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INSECT BIODIVERSITY IN DISTURBED AND UNDISTERBED FORESTS IN THE KERALA PARTS OF WESTERN GHATS

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ABSTRACT

Impact of forest disturbance on insect species diversity was studied at four locations *viz*.. Silent Valley, Nelliyampathy. Sholayar and Parambikulam in the Kerala part of Western Ghats. Incidence of Are (Silent Valley), plantation programmes (Nelliyampathyand Parambikulam) as well as forest cutting for fodder and firewood (Sholayar) were the major disturbances. Of the four areas covered in this study, Silent Valley showed the highest plant diversity (3.90) followed by Nelliyampathy (3.26). Sholayar (3.13) and Parambikulam (2.67). The overall values of insect diversity was found to be the highest for Nelliyampathy (5.13) followed by Silent Valley (4.83). Sholayar (4.74) and Parambikulam (4.50). Forest disturbance had an adverse effect on insect diversity as indicated by the reduction in the diversity indices obtained for the disturbed sites. The values were 4.76 (undisturbed area) and 4.65 (disturbed area) for Silent Valley; 5.21 (undisturbed area) and 3.91 (disturbed area) for Nelliyampathy; 4.79 (undisturbed area) and 3.13 (disturbed area) for Sholayar and 4.64 (undisturbed area) and 3.99 (disturbed area) for Parambikulam.

Altogether 1250 species of insects belonging to 15 Orders were collected from all localities, of which 586 species have been identified Maximum number of species collected belonged to the Orders Lepidoptera and Coleoptera. The lepidopteran families, Pyralidae, Noctuidae and Geometridae and the coleopteran families, Chrysomelidae. Cerambycidae and Tenebrionidae were the most dominant. Based on the collector's curve and distribution models (lognormal distribution), it was concluded that all the areas contain more species than could be collected in this study, indicating the need for further investigations. Similarity index calculated for the various locations indicated that there was considerable difference between the locations and that each area was specialised with respect to its faunal elements.

Based on the extent and nature of disturbance. site specific conservation strategies are essential for protecting the biodiversity in the study areas. Accordingly, strategies involving fire protection (at Silent Valley); raising of fuelwood plantations and pasture areas (at Sholayar) as well as favouring recolonisation of altered habitats (at Nelliyampathy and Parambikulam) were suggested to reduce the impact of disturbance on biodiversity in these areas.

Key words: *Insect dwersity, tropical forests, Western Ghats. Kerala, India.*

1. GENERAL INTRODUCTION

Biodiversity is the bandwagon of this century and a lot of discussions are going on throughout the world on the conservation and sustainable use of natural resources. This is mainly due to the fear that the rapid alteration of the earth's environment may lead to a loss of stability of the ecosystems which will be detrimental to the survival of mankind in this universe (IGBP, 1990).

Diversity is a fundamental property of every living system. The term biodiversity has been defined as the variety and variability among living organisms and the ecological complexes in which they occur. Thus, biological diversity includes all species of plants, animals and micro-organisms and the ecosystems of which they are part. Usually biodiversity is considered at 3 levels - genetic diversity. species diversity and ecosystem diversity.

Genetic diversity covers genetic variation, life history traits, population dynamics etc.. of organisms. The amount of genetic variation within species also determines its potential for subsequent evolutionary change. As all genetic diversity utlimately arises at the molecular level and is the product of pleiotropic and epistatic interactions. it is a resource which cannot be replaced. Species and ecosystem diversity are dependant on the changes in the chemical and physical environment and human induced transformations of the earth's features (Solbrig, 1991).

In addition to the compositional diversity covering genes, species and habitats as discussed above. there are also other aspects of diversity such as the functional diversity covering ecological processes (pollination, dispersal etc.) and structural diversity covering distribution of diversity in space and time (vertical stratification in tropical forests, relative abundance of species, age structure of populations etc.).

