyros discolor, Palmae. Lowland, lower montane forest
Chalcocelis albiguttatus	Snellen	2	1	9	1	0	0	2	Wide range incl. Leguminosae: Acacia, Myrtaceae: Eugenia, Rubiaceae: Coffea, Euphorbiaceae, Flacourtiaceae, Palmae: Cocos
Heringarosa trifurca #	Holloway	0	0	0	0	0	0	2	Lowland, wet heath, hill dipterocarp forest
Nirmides basalis	Walker	1	0	1	0	0	0	0	Lowland, swampy, dry heath, hill dipterocarp, alluvial, lower montane forest
Parasa darma #	Moore	0	0	0	0	0	0	1	Palmae: Cocos. Lowland, kerangas, hill dipterocarp, limestone, montane forest
Pseudidonauton bhaga	Swinhoe	0	0	0	0	0	0	1	Congener on Leguminosae: Dalbergia. Lowland rainforest
Scopelodes albipalpalis	Hering	0	0	4	3	3	0	4	Lowland, wet heath (kerangas) forest
Scopelodes pallivittata	Snellen	1	0	0	0	1	0	4	Musaceae: Musa, Sterculiaceae: Theobroma cacao, Sapindaceae: Nephelium
Scopelodes unicolor	Westwood	0	1	1	0	0	0	0	Sterculiaceae: Theobroma, Myrtaceae: Eugenia, Euphorbiaceae: Ricinus, Sapindaceae: Nephelium and many fruit trees
Setora cupreiplaga	Walker	0	1	0	0	0	0	0	Congener on wide range incl. Musaceae, Palmae, Sterculiaceae, Rubiaceae, Sapindaceae, Theaceae, Rutaceae, Solanaceae, Zingiberaceae
Setora cupreistriga	Walker	1	4	15	1	10	1	0	See S. cupreiplaga above

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Setothosea asigna	van Eecke	1	4	0	1	3	0	1	Palmae: Elaeis, Cocos. Lowland, hill dipterocarp, lower montane, alluvial, kerangas forest
Thosea vetusinua	Holloway	0	0	0	0	0	1	0	Lowlands
	sum	6	11	31	7	21	2	15	
III. Superfamily : Bombycoidea									
i. Family : Lasiocampidae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Euthrix laeta	Walker	1	0	0	0	0	0	0	Grass feeder, Leguminosae: Dalbergia
Gastropacha leopoldi	Tams	1	0	0	0	0	0	0	Apocynaceae: Carissa. Congener on Leguminosae: Enterolobium, Pithecellobium, Euphorbiaceae: Baccaurea, Aporusa
Kunugia austroplacida	Holloway	0	0	0	0	0	0	4	Lowland, montane forest
Odonestis erectilinea	Swinhoe	0	0	0	0	0	0	1	Leguminosae: Acacia mangium (reared), Combretaceae: Combretum. Lowland forest
Paralebeda lucifuga	Swinhoe	1	1	2	2	4	0	1	Melostomataceae: Melastoma malabathricum, Sapindaceae: Nephelium, Rubiaceae: Coffea
Syrastrena sumatrana +	Tams	0	1	0	0	0	0	0	Montane, lowland forest
Takanea diehli	Lajonquiere	0	1	1	3	3	0	0	Lowland rainforest
	sum	3	3	3	5	7	0	6	
ii. Family : Saturniidae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Archaeoattacus staudingeri +	Rothschild	0	0	0	1	0	0	0	Congener on Magnoliaceae: Machilus, Rosaceae: Prunus, Simaroubaceae: Ailanthus. Lowland forest
Samia tetrica	Rebel	0	0	1	0	0	0	2	Congener on wide range incl. Lythraceae: Lagerstroemia indica, Euphorbiaceae: Ricinus communis (castor oil plant)
	sum	0	0	1	1	0	0	2	
iii. Family : Sphingidae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Acosmeryx shervillii	Boisduval	0	1	1	0	3	0	0	Vitaceae: Cayratia, Cissus, Vitis, Leeaceae: Leea, Dilleniaceae: Dillenia, Actinidiaceae: Saurauia
Ambulyx clavata	Jordan	0	1	0	0	0	0	0	Lythraceae: Lagerstroemia. Lowlands
Ambulyx pryeri	Distant	0	0	0	0	2	0	0	Apocynaceae: Plumeria (frangipani). Lowlands to 2600m
Cechenena aegrota	Butler	0	1	0	0	0	0	0	Rubiaceae: Psychotria. Regenerating alluvial forest
Daphnis hypothous	Cramer	0	2	0	0	0	0	0	Rubiaceae: Anthocephalus, Uncaria (gambier), Cinchona, Wendlandia paniculata, Ixora, Pavetta, Apocynaceae: Alstonia
Enpinanga borneensis	Butler	0	1	1	1	1	0	0	Dilleniaceae: Dillenia (Wormia), Tetracera
Marumba juvencus +	Rothschild & Jordan	0	0	0	0	1	0	0	Congeners on Lauraceae, Fagaceae, Rosaceae, Bombacaceae, Euphorbiaceae, Leguminosae, Malvaceae, Sapindaceae, Sterculiaceae
Panacra dohertyi	Rothschild	0	1	0	0	1	0	0	Lowlands
Psilogramma menephron	Cramer	0	1	0	0	0	0	0	Wide range incl. Verbenaceae: Gmelina arborea, Callicarpa, Tectona, Bignoniaceae, Flacourtiaceae, Labiatae, Meliaceae, Oleaceae, Scrophulariceae
Theretra clotho	Drury	0	0	0	0	1	0	0	Leeaceae: Leea, Dilleniaceae: Dillenia, Vitaceae: Cayratia, Cissus, Vitis, Malvaceae: Hibiscus, Araceae, Begoniaceae, Onagraceae, Urticaceae
Theretra latreillei	MacLeay	0	4	2	4	5	0	0	Actinidiaceae: Saurauia, Balsalminaceae: Impatiens, Vitaceae: Vitis, Tetrastigma, Cayratia, Cissus, Lythraceae, Begoniaceae, Dilleniaceae, Onagraceae
Theretra rhesus	Boisduval	1	1	1	2	6	0	0	250m to 1200m
	sum	1	13	5	7	20	0	0	
IV. Superfamily : Geometroidea									
i. Family : Drepanidae									
1. Subfamily : Drepaninae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
?Trotothyris sp.		0	0	0	1	0	0	0	

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Albara hollowayi	Watson	0	0	0	0	0	0	1	Congener on Rosaceae: Rubus. Lowland to lower montane
Callidrepana patrana	Moore	0	2	0	0	0	0	0	Congener on Rhizophoraceae: Bruguiera
Ectothyris trifenestrata	Swinhoe	1	0	0	0	0	0	0	?Lowland
Teldenia specca	Wilkinson	0	0	0	0	0	0	1	Congeners on Combretaceae: Terminalia, Tiliaceae: Grewia, Dipterocarpaceae: Hopea. Lowland to upper montane
Tridrepana fulvata	Snellen	0	0	1	0	0	0	0	Sapindaceae: Nephelium lappaceum. Lowland
Tridrepana microcrocea	Gaede	0	1	4	0	0	0	0	Lowland
Tridrepana subtusmaculata	Gaede	0	0	0	0	1	0	0	
	sum	1	3	5	1	1	0	2	
2. Subfamily : Oretinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Oreta carnea	Butler	0	0	0	1	0	0	0	Congener on Rubiaceae: Mussaenda, Randia, Pavetta. Lowland
Oreta rubromarginata	Butler	0	0	1	0	0	0	0	Lowland
	sum	0	0	1	1	0	0	0	
ii. Family : Uraniidae									
1. Subfamily : Uraniinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Lyssa menoetius	Hopffer	0	8	0	2	2	0	0	Congener on Euphorbiaceae: Endospermum malaccense. Lowland
2. Subfamily : Microniinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Micronia astheniata	Guenee	0	0	0	1	0	0	0	Myrtaceae: Eugenia malaccensis, Euphorbiaceae: Endospermum malaccense. Lowland
Strophidia fasciata	Cramer	0	0	0	1	0	0	0	
	sum	0	0	0	2	0	0	0	
iii. Family : Epiplemidae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Epiplema instabilata	Walker	0	0	0	0	0	0	1	Verbenaceae: Premna. Congeners on Verbenaceae: Gmelina, Mussaenda, Oleaceae: Olea, Linociera. ?Lowland
Epiplema quadricaudata	Walker	2	0	3	1	1	0	2	Rubiaceae: Cinchona, Anthocephalus chinensis, Adina. Lowland
	sum	2	0	3	1	1	0	3	
iv. Family : Geometridae									
1. Subfamily : Oenochrominae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Celerena signata	Warren	0	1	0	0	0	0	0	Lowland, disturbed forest
Heteralex rectilinea	Guenee	0	0	1	0	0	0	0	Lowland
Ozola ?basisparsata	Walker	9	3	7	1	0	0	2	Congener on Verbenaceae: Gmelina, Premna. ?Lowland
	sum	9	4	8	1	0	0	2	

2. Subfamily : Geometrinae

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Berta annulifera	Warren	0	0	1	0	0	0	1	Congener on Sapindaceae: Nephelium lappaceum. Lowland
Berta chrysolineata	Walker	0	0	0	1	0	0	1	Anacardiaceae: Mangifera, Sapotaceae: Chrysophyllum cainito (star-apple), Euphorbiaceae: Ricinus. Lowland
Chloromachia albisparsa	Walker	0	0	0	0	0	0	1	Congeners on Myrtaceae: Myrtus, Eugenia jambolana. Lowland
Comibaena albicatena	Warren	0	0	0	0	1	0	1	Congeners on Leguminosae: Acacia, Anacardiaceae, Rhamnaceae: Zizyphus, Compositae: Tagetes, Myrtaceae: Myrtus, Rutaceae. Montane
Comibaena attenuata	Warren	2	5	1	0	0	2	0	Sapindaceae: Nephelium. Lowland
Doobia puncticosta	Prout	0	0	0	0	1	0	0	Lowland
Gelasma ?magnipuncta	Prout	0	0	0	0	0	2	0	Congeners on Combretaceae: Anogeissus, Terminalia, Myrtaceae: Eugenia, Syzygium, Dipterocarpaceae: Shorea, Euphorbiaceae: Phyllanthus
Gelasma ?waterstradti	Prout	0	0	0	0	0	0	1	Lowland
Gelasma sp.		0	0	0	0	0	0	1	
Gelasma thetydaria	Guenee	0	0	0	0	1	0	0	Montane
Idiochlora ?subtusumbrata	Fuchs	0	0	0	0	0	0	1	Congener on Compositae: Helianthus annuus (sunflower)
Ornithospila submonstrans	Walker	0	0	0	0	1	0	1	Dipterocarpaceae: Shorea parvifolia
Pingasa ruginaria	Guenee	0	1	1	0	2	0	0	Lauraceae: Litsea polyantha, Rubiaceae: Mussaenda, Wendlandia, Sterculiaceae: Sterculia. Lowland, secondary forest
Pingasa tapungkanana	Strand	0	0	1	0	0	0	0	Lauraceae: Litsea polyantha. Lowland
Prasinocyma floresaria	Walker	0	0	1	1	1	0	0	Congener on Combretaceae: Terminalia. Lowland
Tanaorhinus rafflesii	Moore	1	1	1	3	1	0	8	Fagaceae: Quercus. Lowland to montane
Thalassodes ?griseifimbria	Prout	0	0	0	0	1	0	1	Anacardiaceae: Mangifera indica (mango), Sapindaceae: Schleichera trijuga. Congener on Euphorbiaceae: Euphorbia, Barringtoniaceae. Montane
Uliocnemis biplagiata	Moore	2	0	0	0	0	0	1	Leguminosae: Acacia auriculiformis. Lowland
	sum	5	7	6	5	9	4	18	

3. Subfamily : Sterrhinae

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
?Ptochophyle sp.		0	0	0	0	0	0	2	
Antitrygodes divisaria	Walker	0	3	1	2	0	0	0	Verbenaceae, Rubiaceae: Hymenodictyon, congener on Rubiaceae: Anthocephalus cadamba, Marantaceae: Maranta. Lowland
Gnamptoloma aventiaria	Guenee	0	1	0	0	0	0	0	Leguminosae: Paraserianthes falcataria, Acacia confusa, Gramineae. Congener on Myrtaceae: Eucalyptus deglupta, Umbelliferae: Oenanthe javanica
Idaea ?purpurea	Hampson	1	0	0	0	0	0	0	Lowland
Idaea phaeocrossa #	Prout	0	0	0	0	0	0	1	
*Scopula sp. no. 10765**		5	0	1	0	0	1	0	Congeners on Moraceae: Ficus, Gramineae: Oryza sativa, Cruciferae: Brassica chinensis (Chinese cabbage), Sapindaceae: Nephelium lappaceum
Scopula tenuispersata	Fuchs	1	0	1	0	0	0	0	Congeners on Cucurbitaceae: Cucumis sativus (cucumber), Oleaceae: Jasminum, Combretaceae: Lumnitzera, Amaranthaceae: Deeringia. Lowland
Scopula vacuata	Guenee	3	2	5	3	1	0	0	Congeners on grasses. Lowland
Zythos obliterata	Warren	0	4	0	2	3	0	0	Lowland
Zythos strigata	Warren	0	1	0	1	3	0	0	Lowland
Zythos turbata	Walker	0	1	1	2	1	0	0	?Oleaceae or Rubiaceae. Lowland
	sum	10	12	9	10	8	1	3	

4. Subfamily : Larentiinae — Mainly montane species

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Chloroclystis ?dilatata	Walker	0	0	0	0	0	0	1	Euphorbiaceae: Glochidion. Congeners on Euphorbiaceae: Breynia, Actephila, Combretaceae: Terminalia. Montane
Eois memorata	Walker	1	0	0	0	0	0	0	Lowland
Eois sp. 2		0	0	0	0	0	0	1	
Pomasia vernacularia	Guenee	0	0	0	1	0	0	0	Lowland to montane
	sum	1	0	0	1	0	0	2	

5. Subfamily : Ennominae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Achrosis calcicola	Holloway	0	0	0	0	1	0	0	Lowland, lower montane forest
Astygisa metaspila	Walker	0	1	1	1	0	0	0	Genus on Rhamnaceae. Lowland forest
Astygisa vexillaria	Guenee	0	1	0	1	0	0	0	Lowland forest
Borbacha altipardaria	Holloway	0	0	1	0	1	0	0	Lower, upper montane Forest
Bracca maculosa	Walker	0	1	0	0	0	0	0	Lowlands to upper montane
Cleora decisaria	Walker	1	2	2	0	2	23	0	Leguminosae: Paraserianthes falcataria. Lowlands
Cleora determinata	Walker	0	1	1	2	1	1	1	Lowland forest
Cleora pupillata	Walker	1	0	0	1	4	0	7	Regenerating alluvial forest, cultivated lower montane area
Coremecis maculata	Warren	0	0	0	1	0	0	0	Lowland, limestone forest
Craspedosis arycandata	Walker	1	3	0	1	0	0	0	Lowland, disturbed, lower montane forest
Curbia martiata	Guenee	0	0	2	0	0	1	0	Lowland forest
Diplurodes indentata	Warren	0	0	0	0	0	0	1	Hill dipterocarp, lower montane forest
Diplurodes petras	Meyrick	0	0	0	0	0	0	1	Lowlands
Ectropidia exprimata #	Walker	0	0	0	0	0	0	1	Congener on Dipterocarpaceae: Shorea robusta. Lowland, lower montane forest
Ectropidia fimbripedata	Warren	0	3	1	0	0	0	2	Lowland, heath, lower montane forest
Ectropis bhurmitra	Walker	1	0	0	0	0	0	1	Incl. Dipterocarpaceae, Euphorbiaceae, Leguminosae: P. falcataria, A. mangium, Myrtaceae, Rubiaceae, Verbenaceae: Gmelina, Compositae
Fascellina aurifera	Warren	0	3	0	1	1	0	0	Lowland rainforest
Fascellina castanea	Moore	0	0	0	0	1	0	0	Lauraceae: Cinnamomum. Alluvial forest
Fascellina punctata	Warren	0	1	0	0	0	0	0	Lowland, hilly rainforest
Godonela ?translineata	Walker	0	1	0	0	0	0	0	
Godonela avitusaria	Walker	0	0	0	0	0	0	1	Leguminosae: Albizia procera. Lowlands to 1930m
Godonela mutabilis	Warren	0	0	0	0	0	1	0	Lowland forest
Godonela nora	Walker	0	0	3	0	1	0	0	Leguminosae: Acacia. Lowlands to 1930m
Godonela ozararia	Walker	0	1	0	0	0	0	0	Leguminosae: Acacia mangium. Lowland forest
Godonela translineata	Walker	0	0	1	0	1	1	0	Leguminosae: Paraserianthes falcataria, Delonix, Elaeagnaceae: Elaeagnus. Lowland, lower montane forest
Hypephyra brunneiplaga	Swinhoe	0	0	0	0	0	0	1	Lowlands to 1600m
Hypochrosis binexata	Walker	0	6	2	3	7	0	6	Sterculiaceae: Theobroma cacao (cocoa). Lowland, secondary, lower montane forest, agricultural areas
Hypochrosis cryptopyrrhata	Walker	0	0	0	0	1	0	0	Leguminosae: Paraserianthes falcataria. Lowland, lower montane forest
Hypochrosis pyrrhophaeata	Walker	0	1	0	0	0	0	0	Lowland, lower montane forest
Hypomecis costaria	Guenee	0	0	0	1	0	0	0	Lowland, wet kerangas, lower montane forest
Hypomecis separata	Walker	0	0	0	1	0	0	0	Lowland forest
Hypomecis tetragonata	Walker	0	0	0	0	1	0	0	Lowland, kerangas, lower montane forest
Hypomecis transcissa	Walker	2	1	11	4	1	0	5	Euphorbiaceae: Aleurites. Disturbed lowland forest
Hyposidra picaria	Walker	0	1	0	0	0	0	0	Leguminosae: Acacia mangium. Lowland forest
Hyposidra talaca	Walker	0	4	1	1	0	1	0	Incl. Leguminosae: A. mangium, P. falcataria, Myrtaceae: Eucalyptus, Composita, Euphorbiaceae, Moraceae: Ficus, Sterculiaceae, Verbenaceae
Luxiaria submonstrata	Walker	0	0	0	0	1	0	0	Lowland, lower montane, upper montane forest
Nigriblephara semiparata	Walker	1	1	1	0	1	0	0	Lowland dipterocarp forest
Ourapteryx claretta	Holloway	0	1	0	0	0	0	0	Lower, upper montane forest
Ourapteryx podaliriata	Guenee	0	0	0	0	0	0	1	Lowlands to lower montane
Parasynegia lineata	Warren	1	2	3	0	1	0	0	Lowland, alluvial, kerangas forest
Parasynegia sundastriaria	Holloway	1	0	0	1	0	0	0	Lowland forest
Pareumelea eugeniata	Guenee	1	0	0	0	0	0	0	Lowland, lower montane forest
Peratophyga venetia	Swinhoe	0	1	1	0	0	0	0	Lowland, heath, lower montane forest
Petelia medardaria	Herrich-Schaffer	0	0	1	2	0	0	0	Rhamnaceae: Zizyphus, Hovenia, Gouania. Lowland, disturbed habitats
Petelia paroobathra	Prout	0	0	1	1	0	0	0	Lowland, hill dipterocarp, Lower montane, kerangas forest
Plutodes cyclaria	Guenee	0	1	0	0	2	0	0	Lowland, lower montane forest
Pseudalcis cinerascens	Warren	0	0	0	1	1	0	3	Lowland, disturbed forest

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Racotis inconclusa	Walker	0	0	0	0	0	0	1	Lauraceae: Alseodaphne, Annonaceae: Saccopetalum. Lowland to upper montane forest
Serratophyga sterrhoticha	Prout	0	0	1	0	0	0	0	Mangrove, limestone, hill dipterocarp forest
Yashmakia orsinephes +	Prout	0	0	0	0	1	0	0	Lowland, alluvial, swampy, montane forest
Zeheba aureatoides	Holloway	1	0	0	0	0	0	0	Lowlands
	sum	11	37	34	23	30	28	32	
V. Superfamily : Noctuoidea									
i. Family : Notodontidae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Allata argentifera	Walker	0	1	0	1	0	0	0	Leguminosae: Desmodium (Ougeinia), Mucuna, Pongamia, Derris. Lowland rainforest, occasionally montane
Ambadra suriga	Schaus	0	0	0	0	2	0	0	Palmae: Cocos nucifera (coconut). Lowland dipterocarp forest
Brykia horsfieldi	Moore	0	0	0	0	1	0	0	Lowland, dry kerangas, swamp forest
Cerasana anceps	Walker	0	2	0	1	1	0	0	Lowland, alluvial, riverine, dipterocarp, secondary, coastal forest
Gangarides rosea	Walker	0	1	0	0	0	0	0	Lowland forest
Liparopsis sundana	Holloway	0	0	0	0	0	0	1	Lowland, montane forest
Medanella subterminalis	Kiriakoff	0	1	0	3	2	0	1	Lowland dipterocarp forest
Phalera sundana	Holloway	0	0	1	0	0	0	0	Lowland, alluvial, kerangas forest
Pseudohoplitis vernalis	Gaede	0	1	0	0	0	0	0	Mixed dipterocarp, alluvial forest
Sagamora indigofera	Holloway	0	0	0	1	0	0	0	Lowlands to upper montane
Somera viridifusca	Walker	0	1	0	0	0	0	0	Lowlands to 2000m
	sum	0	7	1	6	6	0	2	
ii. Family : Arctiidae									
1. Subfamily : Lithosiinae									Many members are lichen feeders
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Asura ?nigripuncta	Wileman	0	0	0	0	0	1	1	Genus on lichens, congeners on Convolvulaceae: Ipomoea batatas, Xanthophyllaceae: Xanthophyllum, Santalaceae, Nyctaginaceae, Malvaceae
Asura asaphes	Hampson	2	0	0	0	3	0	6	Lowland
Asura birivula	Hampson	1	0	0	0	1	0	11	Lowland, lower montane
Asura biseriata	Hampson	0	0	1	0	0	0	3	Rutaceae: Citrus reticulata
Asura bizonoides	Walker	0	0	0	0	0	0	3	
Asura euprepioides	Walker	1	0	0	0	0	6	1	Lowland
*Asura sp. no. 2708**		0	0	0	0	0	0	3	
*Asura sp. no. 2713**		0	0	0	0	0	0	2	Lowland
*Asura sp. no. 2740**		1	1	0	0	0	0	0	
Asura strigipennis	Herrich-Schaffer	0	0	0	0	0	0	2	
Asura subcruciata	Rothschild	13	2	0	0	2	1	2	Lowland, ?alluvial forest
Chamaita trichopteroides	Walker	0	0	0	0	0	0	1	Lower montane
Cyana costifimbria	Walker	8	1	1	0	0	1	0	Genus on lichens. Congeners on Apocynaceae: Dyera, Anacardiaceae: Mangifera, Zingiberaceae: Elettaria, Meliaceae: Dysoxylum. Lowland
Cyana inconclusa	Walker	0	0	0	1	0	0	0	Congener on Leguminosae: Dalbergia sissoo, Dipterocarpaceae: Shorea robusta, Verbenaceae: Tectona grandis. Lowland
Cyana indonesia	Roesler & Kuppers	1	0	0	0	1	1	1	
Cyana malayensis	Hampson	4	4	1	2	3	3	2	Lowland
Cyana pernata	Walker	5	18	2	7	15	1	0	Lowland
Cyana ridleyi	Hampson	3	0	1	0	1	1	0	Lowland
Cyana selangorica	Hampson	0	1	0	0	0	0	0	Lowland
Eilema apicalis	Walker	0	0	0	0	0	1	0	Mosses, lichens, Leguminosae: Tamarindus, Myrtaceae: Eugenia. Congener on Euphorbiaceae: Hevea brasiliensis. Lowland
Eilema biplagella	Butler	2	0	0	1	2	2	0	