All biodiversity that we find on earth are the products of several million years of evolution. Creation and extinction are two aspects of life. It has been stated that during the more than 3.5 billion year history of life, the average longevity of a species has ranged from less than a million years for some groups of mammals to about 10 million years for certain invertebrates and flowering plants (Wilson and Peter, 1992). The interaction of various species among themselves and with the environment has led to an increase in the diversity of species over years. In addition to this, there are also various evolutionary pathways which produce a vast array of species and ecosystems. On the

contrary, various catastrophies like drastic changes in climate brought about by continental drift, massive volcanic eruptions or asteroid impacts have caused mass extinction of life on various parts of the globe. The fossil records indicate that at least five major episodes leading to mass extinction of life have occurred during the past 450 million years ie., during Ordovician, Devonian, Permian, Triassic and late Cretaceous periods. Nearly 25-50% of biological groups were estimated to be wiped out during these periods (Raup, 1988).

It is stated that the sixth period of extinction is currently underway and the cause is not due to any of the reasons discussed earlier, but due to the rapid environmental changes brought about by human beings themselves. Over one third of the world's forests, major part of freshwater lakes. rivers, seas and most of the grasslands have been either destroyed or altered affecting all life existing in these habitats.

Importance of biodiversity

The importance of biodiversity for maintaining life support systems of the biosphere is well recognized. The recent convention on biological diversity and agenda 21 affirms conservation of biological diversity as a common concern of mankind.

Over centuries in the past, human populations have relied exclusively on biodiversity for their livelihood. Timber. extractives like dyes, gum, incense, oils. resins, various fruits, nuts, fish. honey, spices etc.. are obtained from nature. Man has also learnt to cultivate and select varieties of crops and livestock breeds to meet diverse nutritional and social needs.

With current developments in technology, we have been able to produce new plant varieties and animal breeds. Much of its success is attributed to the integration of indigenous knowledge and modern technological advancements. Animal and microbial diversity are also important in the manufacture of various pharmaceutical products, as biocontrol agents against various pests and diseases, as material for advanced biological research and as indicators of environmental quality. However, much of the plant and animal genetic diversity are being lost at an alarming rate. An understanding of the flora and fauna and their interrelations is very essential for the sustainable utilization of biodiversity to the advantage of mankind (Johnson, 1995).

Distribution of biological diversity

Udvardy (1975) has recognized, 193 biogeographical provinces of biodiversity on earth under eight realms. Each biogeographical province is composed of

ecosystems, which consist of living species existing in an ecological region. Of about 1,22,50,000 species existing on earth (WCMC, 1992). nearly 16.04.000 species of plants, animals and micro-organisms are so far described. These species exist on land, in fresh water, in marine habitats or in association with other organisms. Of these, the terrestrial and marine habitats are known for their rich biodiversity. In the former, the forests are the major centres of biodiversity.

Diversity in forests

According to a report by FAO, the total forest cover on the globe is about 3624.7 million hectares. Of this, roughly 1714.8 million hectares are tropical forests and the remaining are boreal or temperate forests. Compared to the temperate forests which are only recently colonised, the tropical forests are very rich in species. Because of this, there is a concern over its destruction. It has been estimated that about 16 million hectares of tropical forests are being cleared annually and that at this rate at least 5-10% of tropical species may face extinction in the next 30 years.

The major threats of tropical forests are due to poverty, inadequate land distribution, low agricultural productivity, poor land use pattern and so on. Most of these forests are located in underdeveloped or developing countries where the local population depends mostly on these forests for firewood. fodder and agriculture. Due to various reasons such as lack of resources, expertise or inaccessability, most of the tropical forests are not fully explored for its biodiversity. Of the various organisms, the insects which constitute about 75% of all life forms found on earth. are economically as well as ecologically very important. Information on the various forms found in the tropical forests. their ecological and economic importance as well as their interrelationships will be very useful in understanding the dynamics of tropical forest ecosystems and for utilizing them for the benefit of the mankind.

Studies on forest insect diversity in India

Of the 75 million ha (23% of the total land area) of forest land in India, about half (37.8 million ha) are closed forests (FSI. 1987). However, this may not hold true considering the fact that it includes monocultures and exotic species plantations, According to Mackinnen & Mackinnen (1986), India has lost 80% of its original habitats and the contained biodiversity.