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Eugoa aequalis	Walker	3	3	5	1	3	0	0	
Eugoa crassa	Walker	0	0	0	2	0	0	7	
Eugoa sp.		0	0	1	0	0	0	0	
*Eugoa sp. no. 2758**		0	1	0	0	0	0	0	
*Eugoa sp. no. 2765**		0	0	0	1	0	0	0	
Eugoa sp. no. 2768 #*		0	0	0	0	0	0	2	
Garudinia acornuta +	Holloway	0	0	0	1	0	0	0	
Lithosiinae no. 2655*		1	0	0	0	0	0	0	
Lithosiinae no. 2744*		0	1	0	0	0	1	0	
Lithosiinae no. 2787*		1	0	0	0	0	0	0	
Lobobasis niveimaculata #	Hampson	0	0	0	0	0	0	1	
Macotasa nubeculoides	Holloway	0	0	0	1	2	1	0	Congener on Leguminosae: Albizia moluccana
Miltochrista cornicornutata	Holloway	0	2	1	0	0	0	1	
Miltochrista cruciata	Walker	0	0	0	1	0	0	0	Lowland
Miltochrista cuneonotatus	Walker	1	0	0	0	1	1	0	Genus on lichens
Miltochrista roseororatus	Butler	4	2	1	2	0	4	0	Sterculiaceae: Theobroma cacao
Miltochrista sp. #		0	0	0	0	0	0	1	
Nishada nodicornis	Walker	0	0	1	0	1	0	0	Lowland
Nishada sambara	Moore	0	0	0	0	0	2	0	Lowland
Padenia duplicana	Walker	1	2	0	0	0	0	8	Lowland, lower montane
Parasiccia marginipuncta	Talbot	1	0	0	0	0	0	2	Upper montane
Philenora lauta	Swinhoe	0	0	0	0	0	0	1	Lowland, kerangas
	sum	53	38	15	20	35	27	61	
2. Subfamily : Syntominae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Amata cinctelisa +	Holloway	0	0	1	0	0	0	0	Congeners on mosses, lichens, rice, Convolvulaceae, Leguminosae, Compositae, Santalaceae, Cruciferae: Brassica
Amata egenaria	Walker	25	19	4	9	24	2	0	Lowland forest
Amata prepuncta	Holloway	47	54	29	22	62	2	10	Lowland rainforest
	sum	72	73	34	31	86	4	10	
3. Subfamily : Arctiinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Amerila astreus	Drury	0	0	0	1	0	0	0	Dioscoreaceae: Dioscorea, Smilacaceae: Smilax, Rubiaceae: Ixora, Asclepiadaceae, Apocynaceae: Beaumontia. Lowlands to 2000m
Amerila omissa	Rothschild	0	2	0	0	0	1	0	Lowlands, montane
Creatonotos transiens	Walker	1	1	3	1	2	9	0	Wide range incl. Gramineae: Paspalum, Leguminosae, Vitaceae: Cayratia, Meliaceae, Dioscoreaceae, Musaceae, Salicaceae, Chenopodiaceae
Nyctemera adversata	Schaller	0	0	0	0	0	1	0	Compositae: Erechtites, Erigeron, Gynura, Picris, Senecio. Open, secondary forest
Nyctemera sonticum	Swinhoe	0	1	0	0	0	0	0	
Pareuchaetes pseudoinsulata	Rego Barros	1	1	0	0	0	0	0	Compositae: Chromolaena odorata. Weedy habitats
Spilosoma griseabrunnea	Holloway	0	1	1	0	1	0	0	Congeners on Compositae, Gramineae: Paspalum, Leguminosae, Convolvulaceae, Musaceae, Orchidaceae. Disturbed habitats
Spilosoma hosei	Rothschild	1	1	0	5	2	0	1	Lowland forest
Spilosoma hypogopa +	Hampson	0	2	0	0	0	0	0	Lowland, secondary, lower montane forest
Spilosoma thomasi +	Holloway	0	0	0	0	0	0	1	Montane
	sum	3	9	4	7	5	11	2	

iii. Family : Lymantriidae

Species	Authority	No. of individuals captured . Two replicates per site (7-8pm on different nights) T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
?Dasychira sp.		0	0	0	0	1	0	0	Leguminosae: A. mangium
Cassidia peninsularis	Holloway	1	0	0	0	2	0	0	?Lowland
Dasychira angulata	Hampson	0	0	0	1	0	0	0	Genus on wide range incl. Palmae, Ebenaceae, Rutaceae, Leguminosae, Melastomataceae, Sterculiaceae, Casuarinaceae, Myrtaceae, Dipterocarpaceae
Dasychira inclusa	Walker	0	0	1	0	0	0	0	Leguminosae: Acacia mangium, Annonaceae, Euphorbiaceae: Anthocephalus, Moraceae: Ficus, Dipterocarpaceae: Shorea leprosula, Musaceae
*Dasychira sp. no. 1759**		1	0	0	0	0	0	0	Leguminosae: A. mangium, congeners on Oxalidaceae: Averrhoa carambola (star-fruit shoots), Anacardiaceae: Mangifera, Gramineae, Lecythidaceae
Dura alba	Moore	0	1	0	0	0	0	1	?Lowland
Euproctis ?azela	Collenette	0	0	2	4	1	0	0	Genus on wide range incl. Sterculiaceae, Gramineae, Dipterocarpaceae: Shorea, Leguminosae: Acacia, Verbenaceae, Myrtaceae: Eucalyptus. Lowland
Euproctis ?epinephela	Collenette	0	1	1	0	0	0	0	Congeners on Rhizophoraceae, Anacardiaceae: Anacardium occidentale, Buchanania, Bombacaceae: Bombax, Theaceae, Myrtaceae: Syzygium
Euproctis ?flavolimbata	Aurivillius	2	0	0	0	0	0	0	Congeners on Sonneratiaceae: Sonneratia, Lauraceae: Cinnamomum, Persea, Combretaceae: Terminalia, Leeaceae: Leea, Rosaceae: Rosa. ?Lowland
Euproctis ?limbata	Butler	1	1	0	0	0	1	0	Leguminosae: P. falcataria, congeners on Polypodiaceae, Loranthaceae, Asclepiadaceae, Euphorbiaceae: Ricinus, Hevea, Fagaceae: Quercus
Euproctis cf. olivata	Hampson	1	1	0	1	0	0	0	
Euproctis cincta	Swinhoe	0	0	1	0	1	0	0	
Euproctis civitta	Swinhoe	0	0	0	0	1	0	0	Leguminosae: P. falcataria. Lowland
Euproctis coelebs	Collenette	0	0	0	0	1	0	0	Lowland
Euproctis cosmia	Collenette	1	0	0	0	0	0	0	
Euproctis eclipes	Collenette	2	1	1	1	3	0	0	
Euproctis flavomarginata	Wileman	0	0	0	0	1	0	0	
Euproctis fumosa	Snellen	1	4	1	1	0	0	0	Dipterocarpaceae: Shorea teysmanniana. Lowland
Euproctis guttulata	Snellen	0	0	0	2	1	0	0	Lowland
Euproctis sp. 2		0	0	0	1	0	0	0	
Euproctis sp. 5		0	0	0	0	0	0	1	
*Euproctis sp. no. 1674**		0	0	0	0	0	0	1	
*Euproctis sp. no. 1676**		0	0	0	0	0	0	1	
Euproctis sp. no. 1723 #*		0	0	0	0	0	0	7	
Ilema chloroptera	Hampson	2	1	2	3	2	0	2	Congener on Gleicheniaceae: Dicranopteris. ?Lowland
Lymantria brunneiplaga	Swinhoe	0	1	0	0	0	0	0	Leguminosae: Paraserianthes falcataria. Congeners on Leguminosae, Rosaceae, Palmae, Punicaceae, Rubiaceae, Anacardiaceae, Combretaceae
Lymantria pendleburyi	Collenette	0	0	0	0	0	0	1	Congeners on Myrtaceae: Eucalyptus, Fagaceae, Dipterocarpaceae: Shorea macroptera, Sterculiaceae, Casuarinaceae, Rhizophoraceae
Lymantriidae no. 1767*		2	0	0	0	0	0	0	
Orgyia postica	Walker	0	1	0	0	0	1	0	Leguminosae: Acacia mangium, Albizia, Dipterocarpaceae: Shorea, Euphorbiaceae, Sterculiaceae, Anacardiaceae, Rubiaceae, Tiliaceae, Combretaceae
Redoa ?camurisquama	Collenette	0	3	0	1	2	0	7	Genus on Leguminosae, Dipterocarpaceae: Balanocarpus, Shorea, Elaeocarpaceae, Anacardiaceae, Gramineae, Theaceae, Combretaceae, Lauraceae
Redoa flora	Swinhoe	1	0	0	0	0	0	2	Bombacaceae: Durio zibethinus. Genus majority lowland
Redoa florella #	Collenette	0	0	0	0	0	0	1	Congeners on Lauraceae: Litsea, Anacardiaceae: Anacardia occidentale, Mangifera, Sapindaceae: Nephelium, Bombacaceae: Durio
Redoa marginalis	Walker	0	1	2	1	3	0	1	
Redoa rhopica	Toxopeus	0	2	1	10	1	0	2	
*Redoa sp. no. 1666**		0	0	1	1	0	0	2	
Rhypotoses brooksi	Collenette	2	0	1	2	0	0	0	Lowland
Rhypotoses glebula	Swinhoe	2	9	41	9	17	7	1	Lowland
Rhypotoses strigifimbria	Walker	3	0	0	0	2	0	0	Lowland
Scarpona ennomoides	Walker	0	0	0	1	0	0	0	Ebenaceae: Diospyros discolor. Lowland
Sitvia denudata	Walker	1	0	0	0	0	0	0	
	sum	23	27	55	39	38	9	30	

iv. Family : Noctuidae									
1. Subfamily : Aganainae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Asota egens	Walker	0	0	0	0	1	0	0	Moraceae: Ficus. Lowland, secondary forest
Asota heliconia	Linnaeus	1	7	5	8	18	6	0	Oxalidaceae: Averrhoa (star-fruit). Lowlands, disturbed forest
Asota plana	Walker	0	2	0	0	0	0	0	Moraceae: Ficus. Lowlands to 1900m
Asota producta	Butler	0	0	0	0	1	0	0	Lowland, montane forest
Neochera inops #	Walker	0	0	0	0	0	0	1	Congener on Asclepiadaceae: Marsdenia.
Neochera marmorea	Walker	0	1	0	0	2	0	0	Lowlands
Neochera privata #	Walker	0	0	0	0	0	0	1	
	sum	1	10	5	8	22	6	2	
2. Subfamily : Herminiinae									Many detritus feeders
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Adrapsa ?ereboides	Walker	8	5	2	1	3	3	0	
Adrapsa angulilinea	Prout	1	0	0	0	0	0	0	
Adrapsa sp. 1		1	0	0	0	1	2	1	
Amilaga geometroides	Walker	3	1	0	2	0	1	0	Lowland
Bertula depressalis	Snellen	2	0	1	1	1	0	0	Detritus. Congener on dry grass. Lowland
Bertula erectilinea	Swinhoe	1	2	6	0	5	0	0	?Lowland
Bertula tespisalis	Walker	0	0	0	0	1	0	0	Lower montane
Bocana manifestalis	Walker	0	0	0	0	0	1	0	Meliaceae: Dysoxylum. Detritus, ?grasses. Lowland to montane
Bocana silenusalis	Walker	2	0	1	0	2	3	0	?Lowland
Catada sp.		0	1	0	0	0	0	0	Congener on Connaraceae: Rourea
Globosusa ?curiosa	Swinhoe	0	0	0	0	0	0	1	
Hadennia prunosa	Moore	0	1	5	6	1	1	0	Lowland
Herminia diagramma	Prout	1	0	0	1	1	0	0	?Detritus. Congener on moss. ?Lowland
Herminiinae 1		2	0	0	0	0	1	0	
Herminiinae 11		0	0	1	0	0	0	0	
Herminiinae 4		0	0	1	0	0	0	0	
Herminiinae 7		0	0	0	0	1	0	0	
Herminiinae 9 #		0	0	0	0	0	0	1	
Hipoepa biasalis	Walker	4	2	4	0	4	0	1	?Detritus. ?Lowland
Hipoepa fractalis	Guenee	10	2	4	2	1	8	0	Leguminosae: Paraserianthes falcataria, Dalbergia, Rubiaceae: Rubia (dry leaves)
Hipoepa sp.		0	0	0	0	0	0	1	
Hydrillodes gravatalis	Walker	0	0	0	1	0	5	1	Congener on dead coconut leaves, decaying grass, Dipterocarpaceae: Dryobalanops lanceolata (fruit). Lowland to montane
Hydrillodes repugnalis	Walker	2	1	5	2	0	9	0	
*Hydrillodes sp. no. 10817**		1	0	3	0	0	2	0	
*Hydrillodes sp. no. 10822**		0	4	2	0	2	1	0	
Hydrillodes toresalis	Walker	0	0	0	2	3	0	0	Lowland to montane
Lysimelia neleusalis	Walker	1	0	0	0	0	0	0	
Mixomelia ?umbripars	Hampson	1	0	0	0	0	0	0	
Nodaria cornicalis	Fabricius	10	3	11	8	5	77	1	Congener on dry leaves of Leguminosae: Dalbergia, grass
Ophiuchidia ?rectivia	Hampson	1	0	0	0	0	0	0	
Ophiuchidia rectiva	Hampson	0	0	0	1	1	0	0	
Pancroides abnormalis	Swinhoe	0	0	0	1	0	0	0	
Progonia oileusalis	Walker	4	0	2	0	0	1	1	Congeners on Rubiaceae: Rubia cordifolia, Rutaceae: Citrus
Progonia sp. 1		1	0	1	0	0	0	0	

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Progonia sp. 3		0	1	0	0	0	0	0	
Progonia sp. 4		0	0	0	0	1	0	1	
Simplicia ?macrotheca	Prout	7	11	0	24	13	5	0	Congeners on dry leaves incl. tea, grass, Musaceae: Musa, Dipterocarpaceae: Dipterocarpus, Palmae: Cocos
Simplicia caeneusalis	Walker	8	2	0	2	0	0	0	Palmae: Metroxylon, Gramineae: Sorghum, Solanaceae: Solanum tuberosum, Urticaceae: Pipturus (stem-borer)
Simplicia circumscripta	Walker	5	6	0	17	12	1	0	Lowland
Simplicia renota	Swinhoe	0	0	1	0	0	7	0	Lowland
Simplicia rufa occidentalis	Holloway	10	19	0	14	0	5	0	Detritus
	sum	86	61	50	85	58	133	9	
3. Subfamily : Hypeninae									Many detritus feeders
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Alelimma ?ochrodes +	Hampson	0	0	1	0	0	0	0	
Echanella temperate	Prout	0	1	0	0	0	1	0	Detritus. Lowland to montane
Hypena ?disualis	Swinhoe	0	0	1	0	1	0	0	Congeners on Verbenaceae: Lantana, Lippia, Commelinaceae: Commelina, Leguminosae: Indigofera, Desmodium, Abrus, Combretaceae: Combretum
Hypena iconicalis	Walker	0	0	0	0	0	0	5	Leguminosae: Desmodium gangeticum, Butea frondosa, Millettia. Lowland
Hypena iconicalis similata	Moore	0	1	1	1	0	0	0	Congeners on Rutaceae: Citrus, Polygonaceae, Acanthaceae: Hemigraphis, Hygrophila. Lowland to montane
Hypena kanshireiensis	Wileman	0	1	4	1	3	0	2	
*Hypena sp. D***		0	0	0	0	1	0	0	
Mosopia endoxessalis	Walker	0	0	1	1	1	0	0	
	sum	0	3	8	3	6	1	7	
4. Subfamily : Catocalinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Artena inversa	Walker	0	0	0	2	0	0	0	Congener on Combretaceae: Calycopteris, Combretaceae, Terminalia, Quisqualis. Lowland to montane
Ercheia cyllaria	Cramer	0	2	3	1	4	0	2	Grass, Leguminosae: Dalbergia, Tiliaceae: Grewia, Liliaceae: Asparagus. Lowland to montane
Erebus caprimulgus	Fabricius	2	3	2	6	3	0	1	Genus on Smilacaceae: Smilax macrophylla. Congener on Leguminosae: Acacia. Lowland
Grammodes samosira	Kobes	0	0	0	0	0	1	0	Congeners on Euphorbiaceae: Phyllanthus, Glochidion, Rhamnaceae: Zizyphus, Gramineae, Ebenaceae: Diospyros, Linaceae: Linum (linseed)
Hypersypnoides ochreicilia borneensis +	Berio	0	0	0	0	1	0	0	
Hypopyra pudens	Walker	9	4	7	4	4	2	0	Leguminosae: Paraserianthes falcataria. Lowland to montane
Lygniodes endoleucus	Guerin-Meneville	0	1	2	0	1	0	1	
Mocis undata	Fabricius	0	0	0	1	0	5	0	Leguminosae: Pueraria, Desmodium, Vigna unguiculata, Phaseolus, Butea
Ophiusa trapezium	Guenee	0	1	0	0	0	1	0	Combretaceae: Terminalia. Congeners on Myrtaceae: Psidium, Eugenia, Dipterocarpaceae: Shorea, Combretaceae: Terminalia, Calycopteris
Parallelia arcuata	Moore	0	0	0	0	0	2	0	Euphorbiaceae: Glochidion, Phyllanthus, Rutaceae: Citrus
Parallelia fulvotaenia	Guenee	0	0	2	0	0	2	0	Lowland
Parallelia palumba	Snellen	0	0	0	1	0	0	0	Rutaceae: Citrus decumanus (pomelo ?fruit piercer), Atalantia, Paramignya. Lowland
Parallelia rigidistria	Guenee	0	0	0	0	1	0	0	?Euphorbiaceae. Lowland to montane
Parallelia umbrosa #	Walker	0	0	0	0	0	0	1	Euphorbiaceae: Sauropus albicans
Pseudathyrma complens	Walker	0	0	0	0	1	0	0	
Pseudathyrma rufiscripta	Hampson	0	0	0	1	1	0	0	
Pterocyclophora ridleyi	Hampson	0	1	0	0	0	0	0	
Sypnoides gluta	Swinhoe	0	0	0	0	1	0	0	
	sum	11	12	16	16	17	13	5	

5. Subfamily : Ophiderinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
?Blasticorhinus decernens	Walker	0	0	1	0	0	0	0	
?Condate sp.		0	2	3	1	3	0	0	
Ananepa doda	Swinhoe	0	0	0	2	0	0	0	
Anereuthina venosa	Hubner	0	0	0	0	1	0	0	
Anomis cf. albitibia	Walker	0	0	0	0	3	0	0	Congeners on Bombacaceae: Bombax, Menispermaceae: Cissampelos, Leguminosae: Dalbergia, Verbenaceae: Lantana, Amaranthaceae, Rutaceae
Anomis macronephra +	Holloway	0	0	0	0	0	1	0	Sterculiaceae: Waltheria indica, Malvaceae: Hibiscus. Congeners on Rosaceae, Tiliaceae, Combretaceae, Convolvulaceae
Anticarsia creberrima	Walker	0	0	0	3	0	0	0	Leguminosae: Cajanus indicus. Congener on Leguminosae: Vigna, Derris, Cyamopsis. Lowland
Arthisma rectilinea	Roepke	0	1	0	0	0	0	0	Lowland to montane
Avitta quadrilinea	Walker	0	0	2	1	1	1	0	Lauraceae: Alseodaphne
Bematha extensa	Walker	0	0	0	0	1	0	0	Lowland
Bocula microscala	Holloway	0	0	0	1	3	0	0	Congeners on Tiliaceae: Grewia tiliaefolia, Sterculiaceae: Sterculia villosa, Moraceae: Ficus. Lowland
Bocula tuhanensis	Holloway	0	1	6	3	1	0	4	Lowland, ?alluvial forest
Caduca albopunctata	Walker	0	0	1	0	0	0	0	Lowland
Calymniops sp.		1	0	0	0	1	0	0	
Calyptra minuticornis	Guenee	0	0	0	1	1	0	0	Menispermaceae: Cocculus macrocarpus, Cissampelos pareira
Catephia ?longinquua	Swinhoe	0	1	1	0	2	1	1	
Claterna cydonia	Cramer	0	4	5	3	4	0	5	Lowland, ?alluvial forest
Codonodes rectigramma	Hampson	0	1	0	0	0	0	0	Leguminosae: Millettia, Derris
Condate orsilla	Swinhoe	0	0	0	0	1	0	0	Lowland to montane, limestone
Corsa ?lignicolora	Walker	1	1	0	0	0	0	0	
Diascia hayesi	Holloway	0	2	2	4	1	0	0	Lowland to montane
Dinumma ?combusta	Walker	0	0	1	0	0	4	0	Leguminosae: Paraserianthes falcataria. Congener on Verbenaceae: Tectona
Drepanorhina shelfordi	Swinhoe	0	1	0	0	0	0	0	?Lowland
Egnasia mopsa	Swinhoe	0	0	0	0	1	0	0	Congeners on Rubiaceae: Canthium/Plectronia
Episparis costistriga	Walker	0	3	7	0	3	1	0	Congeners on Meliaceae: Chukrasia tabularis, Sapindaceae: Schleichera, Rubiaceae: Stephegyne, Magnoliaceae: Michelia. Lowland
Episparis sejunctata	Walker	0	0	1	0	0	0	1	Lowland, alluvial, secondary forest
Ericeia ?inangulata	Guenee	0	0	2	0	0	5	0	Leguminosae: Cassia, Xylia, Albizia. Montane
Ericeia amanda	Walker	0	1	0	0	0	0	5	Congeners on Leguminosae: Acacia mangium, Mimosa rubicaulis, Dalbergia latifolia, Cassia, Xylia, Albizia. Lowland
Ericeia fuscipuncta	Prout	0	0	0	0	0	1	0	
Ericeia pertendens	Walker	0	1	0	0	0	1	0	Leguminosae. Lowland to montane
Ericeia subcinerea	Snellen	1	0	0	0	0	0	0	Leguminosae. Lowland
Erygia apicalis	Guenee	0	0	0	0	1	0	0	Leguminosae: Desmodium/Ougeinia dalbergioides, Acacia, Albizia, Flemingia. Congener on Leguminosae: Xylia. Lowland to montane
Goniophila excavata	Swinhoe	0	0	0	0	1	0	0	
Gonoglasa nigripalpis	Walker	0	1	0	0	0	0	0	
Homodes ?vivida	Guenee	0	1	0	0	0	0	0	Congeners on Leguminosae: Erythrina subumbrans, Myrsinaceae: Embelia, Euphorbiaceae: Hevea
Hypocala lativitta #	Moore	0	0	0	0	0	0	2	Genus on Ebenaceae: Diospyros
Hyposemansis singha	Guenee	0	2	2	1	0	0	0	Lowland
Ischyja hageni	Snellen	0	0	0	0	1	0	0	Congeners on Dipterocarpaceae: Shorea, Sapindaceae: Cupania anacardioides, Nephelium
Ischyja inferna	Swinhoe	0	1	0	0	1	0	0	Combretaceae: Terminalia, Leguminosae: Xylia, Dalbergia, Meliaceae: Aglaia
Lacera noctilio	Fabricius	0	0	0	0	0	0	1	Nyctaginaceae: Pisonia, Rubiaceae: Canthium, Leguminosae: Caesalpinia. Congener on Leguminosae: Moullava
Loxioda dilutalis	Snellen	0	1	0	0	0	0	0	
Maguda ?multifasciata	Swinhoe	0	0	0	0	1	1	0	
Malagonia cf. acypera	Hampson	0	0	0	1	0	0	0	
Mecodina sumatrana	Kobes	0	1	0	0	1	0	0	Congeners on Apocynaceae: Ichnocarpus, Moraceae: Ficus, Rubiaceae: Hymenodictyon
Oglasa closteroides	Walker	0	1	0	0	1	0	0	Congeners on Leguminosae: Dalbergia, Derris, Sterculiaceae: Sterculia, Tiliaceae: Grewia. Lowland, limestone
Oglasa costisignata	Hampson	0	1	3	3	1	0	0	
Oglasa sp. 1		0	1	1	0	0	0	0	