A discussion on forest biodiversity generally deals with various plants and large animals and birds and rarely centers round smaller organisms like litchens,

insects and microbes. This is probably a reflection of the relatively scanty information available on these groups of organisms. Although smaller in size, such organisms far outnumber all other organisms together both in biomass and in the number of species and individuals. Among these organisms, insects form the most predominant group.

So far, about 67,000 species of insects have been recorded from various ecosystems in India. Of these, 16,000 species are specifically recorded from the forests (Beeson. 1941; Nair and Mathew, 1993). However, this estimate may not hold true considering the fact that many species found in other ecosystems also occur in the forests. The forests of India range from the snow-clad boreal forests of Himalayas to the wet evergreen forests of the Western Ghats. Many parts of these forests are still not explored.

Attempts to study forest insect diversity were initiated in 1900 with the appointment of E.P. Stebbing as the Forest Entomologist who made a pioneering study on Umber beetles (Stebbing, 1914). Much of the early works were on the biology and ecology of important forest pests and all works upto 1941 have been neatly summarised by Beeson (1941). Following this, the major contribution has been a comprehensive 10-volume list covering 2140 plant species and their insect associates (Bhasin and Roonwal. 1954, 1958: Mathur and Singh, 1959. 1960a. 1960b. 1960c. 1961). About 50 volumes covering various insect groups - The Fauna of British India - based on extensive surveys conducted in different parts of the 'country, is an excellent treatment of Indian faunal diversity. In addition to this, excellent treatises have been prepared on various insect groups by the Zoological Survey of India. These studies have shown that the insect fauna of India is very rich and diverse.

Faunal studies in the Kerala part of Western Ghats

Kerala (Fig. 1) with its variety of ecosystems ranging from the high mountains supporting thick tropical evergreen forests, coastal plains, riverine and mangrove vegetations is known for its rich diversity. Although most of the faunal surveys were carried out in the north and north-eastern parts of India, the publications of earlier workers like Sir George Hampson (Lepidoptera). Guy Marshall (Coleoptera), Maulik (Coleoptera), De niceville (Butterflies) also contain references to species found in Kerala.

More recent works on insect diversity in the Kerala part of Western Ghats include a detailed study on the butterflies of the Nilgiri mountains by Larsen (1987,1988); a study on the butterflies and moths of Silent Valley by Mathew and Rahamahulla (1993, 1995): a study of insect fauna in the Malayattoor