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Ophiderinae 11		0	1	0	0	0	0	0	
Ophiderinae 12		0	1	0	0	0	0	0	
Ophiderinae 14		0	0	1	0	2	0	0	
Ophiderinae 20		0	0	0	0	0	0	10	
Ophiderinae 3		0	0	0	0	1	0	0	
Ophiderinae 30		0	0	0	0	0	0	1	
Ophiderinae 31		0	0	0	0	1	0	0	
Ophiderinae 35		1	0	0	0	0	0	0	
Ophiderinae F**		0	0	1	0	0	0	0	Lowland, limestone
Ophiderinae J**		0	0	0	2	1	0	0	Lowland
Ophiderinae K**		0	0	0	0	1	0	0	Lowland
Othreis homaena	Hubner	0	0	1	0	0	0	0	Menispermaceae, Rutaceae: Citrus. Congeners on Amaranthaceae: Achyranthes, Menispermaceae: Tinospora, Cocculus, Stephania
Oxyodes scrobiculata	Fabricius	0	1	1	1	0	1	0	Meliaceae: Amoora/Aglaia, Sapindaceae: Litchi/Euphoria, Nephelium. Lowland to montane
Pandesma anysa	Guenee	0	1	0	0	0	6	0	Leguminosae: Dalbergia. Congeners on Leguminosae: Acacia, Albizia, Xylia
Pangrapta albiseriata	Hampson	4	2	5	0	0	0	0	
Pangrapta holophaea	Hampson	0	0	1	0	1	0	0	Lowland, lower montane
Pangrapta metagona	Walker	1	0	7	1	10	0	0	Lowland, lower montane
Pangrapta parsimonalis	Walker	0	0	2	0	0	0	0	Lowland
Pangrapta shivula	Guenee	0	0	0	0	0	0	1	
Papuacola lignicolor +	Hampson	0	0	0	1	0	0	0	
Papuacola sp.		0	1	0	0	0	0	0	
Parolulis olivescens	Hampson	0	1	0	1	0	0	1	
Platyja umminea	Stoll	0	0	0	0	1	0	0	Lowland to montane
Pseudogyrtona ?modesta	Moore	0	1	2	0	1	0	0	Lowland, ?limestone
Pseudogyrtona ?stipata	Walker	0	0	0	1	1	0	3	
Pseudogyrtona octosema	Hampson	0	0	0	0	1	0	0	Lowland
Pseudosphetta fissisigna	Hampson	0	1	0	1	1	0	0	
Ramadasa fumipennis	Walker	0	0	1	0	1	0	0	
Ramadasa pavo	Walker	0	0	0	0	1	0	0	
Rhesalides cf. cineribasis	de Joannis	0	0	0	0	0	3	0	Leguminosae: Paraserianthes falcataria
Saroba finipalpis	Walker	1	0	0	0	0	0	0	Lowland to montane
Saroba pansa	Swinhoe	0	0	0	1	0	0	0	
Sarobides inconclusa	Walker	0	0	0	1	0	0	0	Lowland
Savara sp.		0	0	0	0	1	0	0	Congener on Sterculiaceae: Sterculia, Heritiera
Singara diversalis +	Walker	0	0	0	0	1	0	0	
Stenocarsia sthenoptera	Swinhoe	0	0	1	0	0	0	0	
Sympis rufibasis	Guenee	0	0	0	0	0	0	2	Sapindaceae: Nephelium litchi. Lowland to montane
Tamba basiscripta	Walker	0	0	0	1	0	0	0	Congener on Barringtoniaceae: Barringtonia
Tamba cosmoloma	Prout	0	1	1	2	1	0	0	
Tamba dichroma	Prout	0	1	1	0	0	0	0	
Tamba hieroglyphica malayana	Prout	1	0	0	0	0	0	0	
Tamba lala	Swinhoe	0	1	0	0	0	0	0	
Tamba magniplaga	Swinhoe	0	0	0	1	0	0	0	
Tamba mnionomera	Hampson	0	0	1	0	0	0	0	Lowland
Tamba ochra	Prout	0	0	0	0	1	0	0	
Throana flavizonata	Hampson	0	0	0	0	1	0	0	
Throana lasiocera	Hampson	0	0	3	0	0	0	0	Lowland
Tiruvaca subcostalis	Walker	0	0	1	0	0	1	0	Bombacaceae: Durio zibethinus, Sterculiaceae: Theobroma. ?Lowland

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Ugia decisa	Walker	0	2	0	0	0	0	0	Lowland
Ugia disjungens	Walker	0	0	2	5	1	0	2	Lowland
Ugia sp. 1 +		1	0	0	0	0	0	0	
Ugia sp. 2 +		0	0	0	0	1	0	0	
*Ugia sp. no. 10780**		0	3	2	2	1	0	0	
Ugia sundana	Hampson	0	0	0	0	1	0	1	
Ugia transversa	Moore	0	0	1	0	1	0	0	
Vestura minereusalis	Walker	0	0	0	0	2	0	0	?Lowland
Zigera eupsema	Swinhoe	0	0	0	0	0	1	0	
	sum	12	47	73	45	71	28	40	
6. Subfamily : Acontiinae									Some species feed on scale insects (Coccoidea)
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Acontiinae 28		0	0	0	0	0	0	1	
Acontiinae 3		1	0	0	0	0	1	0	
Acontiinae 30 +		1	0	0	0	0	0	0	
Acontiinae 32 #		0	0	0	0	0	0	1	
Amyna octo	Guenee	0	0	0	0	0	11	0	Sapindaceae: Cardiospermum, Ulmaceae, Amaranthaceae, Chenopodiaceae, Compositae, Malvaceae, Convolvulaceae, Leguminosae. Lowland
Aroana rubra	Bethune-Baker	0	0	1	0	1	0	0	Congener on Meliaceae: Dysoxylum
Carmara subcervina	Walker	1	2	1	1	0	0	1	
Cerynea ?contentaria	Walker	1	0	1	1	0	2	0	Myrtaceae: Syzygium (rose apple borer)
Cerynea ?melanocephala	Wileman & West	1	0	0	0	0	0	0	
Cerynea ?omphisalis	Walker	0	0	0	0	0	0	2	
Cerynea flavipuncta	Hampson	0	0	0	0	1	0	0	
Corgatha leucosticta	Hampson	1	0	0	0	0	0	0	
Epigrypera eriogona	Hampson	1	0	0	0	0	0	0	
Eublemma rubricilia	Hampson	0	0	1	0	0	0	0	Congeners on Anacardiaceae: Mangifera indica (mango), Solanaceae, Nepenthaceae: Nepenthes, Convolvulaceae, Compositae, cocoa
Hyposada hydrocampata	Guenee	0	0	0	0	0	1	0	
Lophoruza albicostalis +	Leech	0	0	0	0	1	0	1	Congener on Smilacaceae: Smilax
Lophoruza cithara	Swinhoe	0	0	0	0	1	0	0	
Metamaene atrigutta	Walker	1	0	0	0	0	0	0	Lowland
Oruza ?particolor	Warren	0	0	0	0	0	1	0	Congeners on Dennstaedtiaceae, Leguminosae: Calliandra, Gramineae: Zea mays (tassel)
Oruza fissifascia	Hampson	0	1	0	0	1	0	0	
Zurobata intractata	Walker	0	0	0	0	1	0	0	
Zurobata vacillans	Walker	1	3	0	0	0	0	0	Fungus, lichen
	sum	9	6	4	2	6	16	6	
7. Subfamily : Plusiinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Chrysodeixis diehli	Dufay	0	0	3	0	0	0	0	Lowland, lower montane forest
Chrysodeixis eriosoma	Doubleday	0	0	0	0	0	9	0	Wide range incl. Leguminosae, Solanaceae, Cruciferae, Malvaceae. Agricultural, open habitats
Chrysodeixis illuminata	Robinson	1	1	1	0	0	0	0	
Chrysodeixis minutoides	Holloway	0	0	1	0	0	0	0	Lowland, lower montane forest
Plusia' nigriluna	Walker	0	0	0	0	0	4	0	Euphorbiaceae: Acalypha, Labiatae: Hyptis (mint), Ulmaceae: Trema. Lowlands
	sum	1	1	5	0	0	13	0	

8. Subfamily : Stictopterinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Lophoptera acuda	Swinhoe	2	3	0	2	0	1	0	Lowland, alluvial forest to 2000m
Lophoptera coangulata	Warren	0	0	0	0	0	1	0	Montane, lowland forest
Lophoptera leucostriga	Hampson	0	0	0	1	1	0	0	Lowlands to 2000m
Lophoptera olivascens	Moore	0	0	0	0	0	1	0	Agricultural area, lower montane forest
Lophoptera pallibasis	Holloway	0	0	0	3	0	0	0	Lowland, alluvial, hill dipterocarp, montane forest
Lophoptera parallelnotata	Holloway	1	0	0	0	0	0	0	Dipterocarpaceae: Shorea leprosula. Lowlands
Lophoptera paranthyala	Holland	0	0	1	0	0	0	0	Lowland, dry heath, coastal, alluvial, hill dipterocarp forest
Lophoptera purpurascens occidentalis	Holloway	0	0	0	0	1	0	0	Lowland, hill dipterocarp, montane forest
Lophoptera quadrinotata	Walker	1	0	0	0	0	0	0	Lowlands to 2000m
Lophoptera squammilinea	Holloway	0	0	0	0	0	1	0	Agricultural area, lower montane forest
Lophoptera trilobuncus	Holloway	0	1	0	1	2	1	1	Upper montane, lowland
Odontodes seranensis	Prout	0	1	3	0	2	0	0	Dipterocarpaceae: Shorea robusta. Lowlands to upper montane
Savoca xista	Swinhoe	0	0	0	0	0	2	0	Lowland, kerangas forest
Stictoptera ferrifera	Walker	0	0	0	0	0	0	3	Lowland, hill dipterocarp, montane forest
Stictoptera repleta	Walker	0	0	0	1	0	0	0	Lowland, dipterocarp, dry heath, montane forest
Stictoptera signifera	Walker	0	1	1	2	0	0	0	Lowlands to upper montane
Stictoptera trajiciens	Walker	0	0	1	0	0	0	0	Guttiferae: Garcinia kandis, G. indica. Lowlands, secondary alluvial, dry heath, montane forest
	sum	4	6	6	10	6	7	4	
9. Subfamily : Euteliinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Anigraea phaeopera +	Hampson	0	0	0	1	0	0	1	Congeners on Anacardiaceae: Anacardium, Burseraceae: Canarium, Fagaceae: Castanopsis. Lowlands
Anigraea serratilinea	Warren	0	0	0	1	0	0	0	Lowland, dipterocarp, lower montane forest
Anuga constricta	Guenee	0	0	0	0	1	0	0	Dipterocarpaceae: Anisoptera, Anacardiaceae: Mangifera, Semecarpus. Lowland, montane forest
Atacira dimidiata	Walker	0	0	0	0	0	0	1	Congener on Moraceae: Ficus, Anacardiaceae: Odina. Lowland rainforest
Paectes poliotis	Hampson	0	0	0	0	0	0	1	Congeners on Verbenaceae: Tectona, Dipterocarpaceae: Shorea, Sapindaceae: Pometia. Lowland dipterocarp, lower montane forest
Penicillaria simplex	Walker	0	0	0	0	0	0	1	Congeners on Anacardiaceae: Semecarpus, Mangifera, Combretaceae: Terminalia. Montane, lowland, alluvial, kerangas, hill dipterocarp forest
	sum	0	0	0	2	1	0	4	
10. Subfamily : Nolinae									Many montane species
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Nolinae 2		0	1	0	0	0	0	0	
Roeselia cuneifera	Walker	0	0	0	0	0	0	1	Congener on Combretaceae: Terminalia
Roeselia triangulalis	Leech	1	0	0	0	0	0	0	Lower montane
Sarbena lignifera	Walker	1	0	0	0	0	0	0	
	sum	2	1	0	0	0	0	1	
11. Subfamily : Sarrothripinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
?Aquis sp.		0	1	0	0	1	0	0	
Aquis viridisquama	Walker	0	0	0	0	1	0	0	Lowland
Asinduma exscripta	Walker	1	1	0	1	1	2	0	Leguminosae: flowers of Saraca
Barasa acronyctoides	Walker	0	0	1	0	0	0	0	Myrtaceae: Eugenia jambolana, Syzygium jambos (rose apple), S. aromaticum (cloves). Congener on Combretaceae: Terminalia. Lowland
Blenina chlorophila	Hampson	0	0	0	2	1	1	0	Dipterocarpaceae: Shorea pauciflora. Congener on Leguminosae: Pterocarpus stenoptera, Ebenaceae: Diospyros. Lowland to montane

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species		T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Characoma glaucopasta +	Hampson	0	0	0	0	0	1	0	Congener on pod of ?Leguminosae
Characoma nilotica	Rogenhofer	0	0	1	0	1	0	0	Tamaricaceae: Tamarix, Combretaceae: Terminalia, Sterculiaceae: Heritiera, Leguminosae: Cynometra
Garella ?rotundipennis	Walker	0	0	0	0	0	0	2	Leguminosae: Erythrina, Sterculiaceae: Helicteres, Combretaceae: Terminalia, Guttiferae: Calophyllum. Lowland
Giaura multipunctata	Swinhoe	0	0	0	0	0	0	1	Congener on Tiliaceae: Grewia. ?Montane
Giaura niveidisca	Hampson	0	0	0	0	0	0	2	Sterculiaceae: Pterospermum. Lowland, lower montane
Labanda ?umbrosa	Hampson	0	0	0	1	0	0	0	Congeners on Ebenaceae: Diospyros, Euphorbiaceae: Glochidion
Labanda umbrosa	Hampson	0	0	0	0	0	0	1	
Negritothripa orbifera +	Hampson	0	0	0	0	1	0	0	
Ptisciana seminivea	Walker	0	0	1	0	0	0	0	Euphorbiaceae: Macaranga. ?Lowland
Risoba sp. 2		0	0	1	1	5	1	6	Congeners on Lythraceae: Lagerstroemia flos-reginae, Combretaceae: Quisqualis, Leguminosae: Xylia, Melastomataceae: Melastoma, Osbeckia
Sarrothripinae 2		0	0	0	0	0	0	4	
Sarrothripinae 5 #		0	0	0	0	0	0	1	
Tathothripa continua	Walker	0	0	1	0	0	0	0	Lowland to montane
	sum	1	2	5	5	11	5	17	
12. Subfamily : Chloephorinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Aiteta damnipennis	Walker	0	2	0	0	0	0	1	Congener on Combretaceae: Terminalia
Beara dilatata	Holloway	0	3	0	0	0	0	0	Congener on Rhamnaceae: Zizyphus jujuba, Zeltus, Solanaceae, Verbenaceae: Tectona, Ulmaceae, Tiliaceae, Leguminosae. Lowland
Carea ?trichotmeta	Prout	0	2	1	0	1	0	0	Congeners on Myrtaceae: Eugenia, Cleistocalyx, Syzygium, Eucalyptus, Moraceae: Ficus, Melastomataceae: Memecylon, Bombacaceae. ?Montane
Carea argentiviridis	Holloway	0	0	0	0	2	0	0	?Lower montane
Carea biviata	Hampson	0	1	0	0	0	0	0	
Carea careoides	Warren	1	0	0	1	1	0	1	
Carea carneplagiata	Warren	0	1	0	0	0	0	0	
Carea costiplaga	Swinhoe	1	1	0	0	1	0	1	Lowland
Carea endophaea	Hampson	1	0	0	0	0	0	0	Melastomataceae: Memecylon. ?Montane
Carea exesa	Warren	2	0	0	1	1	0	0	
Carea metaphaea	Hampson	1	2	2	6	4	1	3	Lowland, lower montane
Carea mixticolor	Warren	0	0	0	0	0	0	1	
Carea nexilla	Hampson	0	0	2	2	1	0	8	
Carea pryeri	Druce	0	0	0	0	3	0	1	Lowland
Carea varipes	Walker	0	0	0	0	1	0	1	Myrtaceae: Eugenia xanthocarpa. Lowland, lower montane
Chloephorinae 3 #		0	0	0	0	0	0	1	
Chloroplaga nygmia	Swinhoe	0	0	0	0	0	0	1	Lowland to montane
Chloroplaga pallida	Warren	0	0	0	1	1	0	0	Lowland to montane
Didigua ?effusa	Swinhoe	0	0	1	1	2	0	2	Lowland
Didigua cineracea	Holloway	2	2	3	0	3	0	9	Lowland
*Didigua sp. no. 10716**		0	0	1	0	0	0	2	Lowland
Erizada lichenaria	Walker	0	1	0	1	0	2	0	Bombacaceae: Durio zibethinus. Congener on Tiliaceae: Grewia. ?Lowland
Maceda mansueta	Walker	0	1	0	0	0	0	0	Sterculiaceae: Heritiera. Lowland to montane
Negeta ?sublineata	Walker	0	2	1	0	0	0	1	
Negeta signata	Walker	1	0	1	1	0	0	0	Lowland
Orthocraspis acypera	Hampson	0	0	0	0	0	0	1	
Paracrama dulcissima	Walker	0	1	0	0	0	0	0	Tiliaceae: Grewia
Pterogonia aurigutta	Walker	0	0	0	0	1	0	0	Congener on ?Myrtaceae: Eugenia. Lowland
Pterogonia striatura	Moore	0	0	1	2	1	0	0	Lowland
Siglophora bella	Butler	0	0	0	0	1	0	0	Lowland

		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Westermannia albiorbis	Hampson	0	0	0	0	1	0	0	Genus on Combretaceae: Terminalia belerica. Lowland
Westermannia pangolina	Holloway	0	0	0	0	1	0	0	Congener on Lythraceae: Lagerstroemia. Lowland
Westermannia triangularis	Moore	0	1	0	1	0	0	0	
	sum	9	20	13	17	26	3	34	
13. Subfamily : Amphipyrinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Ancara replicans	Walker	0	0	0	1	0	0	0	Lowlands to upper montane
Athetis bipuncta	Snellen	1	2	6	3	16	94	1	Lowlands to montane, open habitats
Athetis nonagrica	Walker	0	0	0	1	0	1	0	Montane, lowlands, open habitats
Athetis reclusa	Walker	0	0	0	0	0	7	1	Cruciferae: Brassica. Lowlands to 1200m, open habitats
Athetis thoracica	Butler	0	0	0	0	0	1	0	Wide range incl. Gramineae, Leguminosae, Convolvulaceae: Ipomoea, Myrtaceae, Solanaceae, Theaceae, Portulaceae, Commelinaceae
Bagada malayica	Snellen	0	1	0	0	0	0	0	Lowland rainforest
Callopistria emiliusalis	Walker	0	0	1	0	1	1	0	Disturbed, open habitats
Callopistria maillardi	Guenee	0	0	1	0	1	7	0	Davalliaceae: Nephrolepis, Adiantaceae: Adiantum, Pellaea, Schizaeaceae: Lygodium, Piperaceae: Piper
Condica dolorosa	Walker	0	0	2	1	0	0	0	Compositae: Conyza, Elephantopus. Cultivated area, lower montane
Condica illecta	Walker	0	0	8	0	0	40	0	Compositae: Ageratum, Bidens, Carthamus, Coreopsis, Dahlia, Dichrocephala, Acanthaceae. Open habitats, up to 2000m
Corythurus nocturnus	Hampson	0	0	1	0	3	0	0	Lowland, montane forest
Dipterygina dorsipallens	Holloway	1	0	2	1	1	0	5	Congeners on Verbenaceae: Callicarpa. Lowland, montane forest
Dipterygina vagivitta	Walker	2	1	4	2	5	4	17	Lowlands to 1200m
Dyrzela increnulata	Warren	0	0	0	0	0	0	1	Lowland, montane forest
Eulepa niveigutta #	Walker	0	0	0	0	0	0	1	Lowland, alluvial, hill dipterocarp forest
Iambia lyricalis	Holloway	0	0	1	3	0	1	4	Congener on Rhamnaceae: Zizyphus. Lowland forest
Iambia tessellata	Prout	1	0	0	0	2	0	0	Lowland, montane forest
Mudaria major	Warren	0	0	0	0	1	0	0	Congener on Bombacaceae: Durio zibethinus (durian). Lowlands to montane, open, cultivated area
Mudaria tayi	Holloway	0	1	0	0	0	0	0	Lowland, montane forest
Sasunaga interrupta	Warren	1	0	0	0	0	1	0	Congeners on Rhamnaceae
Sasunaga longiplaga	Warren	0	0	0	0	0	7	1	Lowlands to 2600m
Sasunaga tenebrosa	Moore	0	2	0	0	0	0	0	Rhamnaceae: Ventilago. Lowlands to 2600m
Spodoptera litura	Fabricius	0	0	0	0	0	2	0	Wide range incl. Gramineae. Lowland, open, cultivated, distubed area
Spodoptera mauritia	Boisduval	0	0	0	0	0	0	1	Wide range incl. Gramineae (rice), Compositae. lowland, open, cultivated, disturbed areas
Stenopterygia calida	Walker	0	0	0	0	1	0	0	Congener on Ochnaceae: Ochna. Lowland forest to 2000m
Yepcalphis dilectissima	Walker	2	0	0	0	0	0	0	Verbenaceae: Vitex. Lowland forest, disturbed area
	sum	8	7	26	12	31	166	32	
14. Subfamily : Acronictinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Acronicta rubiginosa	Walker	0	0	0	1	0	0	0	Combretaceae: Terminalia. Montane, lowland forest
Craniophora malesiae +	Holloway	0	0	1	0	0	0	0	?Oleaceae: Olea, Ligustrum, Osmanthus. Montane, lowland foret
Thalathoides conjecturalis #	Swinhoe	0	0	0	0	0	0	1	Oleaceae: Olea. Lowland, dry heath, lower montane forest
	sum	0	0	1	1	0	0	1	
15. Subfamily : Agaristinae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Mimeusemia postica	Walker	0	0	0	0	1	0	0	Congeners on Vitaceae: Cayratia, Dilleniaceae: Dillenia. Lowland forest

16. Subfamily : Hadeninae									
		No. of individuals captured . Two replicates per site (7-8pm on different nights)							
Species	Authority	T1	T2	T3	T4	T5	HL	DV	Recorded host plants/habitat preference
Elusa ceneusalis	Walker	14	2	4	5	9	17	5	Lowland, undisturbed, secondary forest
Elusa penanorum	Holloway	2	0	0	0	1	0	0	Lowland, swamp, alluvial, hill dipterocarp forest
Mythimna calorai	Holloway	0	0	0	0	1	0	0	Cultivated area
Mythimna decisissima	Walker	0	1	0	0	0	0	1	Congener on Gramineae: Saccharum. Lowland, open, secondary vegetation
Mythimna nabalua	Holloway	0	0	0	0	0	3	0	Disturbed habitat
Tiracola plagiata	Walker	0	0	0	1	0	2	0	Wide range incl. Euphorbiaceae (cassava), Leguminosae, Verbenacea, Compositae, Rubiaceae, Sterculiaceae, Zingiberaceae, Piperaceae
	sum	16	3	4	6	11	22	6	
	Total N	363	434	431	383	538	500	358	
	Total S	136	187	172	166	217	109	163	
# Species collected at Danum Valley only									
+ Species not collected at Brumas in 1991									
* Refers to slide number in the Natural History Museum in London prepared by J.D.Holloway									
** Refers to series in J.D.Holloway's collection in the Natural History Museum									

Appendix IV. Light-trap transect samples of macromoths and their recorded host plants/habitat preference: Gmelina transect

Transect from plantation forest to adjacent secondary natural forest in Brumas
With similar sampling at primary natural forest in Danum Valley for comparison.

Plantation :
Gmelina arborea
Sites :
T1 = Middle of plantation
T2 = Plantation site near secondary forest
T3 = Plantation-Secondary forest border
T4 = Secondary forest site near plantation
T5 = Middle of secondary forest
DV = Primary natural forest in Danum Valley

Date :
January/February 1993

MACROLEPIDOPTERA
I. Superfamily : Cossoidea
i. Family : Cossidae

No. of individuals captured . Two replicates per site (7-8pm on different nights)

Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Cossus chloratoides	Holloway	1	0	0	0	0	2	Lowlands, hill dipterocarp foresat
Cossus cinereus	Roepke	0	0	0	0	1	0	Lowland rainforest
Xyleutes ceramica	Walker	0	0	0	0	1	0	Verbenaceae: Gmelina, Callicarpa, Tectona, Clerodendrum, Leguminosae, Bignonoiaceae: Spathodea, Sonneratiaceae: Duabanga
	sum	1	0	0	0	2	2	

ii. Family : Metarbelidae

No. of individuals captured . Two replicates per site (7-8pm on different nights)

Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Squamura disciplaga	Swinhoe	0	1	0	0	1	0	Lauraceae: Persea (avocado), Rutaceae: Citrus

II. Superfamily : Zygaenoidea
i. Family : Limacodidae

No. of individuals captured . Two replicates per site (7-8pm on different nights)

Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Allothosea lola	Swinhoe	0	2	0	0	1	1	Theaceae: Camellia (tea). Lowland rainforest
Atosia trusmadia	Holloway	0	0	1	0	0	0	Congener on Leguminosae: Erythrina
Birthamula chara	Swinhoe	0	0	0	1	0	0	Palmae: Elaeis (oil palm). Alluvial, coastal, swamp, heath forest
Cania bandura	Moore	0	1	6	0	0	0	Ebenaceae: Diospyros discolor, Palmae. Lowland, lower montane forest
Chalcocelis albiguttatus	Snellen	0	2	3	5	16	6	Wide range incl. Leguminosae: Acacia mangium, Myrtaceae: Eugenia, Rubiaceae: Coffea, Euphorbiaceae, Flacourtiaceae, Palmae: Cocos
Griseothosea cruda	Walker	0	1	0	0	0	0	Lowland rainforest, swamp, dry heath forest, occasionally montane
Heringarosa trifurca #	Holloway	0	0	0	0	0	1	Lowland, wet heath, hill dipterocarp forest
Idonauton apicalis	Walker	1	0	0	0	0	0	Palmae: Cocos
Narosa concinna	Swinhoe	0	0	0	0	1	0	Lowlands, mangrove
Nirmides basalis	Walker	0	0	0	0	1	2	Lowland, swampy, dry heath, hill dipterocarp, alluvial, lower montane forest

		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Pseudidonauton bhaga	Swinhoe	0	0	0	1	0	0	Congener on Leguminosae: Dalbergia. Lowland rainforest
Scopelodes pallivittata	Snellen	1	3	5	2	3	4	Musaceae: Musa, Sterculiaceae: Theobroma cacao, Sapindaceae: Nephelium
Scopelodes unicolor	Westwood	0	0	0	0	0	1	Sterculiaceae: Theobroma, Myrtaceae: Eugenia, Euphorbiaceae: Ricinus, Sapindaceae: Nephelium and many fruit trees
Setora cupreistriga	Walker	4	0	0	4	11	1	Congener on wide range incl. Musaceae, Palmae, Sterculiaceae, Rubiaceae, Sapindaceae, Theaceae, Rutaceae, Solanaceae, Zingiberaceae
Setothosea asigna	van Eecke	0	0	0	0	0	2	Palmae: Elaeis, Cocos. Lowland, hill dipterocarp, lower montane, alluvial, kerangas forest
Susica heringi	Holloway	0	0	0	0	0	1	Palmae: Elaeis (oil palm). Lowland dipterocarp, heath, lower montane forest
	sum	6	9	15	13	33	19	
ii. Family : Zygaenidae								
1. Subfamily : Chalcosianae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Anarbudas ?bipartita #	Walker	0	0	0	0	0	1	
III. Superfamily : Bombycoidea								
i. Family : Lasiocampidae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Gastropacha leopoldi	Tams	0	0	0	0	0	1	Apocynaceae: Carissa. Congener on Leguminosae: Enterolobium, Pithecellobium, Euphorbiaceae: Baccaurea, Aporusa
Paralebeda lucifuga	Swinhoe	3	2	2	0	3	0	Melastomataceae: Melastoma malabathricum, Sapindaceae: Nephelium, Rubiaceae: Coffea
Suana concolor	Walker	0	0	0	0	2	0	Wide range incl. Dipterocarpaceae: Shorea, Leguminosae: Acacia, Albizia, Myrtaceae: Eucalyptus, Verbenaceae, Sterculiaceae, Fagaceae, Lauraceae
Takanea diehli	Lajonquiere	0	0	0	0	0	1	Lowland rainforest
	sum	3	2	2	0	5	2	
ii. Family : Sphingidae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Acherontia lachesis	Fabricius	0	0	0	0	1	0	Wide range incl. Solanaceae, Verbenaceae, Leguminosae, Oleaceae, Bignoniaceae, Labiatae, Compositae, Convolvulaceae: Merremia, Euphorbiaceae
Acosmeryx shervillii	Boisduval	0	0	0	0	1	0	Vitaceae: Cayratia, Cissus, Vitis, Leeaceae: Leea, Dilleniaceae: Dillenia, Actinidiaceae: Saurauia
Daphnis hypothous	Cramer	1	1	0	0	1	0	Rubiaceae: Anthocephalus, Uncaria (gambier), Cinchona, Wendlandia paniculata, Ixora, Pavetta, Apocynaceae: Alstonia
Elibia dolichus	Westwood	0	1	0	0	2	0	Actinidiaceae: Saurauia, Leeaceae: Leea, Vitaceae: Cayratia, Tetrastigma. Lowlands
Enpinanga borneensis	Butler	1	0	0	0	4	0	Dilleniaceae: Dillenia (Wormia), Tetracera
Enpinanga vigens +	Butler	0	0	0	0	1	0	Dilleniaceae: Tetracera. Lowland rainforest
Panacra mydon	Walker	0	0	0	0	1	0	Araceae: Colocasia antiquorum, Amorphophallus, Caladium, Arisaema curvatum, Alocasia, Dieffenbachia, Homalonema, Vitaceae: Vitis
Psilogramma menephron	Cramer	1	0	0	0	1	0	Wide range incl. Verbenaceae, Gmelina arborea, Callicarpa, Tectona, Bignoniaceae, Flacourtiaceae, Labiatae, Meliaceae, Oleaceae, Scrophulariaceae
Rhyncholaba acteus	Cramer	0	1	0	0	0	0	Leeaceae: Leea, Vitaceae: Vitis, Begoniaceae, Commelinaceae, Araceae
Theretra latreillei	MacLeay	0	1	0	0	2	0	Actinidiaceae: Saurauia, Balsalminaceae: Impatiens, Vitaceae: Vitis, Tetrastigma, Cayratia, Cissus, Lythraceae, Begoniaceae, Dilleniaceae, Onagraceae
	sum	3	4	0	0	14	0	
IV. Superfamily : Geometroidea								
i. Family : Drepanidae								
1. Subfamily : Drepaninae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Canucha specularis	Moore	0	0	0	0	0	1	Lowland to lower montane

2. Subfamily : Oretinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Spectroreta hyalodisca #	Hampson	0	0	0	0	0	2	
ii. Family : Uraniidae								
1. Subfamily : Microniinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Micronia astheniata	Guenee	0	0	0	0	2	0	Myrtaceae: Eugenia malaccensis, Euphorbiaceae: Endospermum malaccense. Lowland
iii. Family : Epiplemidae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Dirades rufinervis	Holloway	0	0	0	0	1	0	Congeners on Rubiaceae: Morinda, Canthium/Plectronia, Vangueria, Randia, Adina. ?Lower montane
Epiplema instabilata	Walker	0	2	0	0	0	0	Verbenaceae: Premna. Congeners on Verbenaceae: Gmelina, Mussaenda, Oleaceae: Olea, Linociera. ?Lowland
Epiplema quadricaudata	Walker	0	0	0	2	1	1	Rubiaceae: Cinchona, Anthocephalus chinensis, Adina. Lowland
	sum	0	2	0	2	2	1	
iv. Family : Geometridae								
1. Subfamily : Oenochrominae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Derambila saponaria "complex" +	Guenee	0	0	1	0	0	0	
Naxa guttulata #	Warren	0	0	0	0	0	1	Congener on Oleaceae: Olea
Ozola ?basisparsata	Walker	1	0	0	0	0	0	Congener on Verbenaceae: Gmelina, Premna. ?Lowland
	sum	1	0	1	0	0	1	
2. Subfamily : Geometrinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
?Idiochlora pudentifimbria	Prout	0	1	0	0	0	0	
Comibaena attenuata	Warren	1	2	1	0	2	0	Sapindaceae: Nephelium. Congeners on Leguminosae, Anacardiaceae, Rhamnaceae, Compositae, Myrtaceae, Rutaceae. Lowland
Dysphania transducta	Walker	0	0	0	0	1	0	Rhizophoraceae; Carallia eugenoides, congeners on Guttiferae: Garcinia. Lowland
Epipristis minimaria #	Guenee	0	0	0	0	0	1	
Gelasma ?magnipuncta	Prout	3	3	0	2	1	0	Congeners on Combretaceae: Anogeissus, Terminalia, Myrtaceae: Eugenia, Syzygium, Dipterocarpaceae: Shorea, Euphorbiaceae: Phyllanthus
Gelasma sp.		0	2	0	2	1	0	
Pingasa rubicunda	Warren	0	0	0	1	0	0	Lauraceae: Litsea polyantha, Dipterocarpaceae: Shorea acuminata (flower feeder). Lowland
Pingasa ruginaria	Guenee	0	0	0	0	1	0	Lauraceae: Litsea, Rubiaceae: Mussaenda, Wendlandia, Sterculiaceae, Sapindaceae: Nephelium, Rhamnaceae, Combretaceae, Leguminosae
Prasinocyma floresaria	Walker	0	0	0	1	1	1	Congener on Combretaceae: Terminalia. Lowland
Tanaorhinus rafflesii	Moore	0	0	0	0	0	1	Fagaceae: Quercus. Lowland to montane
Thalassodes ?griseifimbria	Prout	0	0	0	0	3	0	Anacardiaceae: Mangifera indica (mango), Sapindaceae: Schleichera trijuga. Montane
	sum	4	8	1	6	10	3	

3. Subfamily : Sterrhinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Anisodes ?thermosaria	Walker	0	0	0	0	1	0	Congeners on Myrtaceae, Compositae, Leguminosae, Annonaceae, Anacardiaceae, Connaraceae, Celastraceae, Lauraceae
Antitrygodes divisaria	Walker	0	0	1	0	0	0	Verbenaceae, Rubiaceae: Hymenodictyon, Mussaenda, congener on Rubiaceae: Anthocephalus cadamba, Marantaceae: Maranta. Lowland
Idaea ?phaeocrossa	Prout	0	0	0	0	1	0	
Idaea sp. 1		0	2	0	1	0	0	
Idaea sp. 2		0	1	0	0	0	0	
Problepsis plenorbis	Prout	0	0	0	0	0	1	Oleaceae: Jasminum. Congener on Oleaceae: Olea. Lowland
*Scopula sp. no. 10765**		0	1	1	2	0	2	Congeners on Moraceae, Gramineae, Cruciferae, Sapindaceae, Cucurbitaceae, Oleaceae, Combretaceae, Amaranthaceae
Sterrhinae 1		0	2	0	0	0	0	
Symmacra solidaria	Guenee	0	0	0	0	1	0	Lowland
Zythos strigata	Warren	0	0	1	1	0	0	Lowland
Zythos turbata	Walker	0	0	0	0	0	1	?Oleaceae or Rubiaceae. Lowland
	sum	0	6	3	4	3	4	
4. Subfamily : Larentiinae								Mainly montane species
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Chloroclystis ?dilatata	Walker	0	0	0	0	0	1	Euphorbiaceae: Glochidion. Congeners on Euphorbiaceae: Breynia, Actephila, Combretaceae: Terminalia. Montane
Eois phaneroscia	Prout	0	0	0	0	1	0	Lowland
Eois sp. 1		0	0	0	0	1	0	
	sum	0	0	0	0	2	1	
5. Subfamily : Ennominae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Bracca maculosa	Walker	0	0	1	0	0	0	Lowlands to upper montane
Cleora decisaria	Walker	34	12	15	26	13	0	Leguminosae: Paraserianthes falcataria. Lowlands
Cleora determinata	Walker	0	0	0	0	1	0	Lowland forest
Cleora repetita	Butler	0	1	0	1	1	0	Combretaceae: Terminalia, Verbenaceae: Premna, Lauraceae: Persea, Myrtaceae: Callistemon, Eucalyptus, Fenzlia, Rutaceae: Flindersia
Corymica latimarginata	Swinhoe	0	0	0	0	0	1	Lowland forest
Curbia martiata	Guenee	0	3	2	3	7	0	Lowland forest
Ectropidia fimbripedata	Warren	0	0	0	0	0	2	Congener on Dipterocarpaceae: Shorea robusta. Lowland, heath, lower montane forest
Fascellina aurifera	Warren	1	0	1	0	4	0	Lowland rainforest
Fascellina castanea	Moore	1	0	0	1	0	0	Lauraceae: Cinnamomum. Alluvial forest
Godonela translineata	Walker	0	1	0	1	0	0	Leguminosae: Paraserianthes falcataria, Delonix, Elaeagnaceae: Elaeagnus. Lowland, lower montane forest
Heterostegane insulata	Warren	1	1	0	0	1	0	Lowlands
Hypochrosis binexata	Walker	0	0	0	0	0	5	Sterculiaceae: Theobroma cacao (cocoa). Lowland, secondary, lower montane forest, agricultural areas
Hypomecis costaria	Guenee	1	0	0	0	0	0	Congener on Euphorbiaceae: Aleurites. Lowland, wet kerangas, lower montane forest
Hypomecis subdetractaria	Prout	0	0	0	0	0	1	Lowland, wet kerangas forest
Hyposidra talaca	Walker	0	1	0	0	0	0	Incl. Leguminosae: A. mangium, P. falcataria, Myrtaceae: Eucalyptus, Compositae, Euphorbiaceae, Moraceae: Ficus, Sterculiaceae, Verbenaceae
Luxiaria submonstrata	Walker	0	0	0	0	0	1	Lowland, lower montane, upper montane forest
Mesaster albidiscata	Warren	0	0	0	0	1	0	Lowland, lower montane forest
Peratophyga venetia	Swinhoe	0	3	1	0	0	0	Lowland, heath, lower montane forest
Pseudalcis catoriata	Warren	0	0	0	0	1	0	Lowland, disturbed forest
Serratophyga sterrhoticha	Prout	0	0	2	0	0	0	Mangrove, limestone, hill dipterocarp forest
Zamarada denticulata	Fletcher	0	0	0	0	0	3	Alluvial forest
Zamarada eogenaria	Snellen	0	0	0	0	0	1	Sterculiaceae: Theobroma cacao (cocoa). Lowland forest
	sum	38	22	22	32	29	14	

V. Superfamily : Noctuoidea								
i. Family : Notodontidae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Medanella subterminalis	Kiriakoff	0	0	0	0	0	3	Lowland dipterocarp forest
ii. Family : Arctiidae								
1. Subfamily : Lithosiinae								Many members are lichen feeders
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
?Meteugoa sp.		0	1	0	0	0	0	
Asura ?nigripuncta	Wileman	1	0	1	1	1	2	Genus on lichens, congeners on Convolvulaceae: Ipomoea batatas, Xanthophyllaceae, Santalaceae, Rutaceae, Nyctaginaceae, Malvaceae
Asura asaphes	Hampson	0	1	5	1	0	8	Lowland
Asura birivula	Hampson	0	0	0	0	0	6	Lowland, lower montane
Asura biseriata	Hampson	2	2	0	1	1	7	
Asura bizonoides	Walker	0	0	0	0	0	3	
Asura crustata	Talbot	0	1	0	0	0	3	
Asura euprepioides	Walker	1	0	2	0	2	0	Lowland
Asura peloa	Swinhoe	0	0	1	0	0	0	
Asura pudibunda	Snellen	0	0	0	0	0	1	Lowland
Asura sp. 1		0	0	0	0	0	1	
*Asura sp. no. 2708**		0	0	0	0	0	1	
*Asura sp. no. 2740**		1	0	2	0	4	4	
Asura strigipennis	Herrich-Schaffer	0	0	2	0	0	1	
Asura subcruciata	Rothschild	0	0	0	0	1	0	Lowland, ?alluvial forest
Chamaita trichopteroides	Walker	0	0	1	0	0	0	Lower montane
Cyana costifimbria	Walker	0	3	5	6	2	0	Genus on lichens, congeners on Apocynaceae, Anacardiaceae, Zingiberaceae, Meliaceae, Leguminosae, Dipterocarpaceae, Verbenaceae. Lowland
Cyana inconclusa	Walker	0	0	1	0	1	0	Lowland
Cyana infantula	Hampson	0	1	0	1	0	0	
Cyana malayensis	Hampson	0	1	4	1	2	1	Lowland
Cyana pernata	Walker	12	1	0	1	13	1	Lowland
Cyana ridleyi	Hampson	0	0	0	0	1	0	Lowland
Eilema ?cretacea	Hampson	0	0	0	0	1	0	Mosses, lichens, Leguminosae: Tamarindus, Myrtaceae: Eugenia. Congener on Euphorbiaceae: Hevea brasiliensis. ?Lower montane
Eilema ?pulvereola	Hampson	0	0	0	0	1	0	Lowland to lower montane
Eilema apicalis	Walker	0	0	0	1	1	0	Lowland
Eilema chiloides	Walker	0	0	0	0	2	1	Lowland
Eilema griseadisca	Holloway	0	0	0	1	0	0	
Eilema sp.		0	0	0	0	0	1	
Eilema tetragona #	Walker	0	0	0	0	0	1	
Eugoa aequalis	Walker	0	2	0	1	1	0	
Eugoa crassa	Walker	0	0	5	1	1	2	
*Eugoa sp. no. 2754**		0	1	0	0	0	0	
*Eugoa sp. no. 2758**		0	0	0	0	1	0	
Hemonia ciliata	Hampson	0	1	0	0	1	0	
Lithosiinae 4		4	0	0	0	0	0	
Lithosiinae 5		0	1	0	0	0	0	
Lithosiinae 8		0	0	1	0	0	0	
Lithosiinae no. 2681*		0	0	0	0	0	2	
Macotasa nubeculoides	Holloway	0	1	2	1	0	0	Congener on Leguminosae: Albizia moluccana
Mantala tineoides +	Walker	0	2	0	0	0	0	