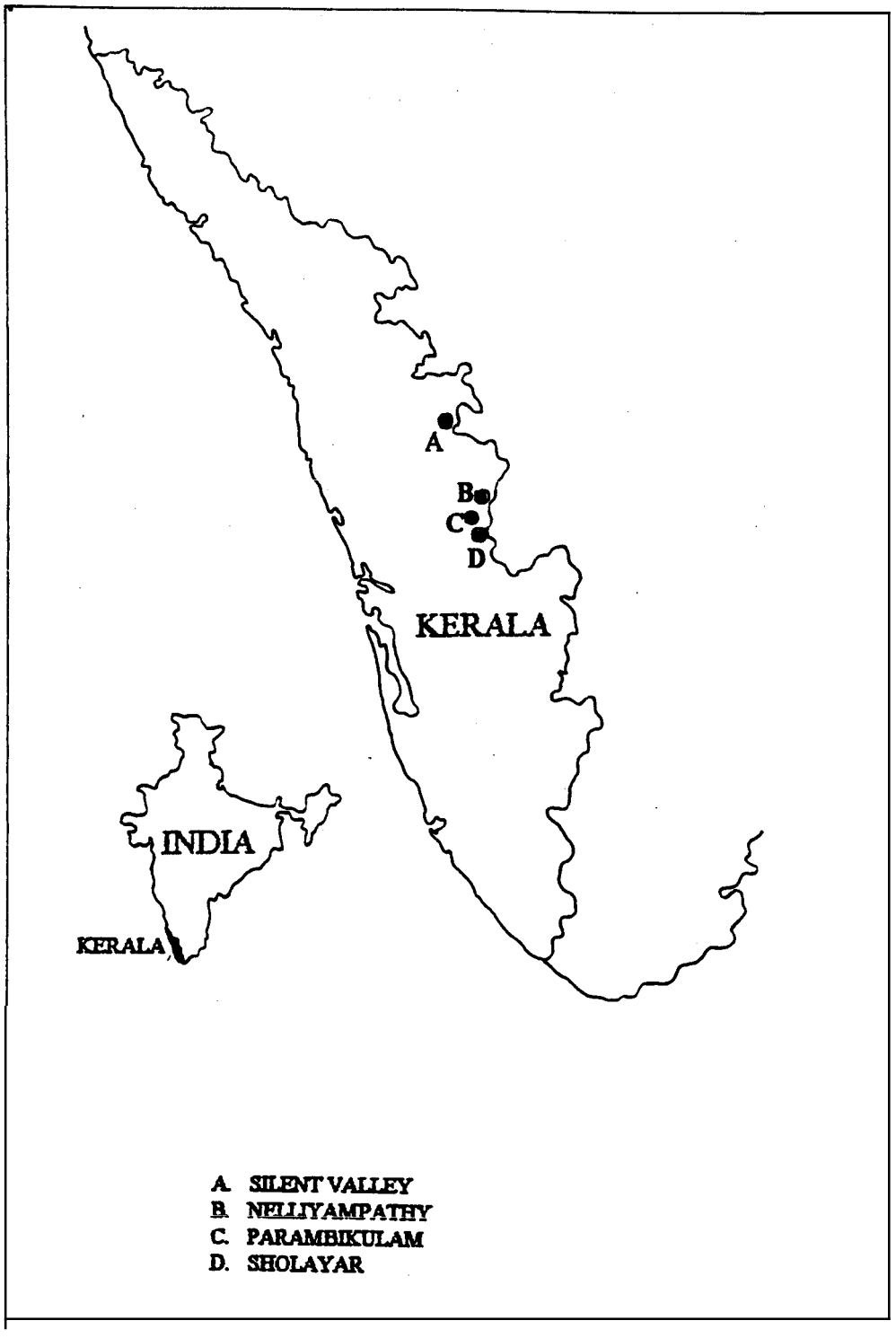

Fig. 1. Map of Kerala showing the study sites

forests by Mathew (1992)and a study of insects in the hydal areas of Idukki by Cherian (1983).These studies have shown that the Kerala part of W.Ghats is extremely rich in species diversity and several locations are considered to be biodiversity 'hotspots'. However, due to various disturbances, many areas in this region are under considerable pressure of anthropogenic origin and many species are likely to become extinct if appropriate conservation strategies are not undertaken. Incidence of fire, plantation programmes, forest cutting for fodder and firewood as well as cattle grazing are the important disturbances in these areas. Documentation of floral and faunal diversity and evaluation of the impact of various disturbances on species diversity patterns is fundamental to any conservation programme. In the present study, an attempt is made to generate baseline data on species diversity patterns in selected 'biodiversity hotspots' and to assess the impact ofvarious forest disturbances on biodiversity.

2. STUDY SITES

2.1. THE WESTERN GHATS

The Western Ghats which is the most imposing, but extremely threatened topographical, floristic and faunistic feature of the Indian sub continent, is one of the 18 biodiversity hotspots of the world. Spread over an area of 175,000 Sq. km in six States, this mountain range extends more or less parallel to the west coast of Indian Peninsula from Kerala to Gujarat traversing a length of about 1600 km. Parts of this mountain range are also present In Tamil Nadu. Karnataka. Goa and Maharashtra.

The present study was carried out at four locations in the Kerala part of Western Ghats *viz.,* Silent Valley, Nelliyampathy. Sholayar and Parambikulam (Figs. 2 to 4). The location, vegetation types and the major reasons of disturbance in each of the sites selected for the present study are discussed below.