		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Meteugoa sp. #		0	0	0	0	0	1	Congener on Euphorbiaceae: Hevea
Miltochrista cornicornutata	Holloway	0	0	1	0	0	1	Genus on lichens
Miltochrista cruciata	Walker	0	0	0	1	0	0	Lowland
Miltochrista hypoprepioides	Walker	0	1	0	0	0	0	
Miltochrista lineata	Walker	1	0	0	0	0	2	Lowland
Miltochrista roseororatus	Butler	0	0	0	1	3	1	Sterculiaceae: Theobroma cacao
Miltochrista rubricostata	Herrich-Schaffer	1	0	0	0	1	0	Lowland, lower montane
Miltochrista sp. nr. inflexa	Moore	0	0	0	0	0	1	
Miltochrista vagilinea #	Walker	0	0	0	0	0	1	
Nishada nodicornis	Walker	0	0	0	0	1	0	Lowland
Nishada sambara	Moore	0	0	1	0	0	0	Lowland
Oeonistis entella	Cramer	0	0	0	0	1	1	Lichens, Convolvulaceae: Cuscuta, Flacourtiaceae: Flacourtia, Moraceae: Ficus. Lowland
Padenia duplicana	Walker	0	1	0	0	3	0	Lowland, lower montane
Parasiccia marginipuncta	Talbot	0	0	0	0	0	1	Upper montane
Poliosia muricolor	Walker	0	11	3	11	1	0	
Scaptesyle aurigena #	Walker	0	0	0	0	0	1	
Siccia sp. 2		0	0	0	1	0	0	?Lichens
Siccia sp. 3 +		1	0	0	0	0	1	
Trischalis subaurana	Walker	1	0	0	0	0	0	
	sum	25	32	37	31	47	57	
2. Subfamily : Syntominae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Amata egenaria	Walker	0	1	0	1	3	4	Congeners on mosses, lichens, rice, Convolvulaceae, Leguminosae, Compositae, Santalaceae. Lowland forest
Amata prepuncta	Holloway	1	0	0	0	0	3	Lowland rainforest
	sum	1	1	0	1	3	7	
3. Subfamily : Arctiinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Creatonotos transiens	Walker	1	3	1	5	7	0	Wide range incl. Gramineae: Paspalum, Leguminosae, Vitaceae: Cayratia, Meliaceae, Dioscoreaceae, Musaceae, Salicaceae, Chenopodiaceae
Nyctemera baulus	Boisduval	0	0	0	0	1	0	Compositae: Crassocephalum, Emilia, Cruciferae: Brassica. Secondary, disturbed, agricultural habitats
Nyctemera muelleri	Vollenhoven	0	0	0	0	0	1	Lowlands to 2000m, disturbed habitats
Pareuchaetes pseudoinsulata	Rego Barros	0	1	0	0	0	0	Compositae: Chromolaena odorata. Weedy habitats
Spilosoma griseabrunnea	Holloway	0	0	0	1	0	0	Congeners on Compositae, Gramineae: Paspalum, Leguminosae, Convolvulaceae, Musaceae, Orchidaceae. Disturbed habitats
Spilosoma hosei	Rothschild	0	0	0	0	0	6	Lowland forest
Spilosoma thomasi +	Holloway	0	0	0	1	0	0	Montane
	sum	1	4	1	7	8	7	
iii. Family : Lymantriidae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Cobanilla plumbacea	Swinhoe	0	0	0	0	2	0	Congener on Ebenaceae: Diospyros
Euproctis ?flavolimbata	Aurivillius	0	0	0	0	1	0	Genus on wide range incl. Sterculiaceae, Gramineae, Dipterocarpaceae: Shorea, Leguminosae: Acacia, Verbenaceae, Myrtaceae: Eucalyptus
Euproctis ?limbata	Butler	1	0	0	0	3	0	Leguminosae: P. falcataria, congeners on Rhizophoraceae, Anacardiaceae, Bombacaceae, Theaceae, Sonneratiaceae, Lauraceae, Combretaceae
Euproctis cincta	Swinhoe	0	0	0	0	0	1	Congeners on Polypodiaceae, Loranthaceae, Asclepiadaceae, Euphorbiaceae, Fagaceae, Leeaceae, Rosaceae
Euproctis eclipes	Collenette	0	3	0	0	1	0	

		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Euproctis flavomarginata	Wileman	0	0	0	0	0	1	
Euproctis guttulata	Snellen	1	0	0	0	2	4	Lowland
*Euproctis sp. no. 1676**		0	0	0	1	0	1	
*Euproctis sp. no. 1691**		0	0	0	0	0	3	
Euproctis sp. no. 1723#*		0	0	0	0	0	5	
Ilema chloroptera	Hampson	0	0	0	1	0	0	Congener on Gleicheniaceae: Dicranopteris. ?Lowland
Orgyia postica	Walker	4	5	2	1	2	0	
Redoa ?camurisquama	Collenette	0	0	1	0	0	1	Genus on Leguminosae, Dipterocarpaceae: Balanocarpus, Shorea, Elaeocarpaceae, Anacardiaceae, Gramineae, Theaceae, Combretaceae, Lauraceae
Redoa ?egerina	Swinhoe	0	0	0	0	0	1	Genus majority lowland
Redoa flora	Swinhoe	0	0	0	0	0	2	Bombacaceae: Durio zibethinus
Redoa marginalis	Walker	0	0	0	0	0	2	
Redoa rhopica	Toxopeus	0	0	0	0	0	5	
Rhypotoses brooksi	Collenette	0	0	0	0	1	1	Lowland
Rhypotoses glebula	Swinhoe	0	0	1	1	0	0	Lowland
Rhypotoses strigifimbria	Walker	0	0	0	0	0	1	Lowland
Scarpona ennomoides	Walker	1	0	0	0	0	0	Ebenaceae: Diospyros discolor. Lowland
	sum	7	8	4	4	12	28	
iv. Family : Noctuidae								
1. Subfamily : Aganainae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Asota egens	Walker	2	0	0	0	0	0	Moraceae: Ficus. Lowland, secondary forest
Asota heliconia	Linnaeus	0	0	0	1	1	1	Oxalidaceae: Averrhoa (star-fruit). Lowlands, disturbed forest
Asota plana	Walker	0	0	1	0	0	0	Moraceae: Ficus. Lowlands to 1900m
Euplocia membliaria	Cramer	0	0	1	0	0	0	Lowlands
	sum	2	0	2	1	1	1	
2. Subfamily : Herminiinae								Many are detritus feeders
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Adrapsa ?ereboides	Walker	0	0	1	0	0	0	
Adrapsa angulilinea	Prout	0	1	0	0	0	0	
Adrapsa sp. 1		0	0	0	0	1	0	
Adrapsa sp. 2		0	0	0	0	2	0	
Amilaga geometroides	Walker	0	0	0	0	1	0	Lowland
Bertula depressalis	Snellen	1	0	1	1	0	0	Detritus. Congener on dry grass. Lowland
Bertula tespisalis	Walker	0	0	0	0	2	0	Lower montane
Bocana manifestalis	Walker	0	0	1	0	1	0	Meliaceae: Dysoxylum. Detritus, ?grasses. Lowland to montane
Catada picta	Moore	0	0	0	0	1	0	Congener on Connaraceae: Rourea. ?Lowland
Catada sp.		0	0	0	1	5	0	
Hadennia prunosa	Moore	0	0	1	0	1	0	Lowland
Herminia diagramma	Prout	3	1	1	0	0	0	?Detritus. Congener on moss. ?Lowland
Herminiinae 1		0	1	1	2	2	0	
Herminiinae 10 #		0	0	0	0	0	1	
Hipoepa biasalis	Walker	2	0	1	1	12	1	?Detritus. ?Lowland
Hipoepa fractalis	Guenee	5	10	1	1	4	0	Leguminosae: Paraserianthes falcataria, Dalbergia, Rubiaceae: Rubia (dry leaves)
Hipoepa sp.		0	0	1	1	2	0	

		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Hydrillodes gravatalis	Walker	1	0	0	1	3	0	Congener on dead coconut leaves, decaying grass, Dipterocarpaceae: Dryobalanops lanceolata (fruit). Lowland to montane
Hydrillodes repugnalis	Walker	1	0	0	2	3	0	
*Hydrillodes sp. no. 10817**		1	0	1	0	0	1	
*Hydrillodes sp. no. 10822**		0	0	0	0	0	1	
Hydrillodes toresalis	Walker	0	0	1	1	1	0	Lowland to montane
Lysimelia ?nigripes	Hampson	0	0	0	0	2	0	
Lysimelia neleusalis	Walker	1	0	0	0	0	0	
Mixomelia ?umbripars	Hampson	0	1	1	0	0	0	
Naarda ?nodariodes	Prout	0	1	2	0	0	0	Congener on Dipterocarpaceae: Dryobalanops lanceolata (fruit)
Nodaria cornicalis	Fabricius	4	11	2	13	14	0	Congener on dry leaves of Leguminosae: Dalbergia, grass
Oxaenanus brontesalis +	Walker	0	0	1	0	0	0	
Progonia oileusalis	Walker	0	1	1	0	0	0	Congeners on Rubiaceae: Rubia cordifolia, Rutaceae: Citrus
Progonia sp. 4		0	0	0	0	0	1	
Simplicia ?macrotheca	Prout	1	0	0	0	1	0	Congeners on dry leaves incl. tea, grass, Musaceae: Musa, Dipterocarpaceae: Dipterocarpus, Palmae: Cocos
Simplicia circumscripta	Walker	0	0	0	0	1	0	Lowland
Simplicia renota	Swinhoe	1	0	0	0	2	0	Lowland
Simplicia rufa occidentalis	Holloway	0	1	2	0	0	2	Detritus
	sum	21	28	20	24	61	7	
3. Subfamily : Hypeninae								Many detritus feeders
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Hypena iconicalis similata	Moore	0	0	1	0	2	0	Congeners on Verbenaceae, Commelinaceae, Leguminosae, Combretaceae, Rutaceae, Polygonaceae, Acanthaceae. Lowland to montane
Hypena jugalis	Walker	0	0	0	0	0	1	Lowland
Hypenagonia sp. 1		0	1	0	0	0	0	
	sum	0	1	1	0	2	1	
4. Subfamily : Catocalinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Chalciope mygdon	Cramer	0	0	0	1	0	1	Genus on Leguminosae: Rhynchosia minima. Congeners on Gramineae: Oryza, Leguminosae: Indigofera
Ercheia cyllaria	Cramer	1	1	0	0	0	6	Grass, Leguminosae: Dalbergia, Tiliaceae: Grewia, Liliaceae: Asparagus. Lowland to montane
Hypopyra pudens	Walker	0	0	1	0	0	0	Leguminosae: Paraserianthes falcataria
Mocis undata	Fabricius	0	0	1	0	0	0	Leguminosae: Pueraria, Desmodium
Ophiusa coronata	Fabricius	0	0	0	1	0	0	Combretaceae: Quisqualis indica, Terminalia, Combretum, Leguminosae: Storckiella. Congener on Sapindaceae: Hemigyrosa/Guioa
Parallelia crameri +	Moore	0	0	0	0	2	0	Euphorbiaceae: Phyllanthus emblica. Congeners on Leguminosae, Rutaceae
Parallelia fulvotaenia	Guenee	0	0	0	0	0	1	Lowland
Pseudathyrma rufiscripta	Hampson	1	0	0	0	0	0	
	sum	2	1	2	2	2	8	
5. Subfamily : Ophiderinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
?Throana sp. #		0	0	0	0	0	1	
Anticarsia creberrima	Walker	0	0	0	0	1	0	Leguminosae: Cajanus indicus. Congener on Leguminosae: Vigna, Derris, Cyamopsis. Lowland
Bocula microscala	Holloway	0	0	0	0	0	2	Congeners on Tiliaceae: Grewia tiliaefolia, Sterculiaceae: Sterculia villosa, Moraceae: Ficus. Lowland
Calymniops sp.		0	0	0	0	1	0	
Catephia ?longinquua	Swinhoe	0	0	0	0	0	1	Euphorbiaceae: Antidesma. Congener on Convolvulaceae: Ipomoea batatas, Merremia, Argyreia, Leguminosae: Cajanus

		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Chilkasa falcata	Swinhoe	0	0	0	0	0	1	Lowland to montane
Claterna cydonia	Cramer	0	0	0	0	1	4	Lowland, alluvial forest
Crithote horridipes	Walker	0	0	0	0	1	0	Leguminosae: Dalbergia
Diascia hayesi	Holloway	0	1	0	0	0	0	Lowland to montane
Dinumma ?combusta	Walker	0	0	0	1	1	0	Leguminosae: Paraserianthes falcataria, congener on Verbenaceae: Tectona
Diomea rotundata +	Walker	2	0	0	0	0	0	Woody fungus
Dunira ?rubripunctalis	Walker	0	0	0	1	1	0	
Dunira sp. 2 #		0	0	0	0	0	1	
Episparis costistriga	Walker	2	3	5	1	5	0	Congeners on Meliaceae: Chukrasia tabularis, Sapindaceae: Schleichera, Rubiaceae: Stephegyne, Adina, Magnoliaceae: Michelia. Lowland
Ericeia ?inangulata	Guenee	0	0	1	0	0	0	Leguminosae: Cassia, Xylia, Albizia. Montane
Ericeia subcinerea	Snellen	0	0	0	0	1	0	Leguminosae. Congeners on Leguminosae: Acacia mangium, Mimosa rubicaulis, Dalbergia latifolia, Cassia, Xylia, Albizia. Lowland
Gesonia obeditalis	Walker	0	0	1	0	0	0	Congener on Leguminosae: Glycine (soy bean), grass
Homodes ?vivida	Guenee	0	0	0	0	1	0	Congeners on Leguminosae: Erythrina subumbrans, Myrsinaceae: Embelia, Euphorbiaceae: Hevea
Hyposemansis singha	Guenee	0	0	0	0	0	2	Lowland
Loxioda dilutalis	Snellen	0	0	0	0	1	0	
Maguda ?multifasciata	Swinhoe	0	0	1	0	0	0	
Malagonia cf. acypera	Hampson	0	0	0	1	0	0	
Mecodina lanceola	Guenee	0	0	0	1	0	0	Congeners on Apocynaceae: Ichnocarpus, Moraceae: Ficus, Rubiaceae: Hymenodictyon
Metaphoenia plagifera	Walker	0	0	0	0	1	0	Lowland, lower montane
Neogabara plagiola	Wileman & West	1	0	0	0	1	0	
Ophiderinae 14		0	1	0	0	1	0	
Ophiderinae 17		0	0	0	1	0	0	
Ophiderinae 18		0	0	0	0	0	1	
Ophiderinae 20		0	0	0	0	0	5	
Ophiderinae 25		0	0	0	0	0	1	
Ophiderinae 26 #		0	0	0	0	0	1	
Ophiderinae 6		0	0	0	0	2	0	
Ophiderinae F**		1	0	1	0	0	0	Lowland, limestone
Oxyodes billeti	de Joannis	0	0	0	0	0	1	Lowland, lower montane
Oxyodes scrobiculata	Fabricius	1	0	0	0	0	6	Meliaceae: Amoora/Aglaia, Sapindaceae: Litchi/Euphoria, Nephelium
Pangrapta parsimonalis	Walker	0	0	0	0	0	1	Lowland
Pantydia metaspila	Walker	0	0	0	0	1	0	Leguminosae: Vigna
Parolulis olivescens	Hampson	0	0	1	0	0	0	
Platyja sumatrana magnimargo	Holloway	1	0	0	0	0	0	
Poeta quadrinotata	Walker	0	0	1	0	3	0	
Pseudogyrtona ?stipata	Walker	0	0	0	0	1	0	
Pseudogyrtona octosema	Hampson	0	0	0	0	0	1	Lowland
Rema costimacula	Guenee	0	0	0	0	0	1	Lowland, ?alluvial forest
Saroba pansa	Swinhoe	0	0	0	0	1	0	
Sympis rufibasis	Guenee	0	0	0	0	0	2	Sapindaceae: Nephelium litchi. Lowland to montane
Tamba cosmoloma	Prout	0	1	0	0	0	0	Congener on Barringtoniaceae: Barringtonia
Tamba sp. 2		1	0	0	0	0	0	
Tipasa renalis	Moore	0	0	0	0	1	1	
Tiruvaca subcostalis	Walker	0	0	0	0	1	0	Bombacaceae: Durio zibethinus, Sterculiaceae: Theobroma. ?Lowland
Ugia disjungens	Walker	0	0	0	0	0	1	Lowland
*Ugia sp. no. 10780**		0	0	0	1	0	0	
	sum	9	6	11	7	27	34	

6. Subfamily : Acontiinae								Some species feed on scale insects (Coccoidea)
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Acontiinae 17		0	0	0	0	1	0	
Acontiinae 28		0	0	0	0	1	0	
Acontiinae 29 +		0	0	0	1	0	0	
Acontiinae 31 +		0	0	1	0	0	0	
Acontiinae 33 +		1	0	0	0	0	0	
Acontiinae 34 +		1	0	0	0	0	0	
Acontiinae 35 +		0	0	0	1	0	0	
Acontiinae 38 +		0	0	0	0	1	0	
Acontiinae 4		0	0	1	0	0	0	
Acontiinae 40 +		1	0	0	0	0	0	
Acontiinae 41 +		0	0	0	0	1	0	
Amyna punctum	Fabricius	4	1	0	1	4	0	Euphorbiaceae: Croton tiglium, C. aromaticum. Herb feeder. Lowland to montane (?hill topping)
Cerynea ?contentaria	Walker	1	2	0	1	0	0	Myrtaceae: Syzygium (rose apple borer)
Cerynea ?omphisalis	Walker	0	0	0	0	0	2	
Cerynea flavipuncta	Hampson	0	0	0	0	1	0	
Corgatha ?binotata	Warren	0	0	0	1	0	0	
Corgatha leucosticta	Hampson	0	0	0	0	1	0	
Eublemma quadripunctata	Warren	1	1	1	0	4	0	Congeners on Anacardiaceae: Mangifera, Solanaceae, Nepenthaceae: Nepenthes, Convolvulaceae, Compositae, cocoa. Lowland
Eublemma sp. nr. brachygonia	Hampson	0	0	0	1	0	0	Pinaceae: Pinus caribaea, congeners on Verbenaceae, Leguminosae, Myrtaceae, Sapindaceae, Moraceae, Euphorbiaceae, Bombacaceae
Eublemma versicolora	Walker	0	0	0	1	0	0	Anacardiaceae: Anacardium occidentale, Mangifera, Euphorbiaceae, Bombacaceae: Durio, Sterculiaceae, Leguminosae, Sapindaceae, Myrtaceae
Metamaene atrigutta	Walker	1	0	0	0	4	0	Lowland
Perynea ruficeps	Walker	0	0	1	1	1	0	
Zurobata vacillans	Walker	0	0	1	0	1	0	Fungus, lichen
	sum	10	4	5	8	20	2	
7. Subfamily : Plusiinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Argyrogramma signata	Fabricius	3	0	0	0	0	0	Myrtaceae: Eucalyptus. Disturbed forest
Chrysodeixis illuminata	Robinson	0	0	0	0	1	0	Congener on Leguminosae, Solanaceae, Cruciferae, Malvaceae. Agricultural, open habitats
Plusia' nigriluna	Walker	3	1	1	3	4	0	Euphorbiaceae: Acalypha, Labiatae: Hyptis (mint), Ulmaceae: Trema. Lowlands
	sum	6	1	1	3	5	0	
8. Subfamily : Stictopterinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Lophoptera acuda	Swinhoe	3	1	0	0	10	0	Congeners on Dipterocarpaceae: Shorea. Lowland, alluvial forest to 2000m
Lophoptera cinnamona	Holloway	1	0	0	0	0	0	Lowland, alluvial forest
Lophoptera huma	Swinhoe	0	1	0	2	0	0	Montane, alluvial forest
Lophoptera pallibasis	Holloway	0	1	0	0	1	0	Lowland, alluvial, hill dipterocarp, montane forest
Lophoptera submarginata	Holloway	0	0	0	0	1	0	Montane, kerangas forest
Odontodes seranensis	Prout	0	0	0	0	1	0	Dipterocarpaceae: Shorea robusta. Lowlands to upper montane
Stictoptera repleta	Walker	0	0	0	0	1	0	Congeners on Guttiferae: Garcinia. Lowland, dipterocarp, dry heath, montane forest
	sum	4	3	0	2	14	0	

9. Subfamily : Euteliinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Anigraea phaeopera +	Hampson	0	0	0	0	0	1	Congeners on Anacardiaceae: Anacardium, Burseraceae: Canarium, Fagaceae: Castanopsis. Lowlands
Anigraea serratilinea	Warren	0	0	0	0	1	0	Lowland, dipterocarp, lower montane forest
Atacira chalybsoides +	Holloway	0	0	0	0	1	0	Congener on Moraceae: Ficus, Anacardiaceae: Odina. Lowland rainforest
Penicillaria simplex	Walker	0	0	0	0	0	1	Congeners on Anacardiaceae: Semecarpus, Mangifera, Combretaceae: Terminalia. Montane, lowland, alluvial, kerangas, hill dipterocarp forest
	sum	0	0	0	0	2	2	
10. Subfamily : Nolinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Celama fasciata	Walker	0	0	0	0	1	0	Congeners (incl. flower feeders) on Sapindaceae: Nephelium, Leguminosae: Acacia, Dipterocarpaceae: Dryobalanops, Verbenaceae: Lantana
Nolinae 2		0	0	0	0	1	0	
Nolinae 7 +		0	0	1	0	0	0	
Sarbena lignifera	Walker	0	0	0	0	2	0	
	sum	0	0	1	0	4	0	
11. Subfamily : Sarrothripinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Characoma nilotica	Rogenhofer	0	0	0	0	1	0	Tamaricaceae: Tamarix, Combretaceae: Terminalia, Sterculiaceae: Heritiera, Leguminosae: Cynometra
Garella ?rotundipennis	Walker	0	0	0	0	1	0	Leguminosae: Erythrina, Sterculiaceae: Helicteres, Combretaceae: Terminalia, Guttiferae: Calophyllum. Lowland
Gyrtothripa pusilla	Moore	0	0	0	0	1	0	Myrtaceae: Melaleuca cajuputi, Sterculiaceae: Heritiera (flower feeder). Lowland, lower montane
Risoba sp. 2		0	0	0	1	2	0	Congeners on Lythraceae: Lagerstroemia flos-reginae, Combretaceae: Quisqualis, Annonaceae: Xylia, Melastomataceae: Melastoma, Osbeckia
Risoba sp. 4		0	0	0	0	1	0	
Sarrothripinae 4 #		0	0	0	0	0	1	
Sarrothripinae no. 10684*		0	0	0	0	0	1	
Selepa discigera	Walker	0	0	0	0	0	1	Combretaceae: Terminalia, Euphorbiaceae: Euphorbia, Loranthaceae: Loranthus, Anacardiaceae: Anacardium occidentale
Selepa nigralba	Hampson	0	0	0	0	1	0	Lowland
Tathothripa continua	Walker	0	0	0	0	0	2	Lowland to montane
	sum	0	0	0	1	7	5	
12. Subfamily : Chloephorinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Aiteta damnipennis	Walker	0	1	0	0	0	0	Congener on Combretaceae: Terminalia
Carea ?effusa	Swinhoe	0	0	1	0	3	0	Congeners on Myrtaceae: Cleistocalyx, Syzygium, Eugenia, Eucalyptus, Moraceae: Ficus, Melastomataceae: Memecylon, Bombacaceae: Bombax
Carea metaphaea	Hampson	0	0	1	0	1	3	Lowland, lower montane
Carea nexilla	Hampson	0	0	0	0	2	4	
Chloephorinae 3 #		0	0	0	0	0	2	
Chloroplaga nygmia	Swinhoe	0	0	0	0	1	0	Lowland to montane
Cossedia hyriodes	Hampson	0	0	0	1	0	0	
Didigua ?effusa	Swinhoe	0	0	0	0	1	0	Lowland
Didigua cineracea	Holloway	0	0	0	0	1	0	Lowland
Didigua vexilla	Swinhoe	0	0	1	0	0	0	?Lower montane
Didigua viridifascia	Swinhoe	0	0	0	0	1	0	

		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Negeta ?sublineata	Walker	0	0	0	0	0	1	
Negeta signata	Walker	0	0	0	1	2	0	Lowland
Siglophora bella	Butler	0	0	0	0	0	1	Lowland
	sum	0	1	3	2	12	11	
13. Subfamily : Amphipyrinae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Athetis bipuncta	Snellen	10	0	2	2	26	11	Lowlands to montane, open habitats
Athetis nonagrica	Walker	0	0	0	0	1	0	Montane, lowlands, open habitats
Athetis reclusa	Walker	1	1	0	0	0	0	Cruciferae: Brassica. Lowlands to 1200m, open habitats
Athetis thoracica	Butler	0	0	0	0	1	0	Wide range incl. Gramineae, Leguminosae, Convolvulaceae: Ipomoea, Myrtaceae, Solanaceae, Theaceae, Portulaceae, Commelinaceae
Callopistria emiliusalis	Walker	1	1	1	0	4	1	Disturbed, open habitats
Callopistria maillardi	Guenee	3	2	0	0	11	0	Davalliaceae: Nephrolepis, Adiantaceae: Adiantum, Pellaea, Schizaeaceae: Lygodium, Piperaceae: Piper
Callopistria thalpophiloides	Walker	0	0	0	0	0	1	Lowland, montane forest
Condica illecta	Walker	1	0	0	0	4	0	Compositae: Ageratum, Bidens, Carthamus, Coreopsis, Dahlia, Dichrocephala, Acanthaceae. Open habitats, up to 2000m
Dipterygina dorsipallens	Holloway	0	0	1	0	2	0	Congeners on Verbenaceae: Callicarpa. Lowland, montane forest
Dipterygina vagivitta	Walker	5	0	0	1	6	5	Lowlands to 1200m
Iambia lyricalis	Holloway	0	0	0	0	0	2	Congener on Rhamnaceae: Zizyphus. Lowland forest
Iambia tessellata	Prout	0	0	0	0	0	3	Lowland, montane forest
Prometopus asahina #	Kobes	0	0	0	0	0	1	Congener on conifer. Lowland rainforest, dry heath forest
Spodoptera mauritia	Boisduval	0	0	0	0	0	1	Wide range incl. Gramineae (rice), Compositae. Lowland, open, cultivated, disturbed areas
	sum	21	4	4	3	55	25	
14. Subfamily : Hadeninae								
		No. of individuals captured . Two replicates per site (7-8pm on different nights)						
Species	Authority	T1	T2	T3	T4	T5	DV	Recorded host plants/habitat preference
Elusa ceneusalis	Walker	7	1	5	4	7	3	Lowland, undisturbed, secondary forest
Elusa penanorum	Holloway	0	0	0	0	0	1	Lowland, swamp, alluvial, hill dipterocarp forest
Mythimna decississima	Walker	0	0	0	1	1	0	Congeners on Gramineae. Lowland, open, secondary vegetation
Tiracola plagiata	Walker	4	0	3	4	9	0	Wide range incl. Euphorbiaceae (cassava), Leguminosae, Verbenaceae, Compositae, Rubiaceae, Sterculiaceae, Zingiberaceae, Piperaceae
	sum	11	1	8	9	17	4	
	Total N	176	149	144	162	402	253	
	Total S	72	76	80	80	168	129	
# Species collected at Danum Valley only								
+ Species not collected at Brumas in 1991								
* Refers to slide number in the Natural History Museum in London Prepared by J.D.Holloway								
** Refers to series in J.D.Holloway's collection in the Natural History Museum								

Appendix V. Some of the macromoths reared from the plantation sites. All scales in mm

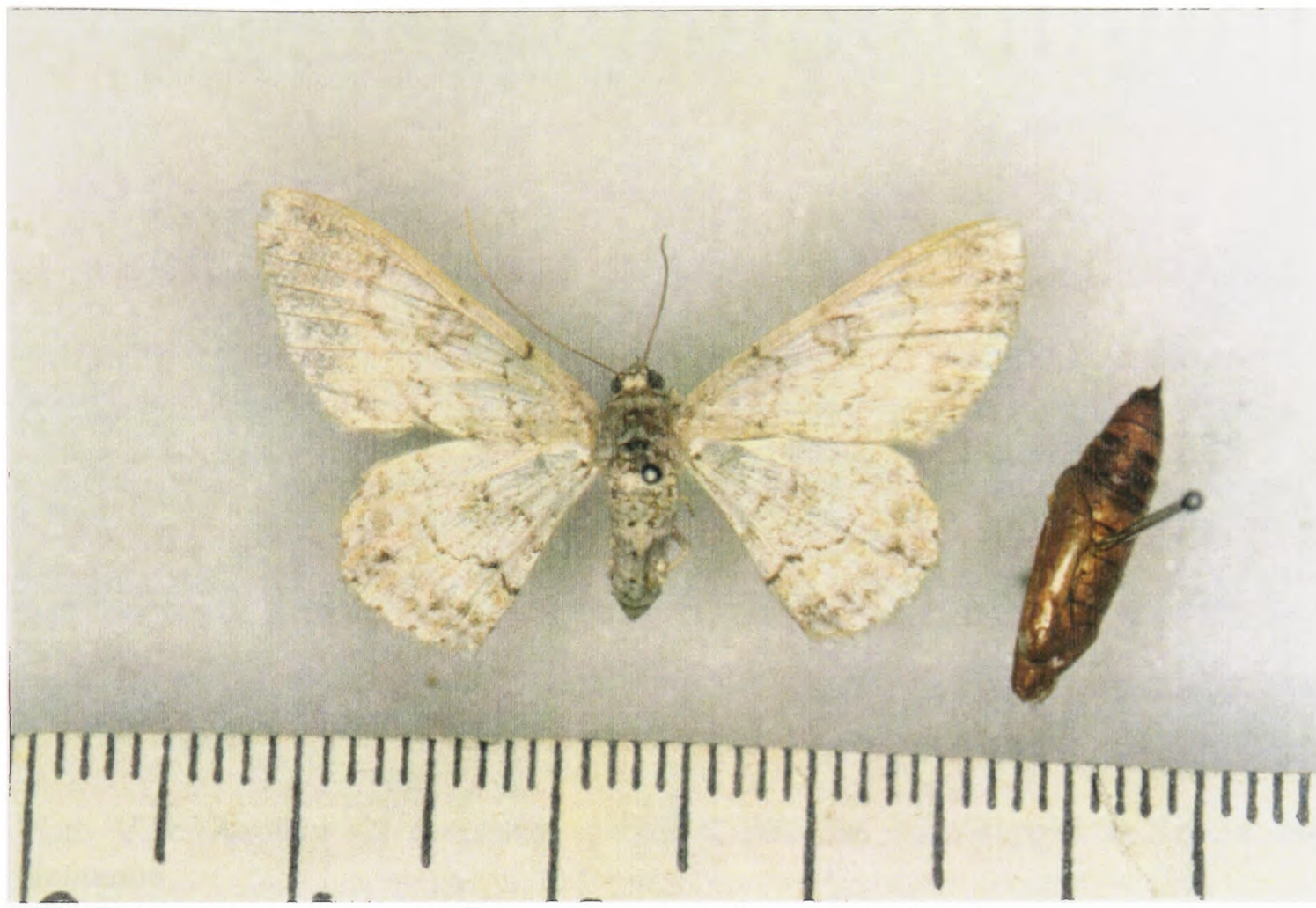

Plate V.1a *Cleora decisaria* Walker (Geometridae: Ennominae)
Ground colour whitish with brown markings, median fasciae conspicuous

Plate V.1b Larva (25mm long) of *C. decisaria*. Robust, apple green in colour tinged with yellow. Probably a legume generalist, pictured here feeding on leaflets of *Paraserianthes falcataria*.
Pupal stage *ca*. 7 days

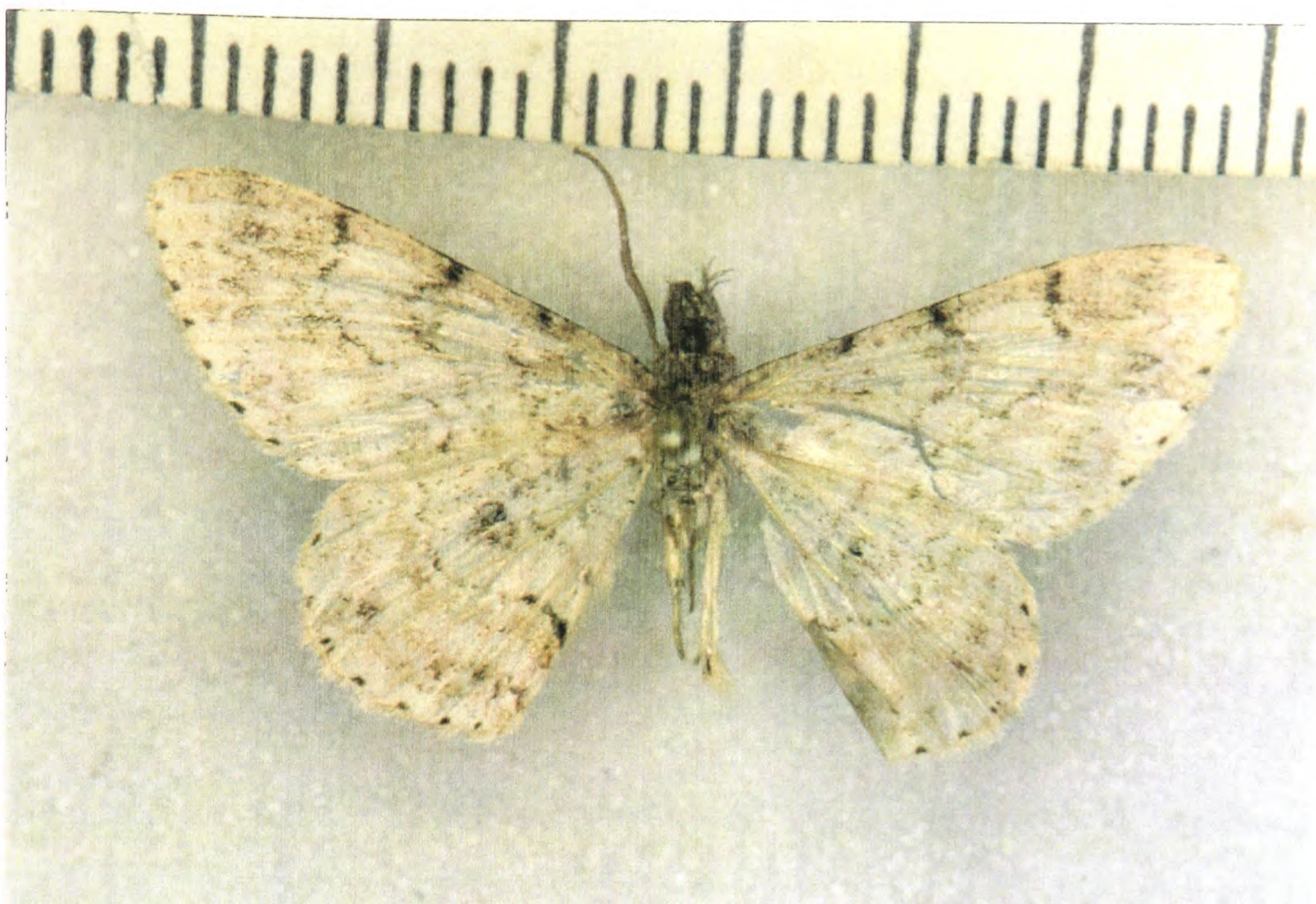

Plate V.1c Another *C. decisaria* specimen, this one light-trapped at *Acacia mangium* plantation

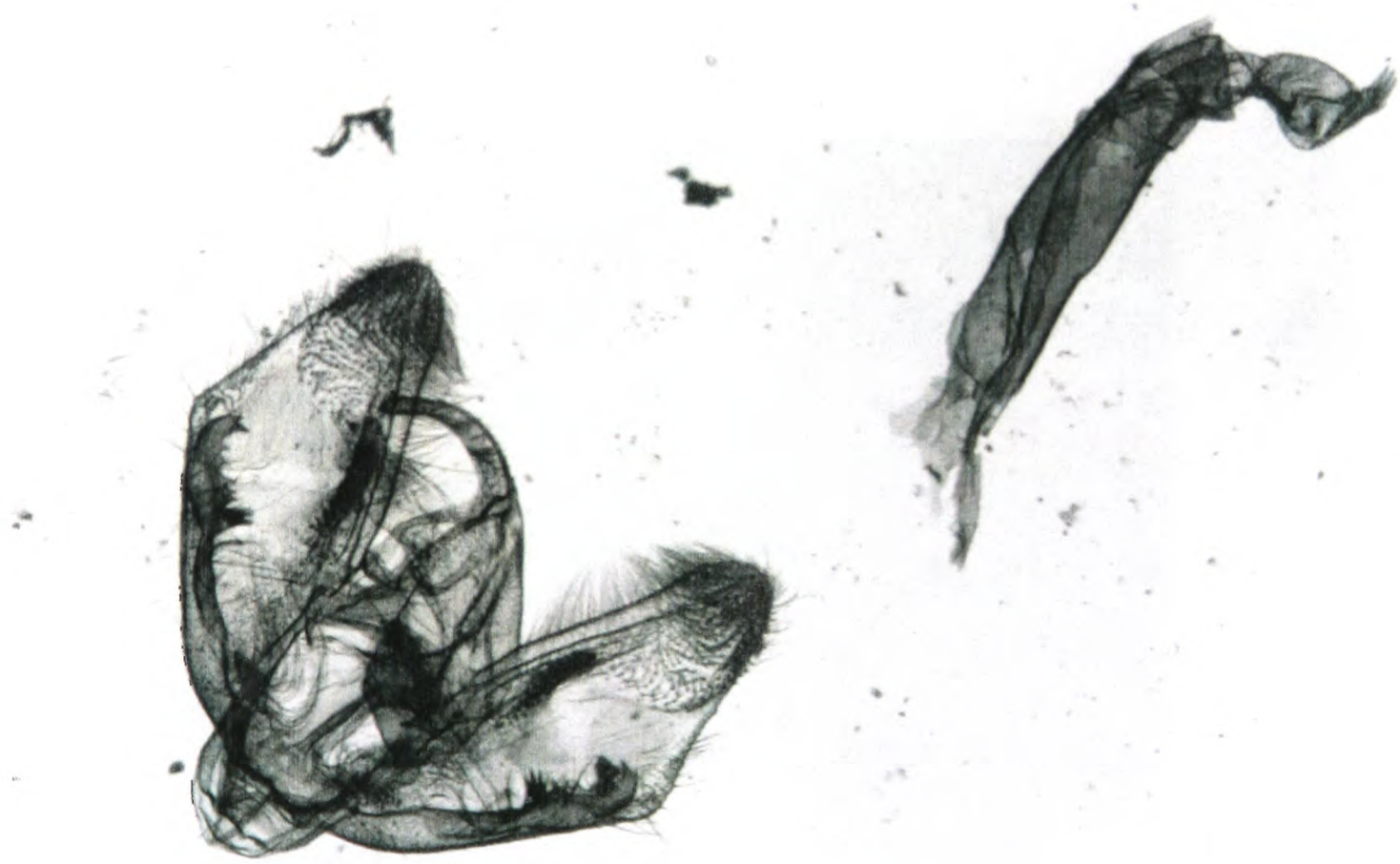

Plate V.1d Male genitalia of *C. decisaria*.
Valve with spiny sacculus, ampulla cylindrical and finely scobinated.
Aedeagus vesica with distinctive cornuti at tip.

Plate V.2a *Godonela translineata* Walker (Geometridae: Ennominae)
Submarginal area with broad brown band, forewing postmedial with acute angle below costa

Plate V.2b Larva (20mm long) of *G. translineata* feeding on *Paraserianthes falcataria* leaflets. Greenish with yellow lateral stripe.
Pupal stage *ca.* 8 days.

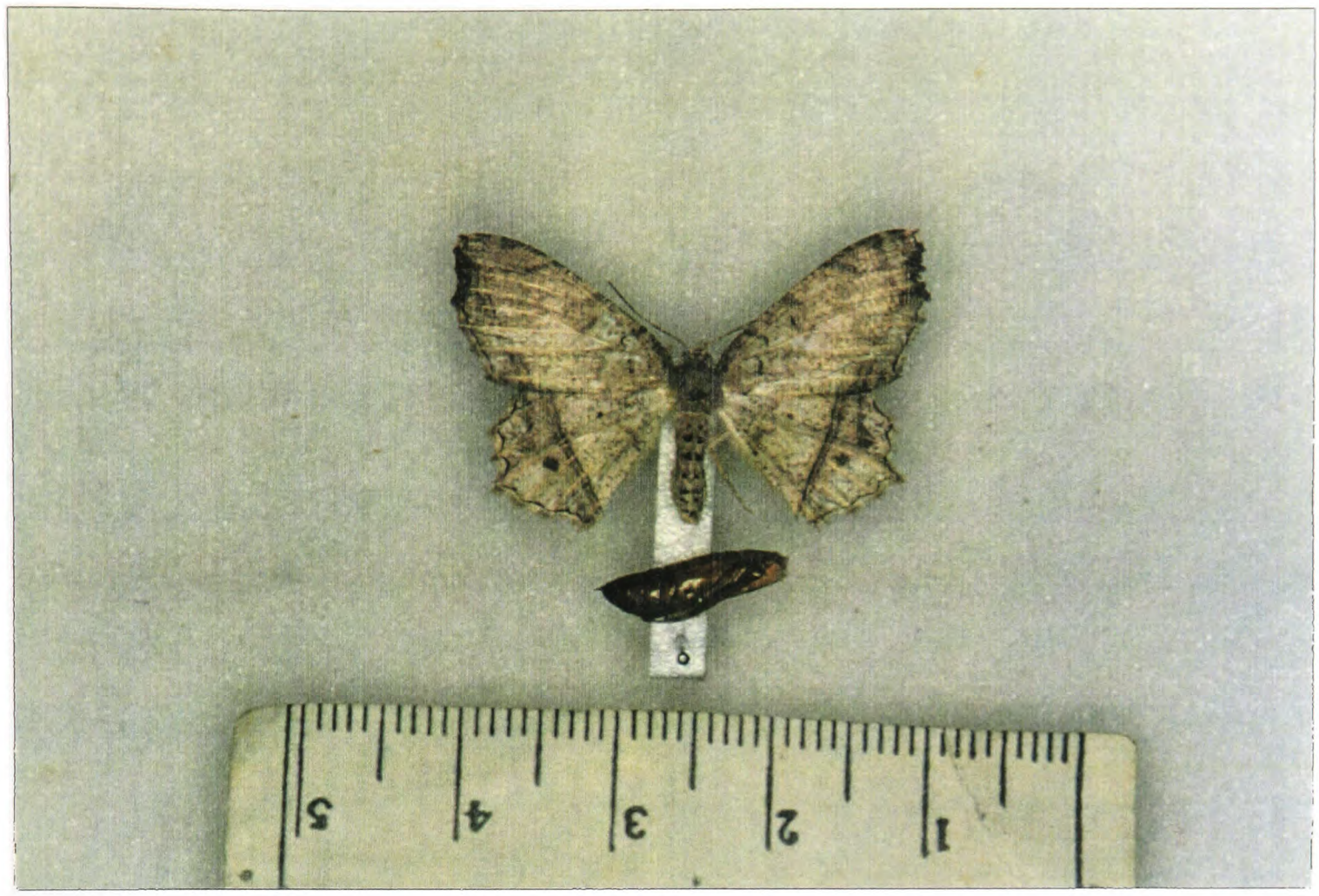

Plate V.3a *Godonela ozararia* Walker (Geometridae: Ennominae)
Forewing postmedial close to margin

Plate V.3b Larva (25mm long) of *G. ozararia*, *Acacia mangium* defoliator. Body covered with black spots, head capsule and caudal region orange.
Pupal stage *ca*. 8 days.

Plate V.4a *Hyposidra talaca* Walker (Geometridae: Ennominae)
Wings dark greyish brown, forewing falcate

Plate V.4b Larva (25mm long) of *H. talaca*. Greyish green, turning darker with later instars.
Highly polyphagous (see Appendix I).
Pupal stage *ca*. 7 days.

Plate V.5a *Biston pustulata* Warren (Geometridae: Ennominae)
Bright creamy yellow, with weakly marked fasciae

Plate V.5b Larva (50mm long) of *B. pustulata*, *Acacia mangium* defoliator. Body pale greyish green. Head capsule rugous, with a 'v' sign on its front. Abdominal segment 8 (A8) with dense, dark markings dorsally.
Pupal stage *ca.* 16 days.

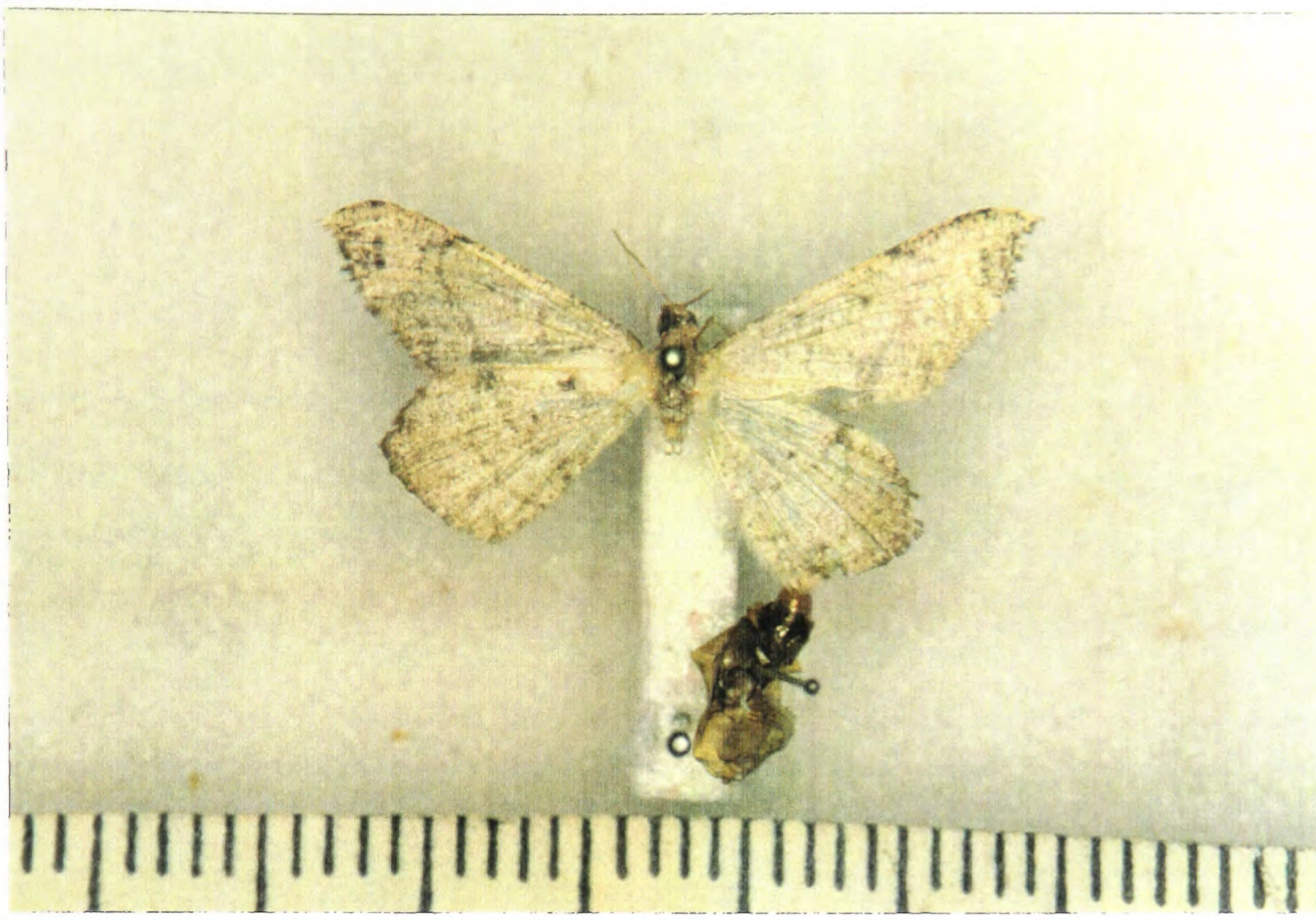

Plate V.6a *Ozola ?minor* Moore. Male. (Geometridae: Oenochrominae)
Male paler, yellow brown in colour. Median fasciae more conspicuous

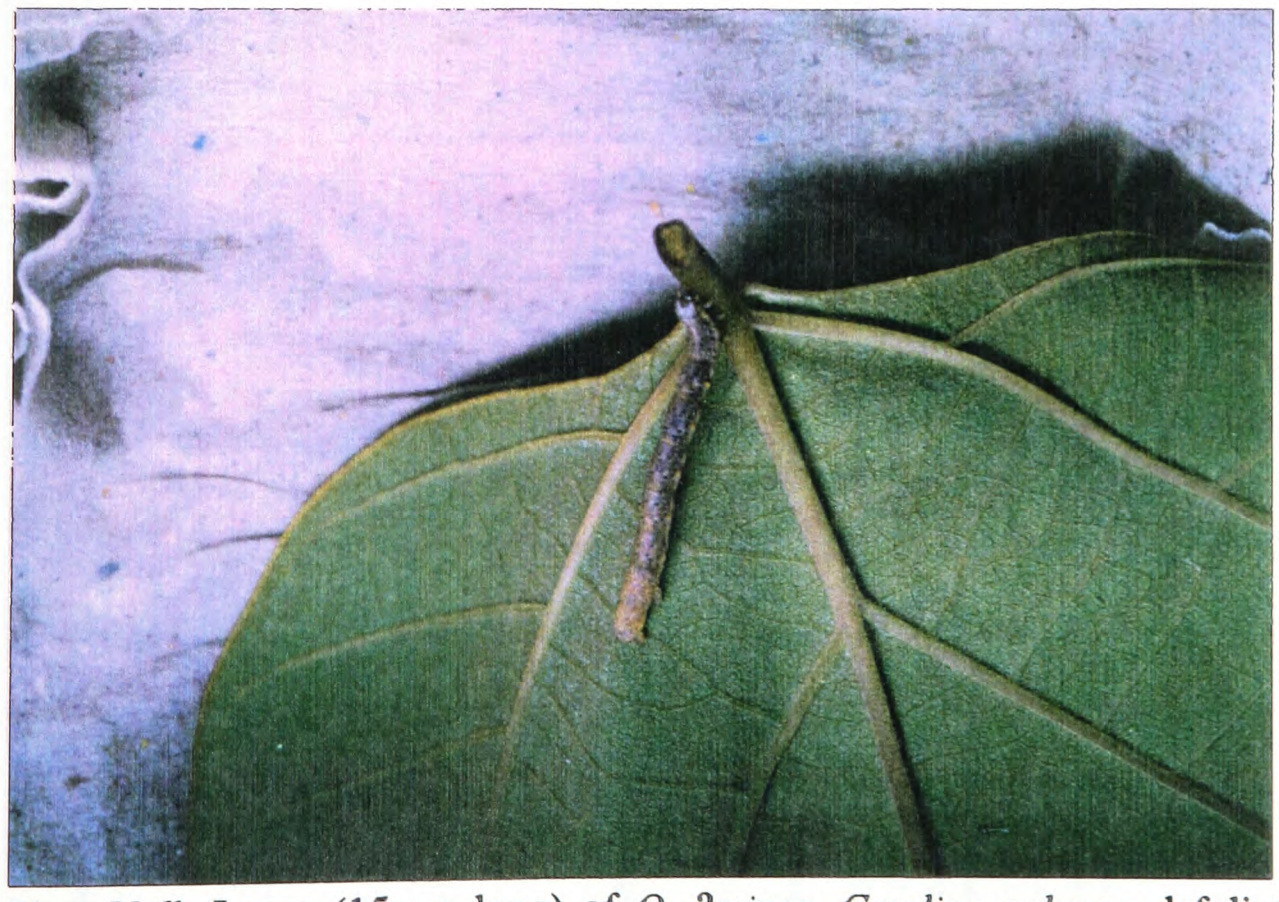

Plate V.6b Larva (15mm long) of *O. ?minor*, *Gmelina arborea* defoliatior. Body slender, greyish brown, pale ventrally.
Pupal stage 5-7 days.

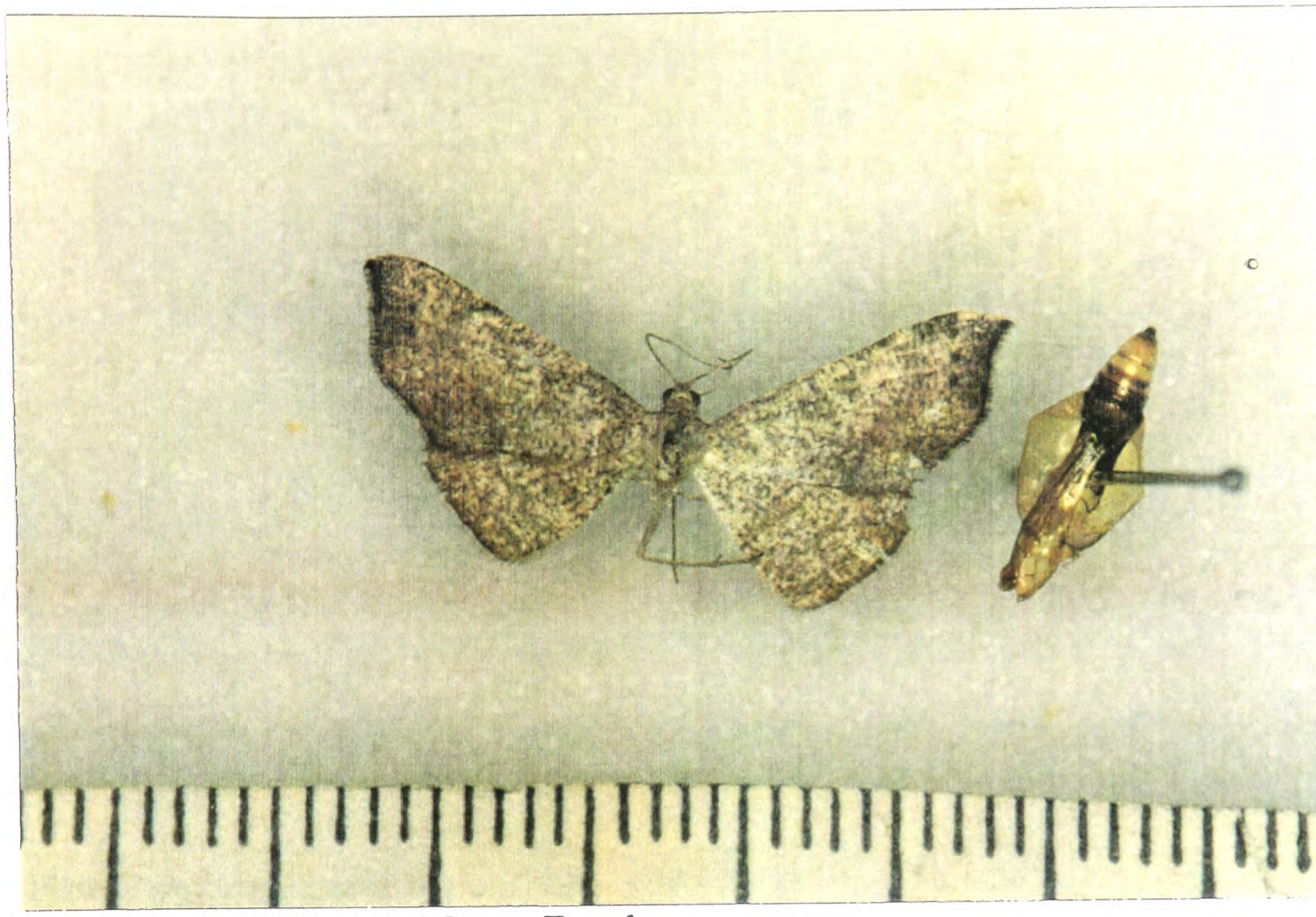

Plate V.6c *Ozola ?minor* Moore. Female

Female darker

Plate V.6d A darkly coloured female of *O. ?minor*

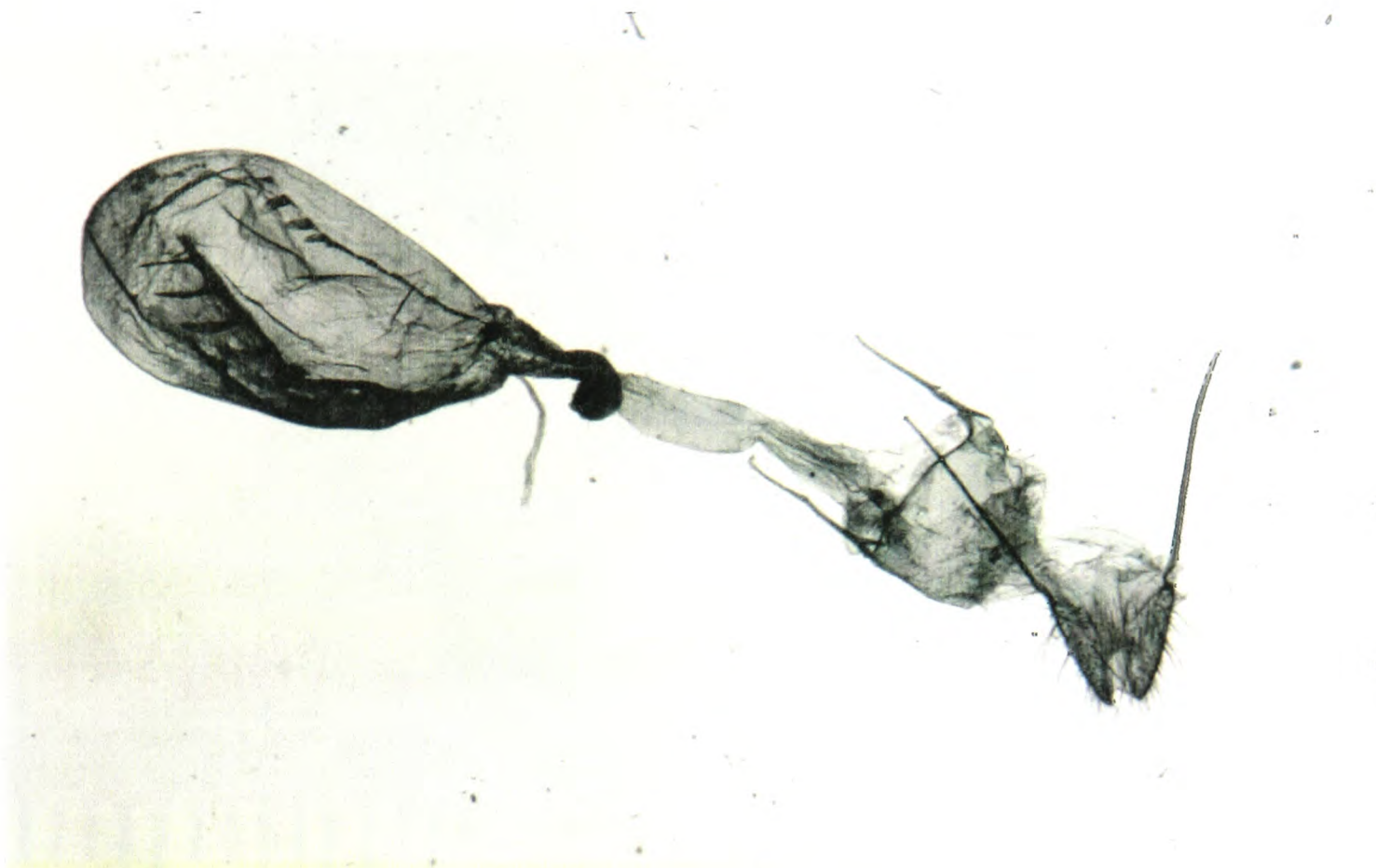

Plate V.6e Female genitalia of *O.* ? *minor*
Bursa copulatrix with two rows of spines

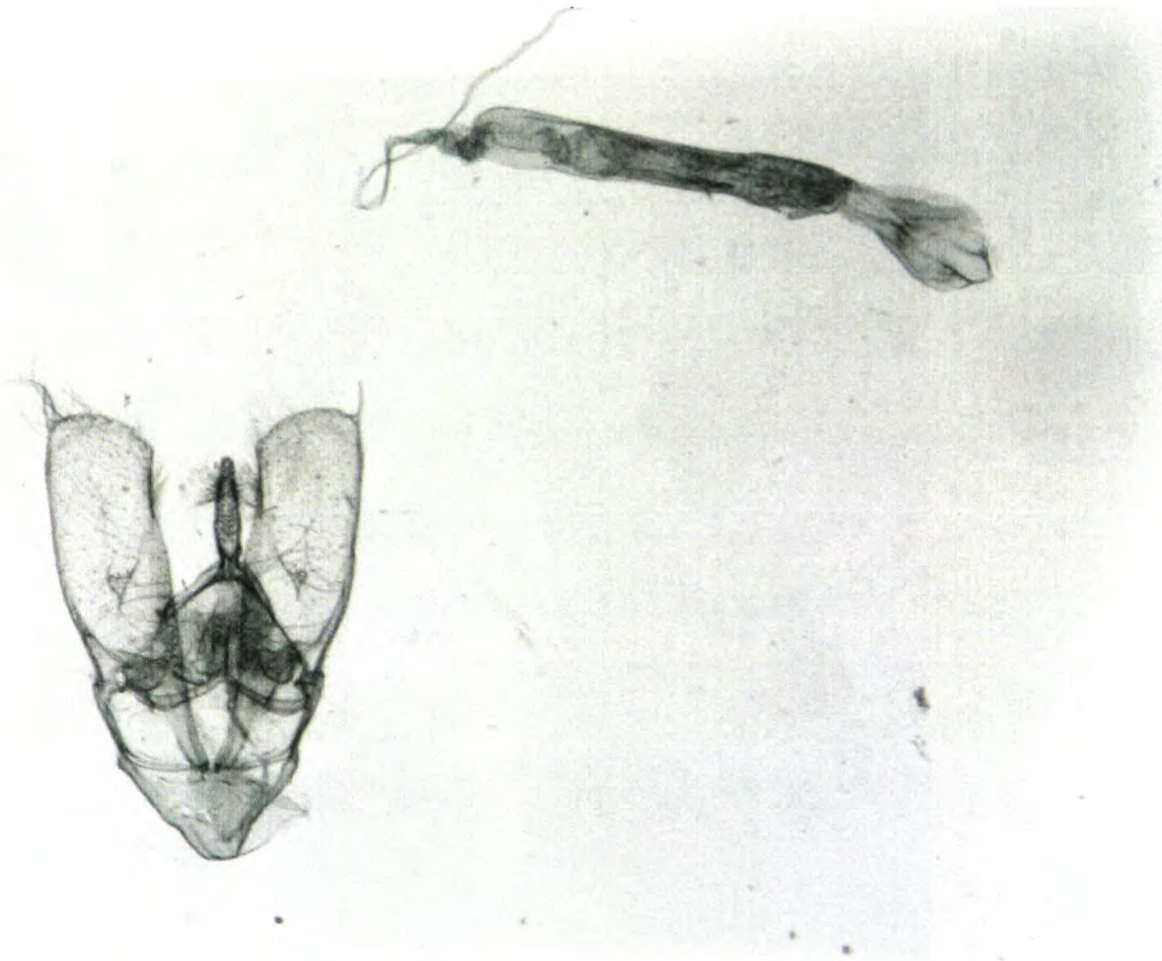

Plate V.6f Male genitalia of *O.* ?*minor*
Valve with an apical spine, ampulla nipple-like.
Aedeagus vesica diamond-shaped

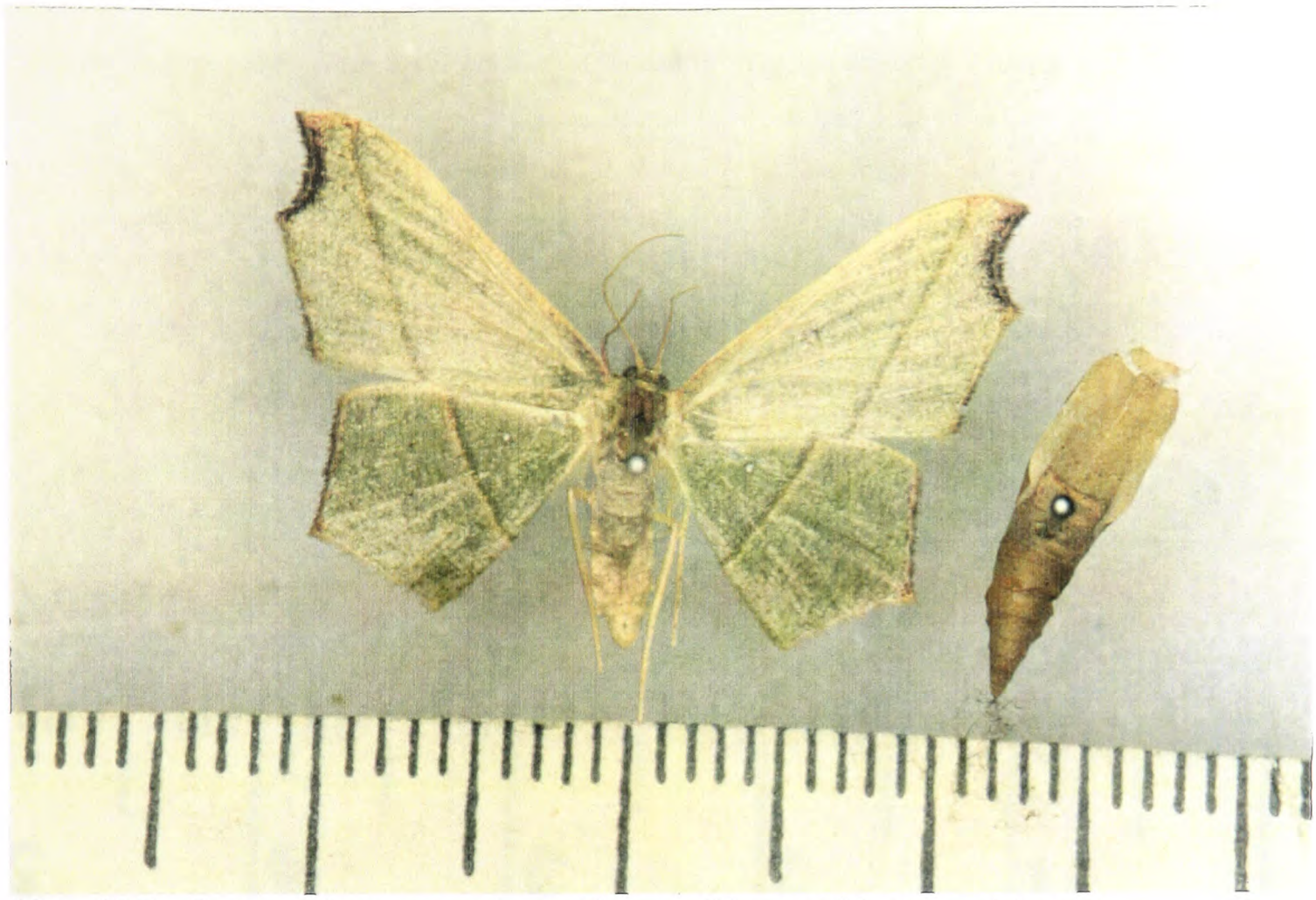

Plate V.7a *Gnamptoloma aventiaria* Guenee (Geometridae: Sterrhinae)
Pale greenish yellow, forewing falcate with brown margin. Postmedial strong, oblique

Plate V.7b Larva of *G. aventiaria* nearing pupation. *Paraserianthes falcataria* defoliator.
Body yellowish green, mid-abdomen with a pair of horns dorsolaterally. Mature larva 20mm long.
Pupal stage *ca*. 6 days.

Plate V.8a *Dinumma ?combusta* Walker (Noctuidae: Ophiderinae)
Forewing chocolate brown with a pair of prominent fasciae

Plate V.8b Larva (33mm long) of *D. ?combusta*, *Paraserianthes falcataria* defoliator.
Body looper-like, wiry, apple green with faint yellow stripes.
Pupal stage *ca.* 7 days.

Plate V.9a *Felinia spissa* Guenee (Noctuidae: Ophiderinae)
Forewing basally darker brown, with a triangular patch near apex

Plate V. 9b Larva (45mm long) of *F. spissa*. *Paraserianthes falcataria* defoliator.
Body brownish, with fine reticulate markings, and rows of small tubercles.
Pupal stage *ca*. 14 days.

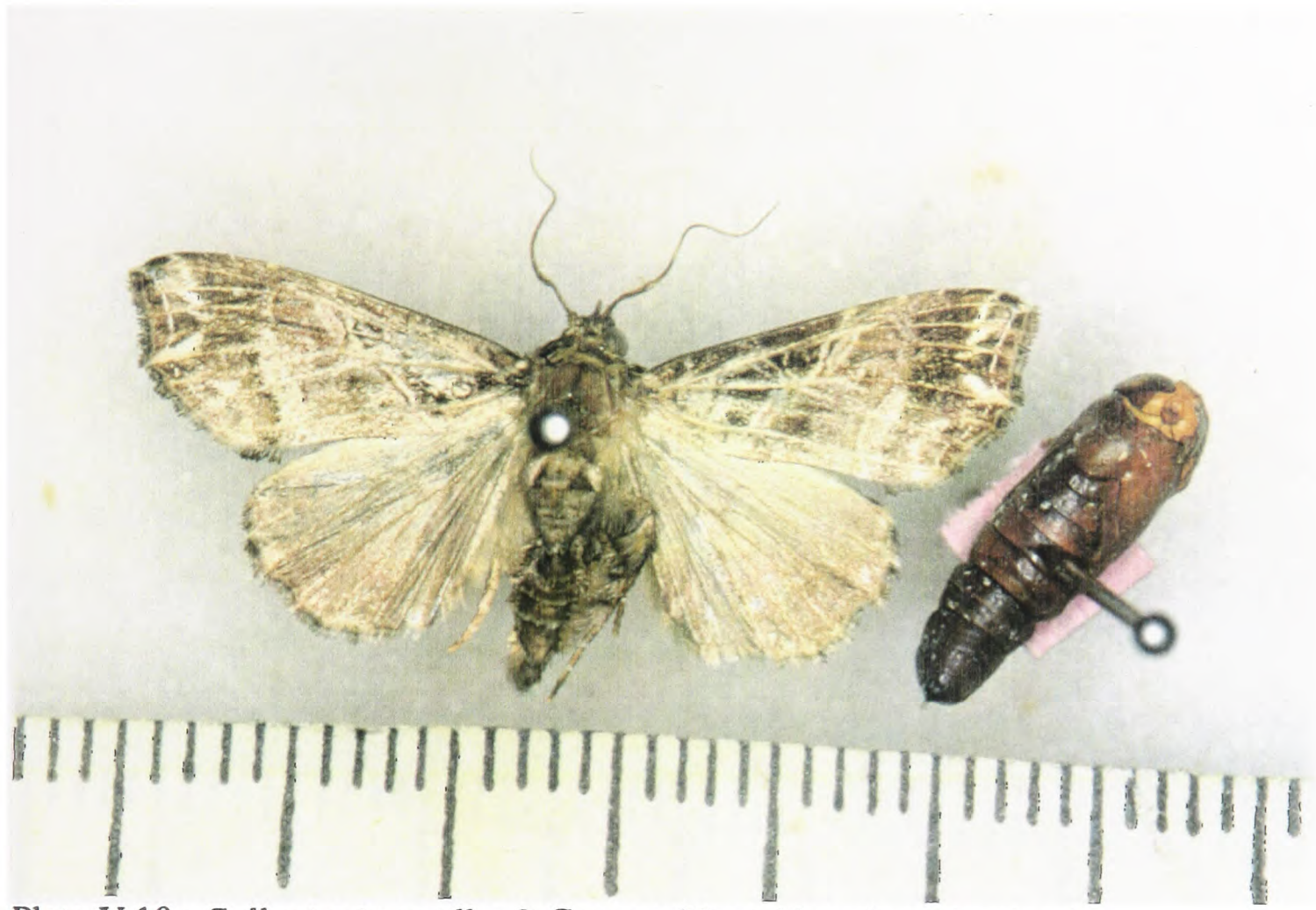

Plate V.10a *Callopistria maillardi* Guenee (Noctuidae: Amphipyrinae)
Forewing apical white crenulate marking separated from postmedial

Plate V.10b Larva (20mm long) of *C. maillardi* on *Piper* sp., in understorey of *Acacia mangium* plantation. Earlier instar pinkish, turning green later.
Pupal stage *ca.* 12 days.

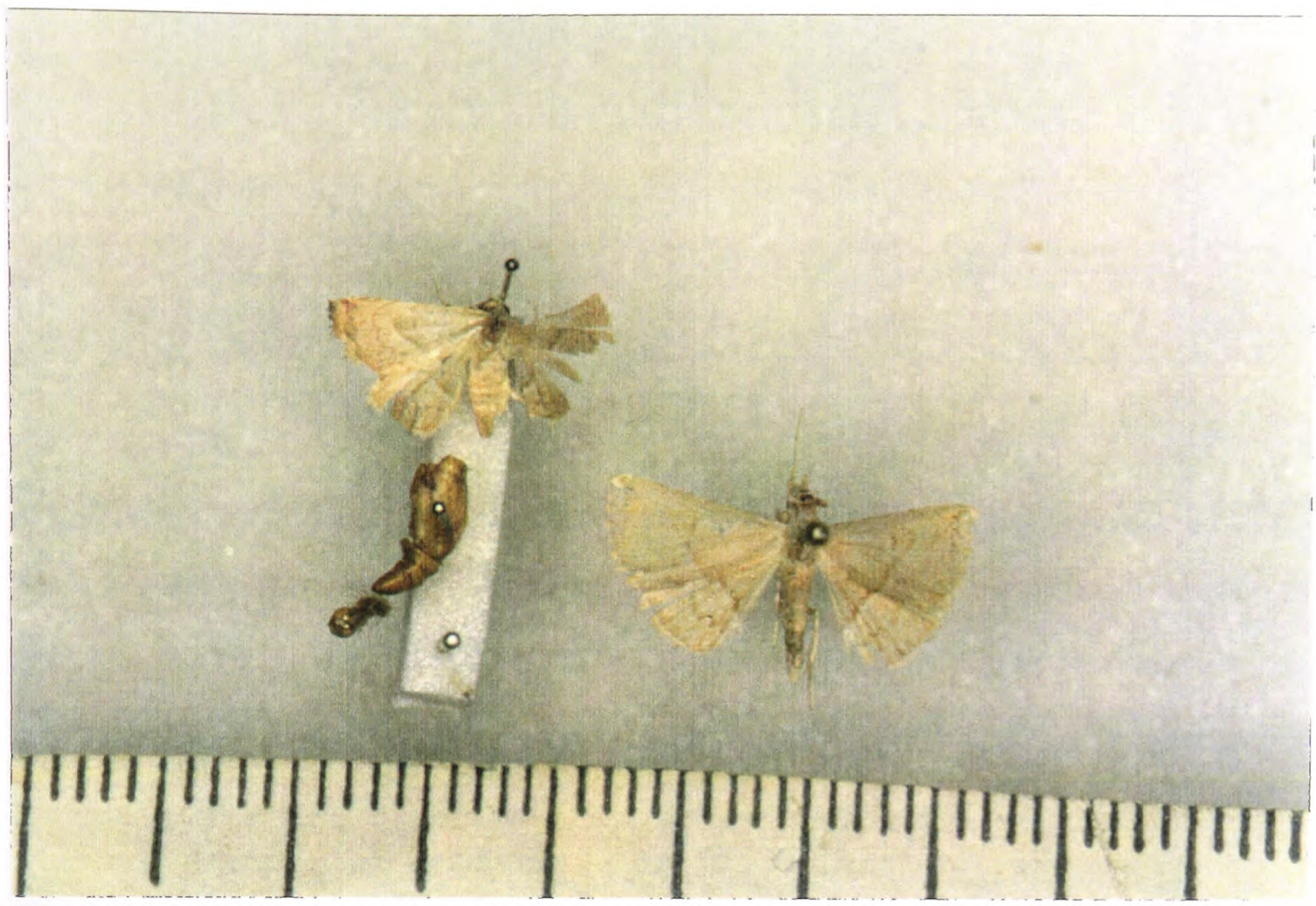

Plate V.11a *Eublemma* sp. nr. *brachygonia* Hampson (Noctuidae: Acontiinae)
Yellowish, with darker median fasciae (left: reared; right: light-trapped)

Plate V.11b Larva (8mm long) of *E.* sp. nr. *brachygonia* feeding on flowers of *Pinus caribaea*. Body light honey brown, with a pale stripe dorsocentrally.
Pupates on flower spike.

Plate V.12a *Lymantria brunneiplaga* Swinhoe (Lymantriidae)
Whitish with dark crenulate fasciae. Abdomen reddish

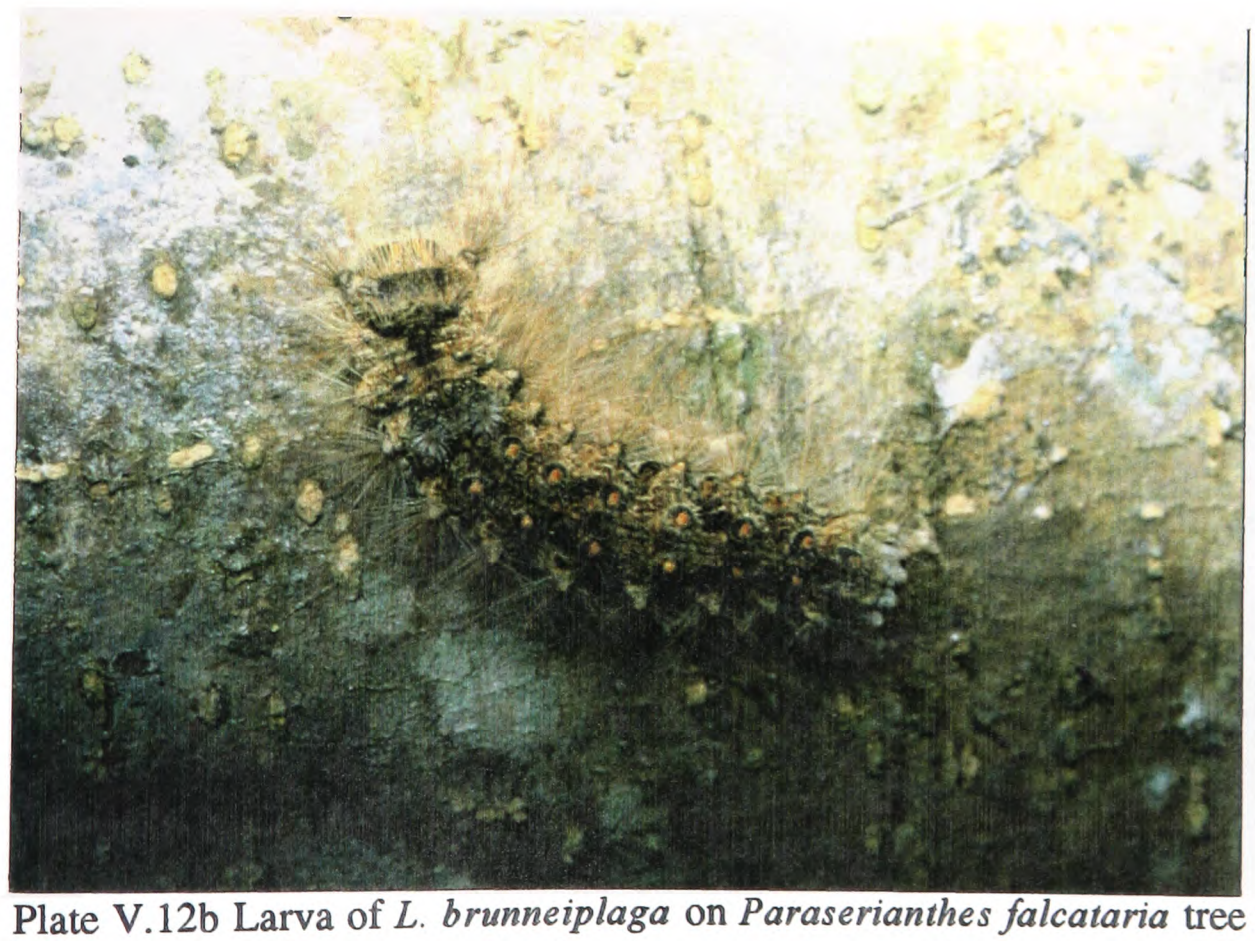

Plate V.12b Larva of *L. brunneiplaga* on *Paraserianthes falcataria* tree trunk. Body mottled with black, white, brown, bearing long setae on rows of verrucae. Mature larva *ca*. 30mm long, often gregarious.
Pupal stage 8-9 days.

Plate V. 13a ?*Dasychira* sp. (Lymantriidae)
Forewing light grey brown, with crenulate markings

Plate V.13b Tufted caterpillar of ?*Dasychira* sp. (35mm long), *Acacia mangium* defoliator. Head capsule reddish, with a pair of long black tufts. Body ornamented with golden orange setae on verrucae.
Pupal stage *ca*. 7 days.

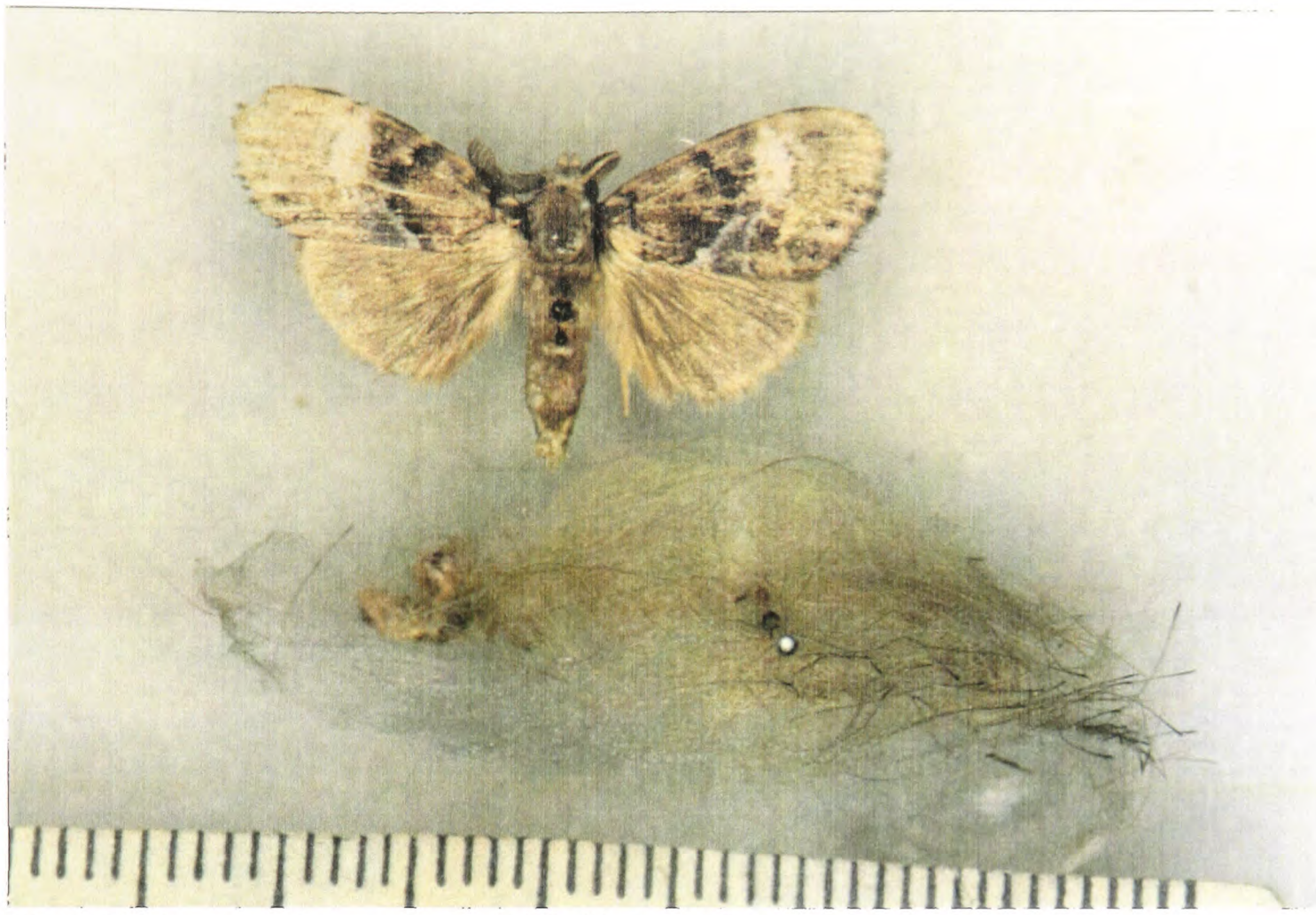

Plate V.14a *Dasychira* sp. no. 1759 (Lymantriidae)
Brownish, forewing basally darker, with a whitish stigma near postmedial

Plate V.14b Tufted caterpillar (25mm long) of above species, *Acacia mangium* defoliator.
Body blackish, covered with long setae, head reddish.
Pupal stage *ca*. 7 days.

Plate V.15a *Euproctis ?limbata* Butler (Lymantriidae)
Light brown, forewing with three yellow spots on margin, hindwing with yellow margin

Plate V.15b Larva (20mm long) of *E. ?limbata*, *Paraserianthes falcataria* defoliator. Body blackish, with a dorsal yellow stripe and a red line in middle, covered with setae on verrucae. Pupal stage *ca.* 10 days.

Plate V.16a *Psilogramma menephron* Cramer (Sphingidae)
Greyish brown, forewing fasciae weak, with faint crenulate markings

Plate V.16b Sphinx caterpillar (60mm long) of *P. menephron*, *Gmelina arborea* defoliator.
Body leaf green, abdomen with oblique yellow markings, with a dark tuberculate horn on A8, spiracles chocolate brown.
Pupal stage 15-18 days.

Appendix VI. A new species collected using light-trap at *Pinus caribaea* plantation, Brumas, on 13 June 1991. The species, *Nigriblephara cheyi*, was named after the author by J.D.Holloway (1993).

Plate VI.1 *Nigriblephara cheyi* Holloway. Male. Scale in mm
(Family: Geometridae, Subfamily: Ennominae, Tribe: Boarmiini)
Rich brown in colour, medial area slightly paler

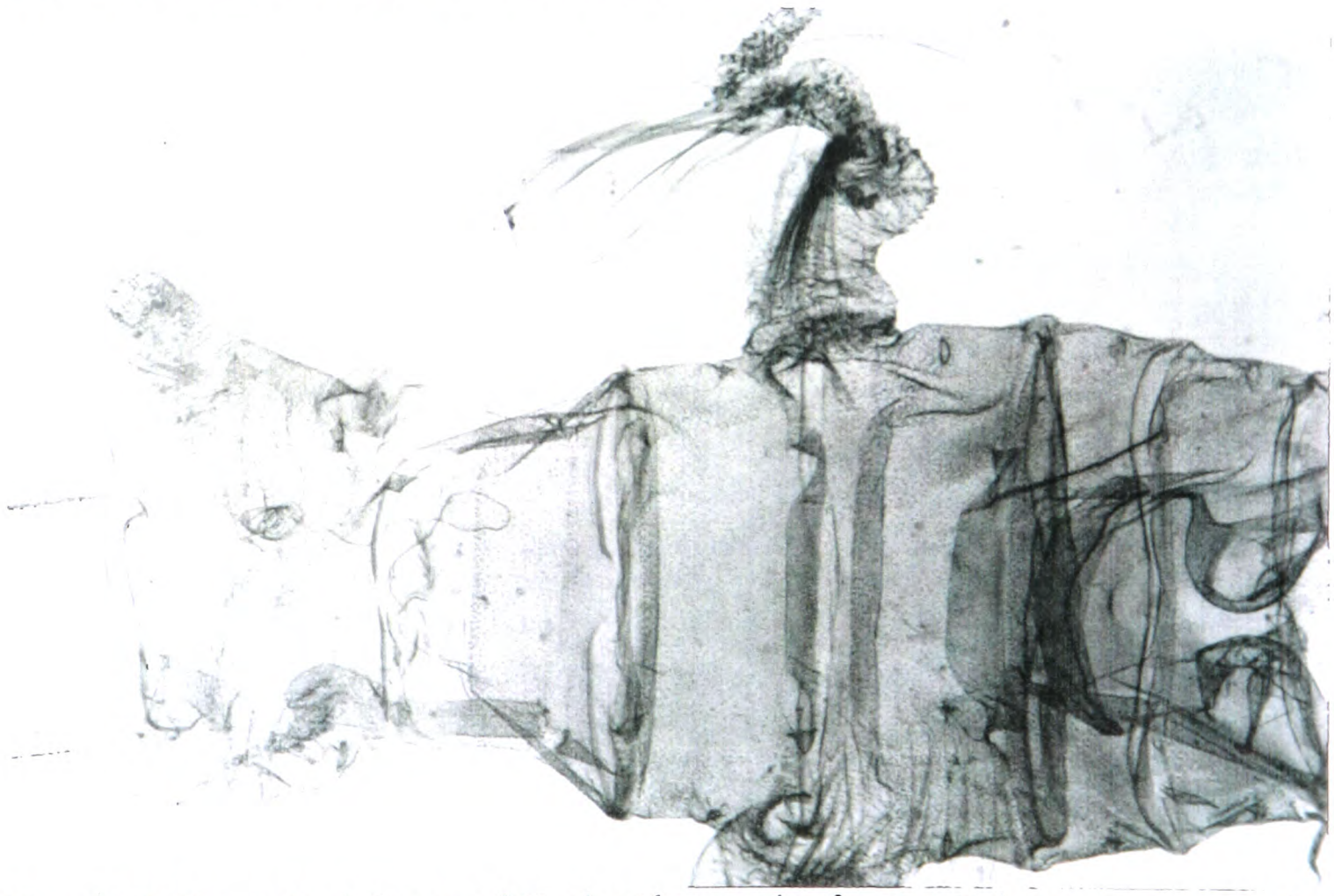

Plate VI.2 The male abdomen of *N. cheyi* has a pair of coremata between segments 4 and 5, and another pair of corematous structures on segment 7

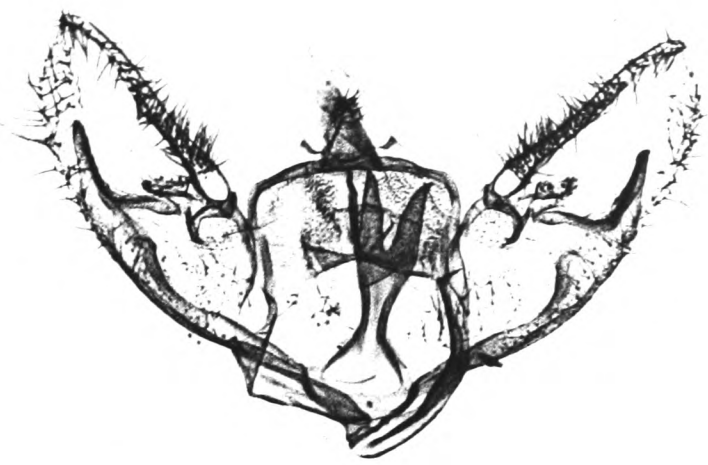

Plate VI.3 Male genitalia of *N. cheyi* with valves spread open.
A small spined lobe present subcostally. Juxta uniquely bifid

Plate VI.4 Aedeagus of *N. cheyi.*
Vesica large and irregular, with a subbasal sclerotised lobe