2.1.1. Silent Valley

Location

The Silent Valley National Park, one of the core zones of the Nilgiri Biosphere Reserve, is situated in the Palghat District of Kerala. between latitudes 11^{o} 3' and 1 1^{o} 15' N and longitudes 76^{o} 23' and 76^{o} 30' E (Fig. 5). The area was declared as a National Park in 1984. As per the world classification of Udvardy (1975) the area falls under the Malabar Rainforest Realm.

Covering an area of about 90 km^2 this Reserve is situated more or less on a plateau at about 1000 m elevation. Its boundaries are formed by the Nilambur Forest Division and parts of Nilgiris in the north, the Vested Forests of Palghat and Vested Forests of Nilambur Forest Divisions in the south and in the west and the Attappady Reserve Forests in the east. The river Kunthipuzha which is a tributary of Bharathapuzha takes its origin among the hillocks in this region.

Accessibility to this area is restricted due to the steep slopes on all sides and this has contributed to the area remaining more or less undisturbed. The adjacent Attappady Reserve which lies to the east of Silent Valley is more accescible and has suffered severe disturbance in its eastern portion.

Fig. 2 a. Under canopy vegetation in a typical wet evergreen forest patch in Silent Valley

Fig. 2 b. A fire affected evergreen forest patch in Silent Valley

A cardamom plantation at Nelliyampathy. In the foreground the solar panel of the light trap can be seen

Fig. 3 b. A forest patch in Sholayar subjected to disturbances like tree cutting and cattle grazing

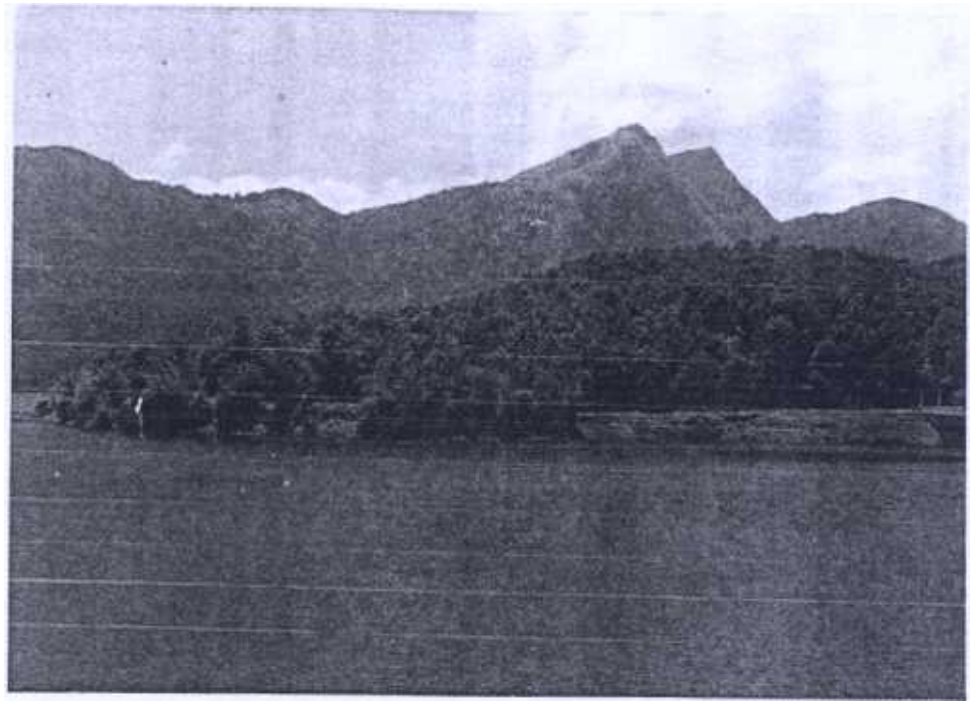

Fig. 4 a. A panoramic view of hill ranges in the Parambikulam Wildlife Sanctuary. Vegetation in the foreground is teak plantation.

Fig. 4 b. Inside a teak plantation in Parambikulam.

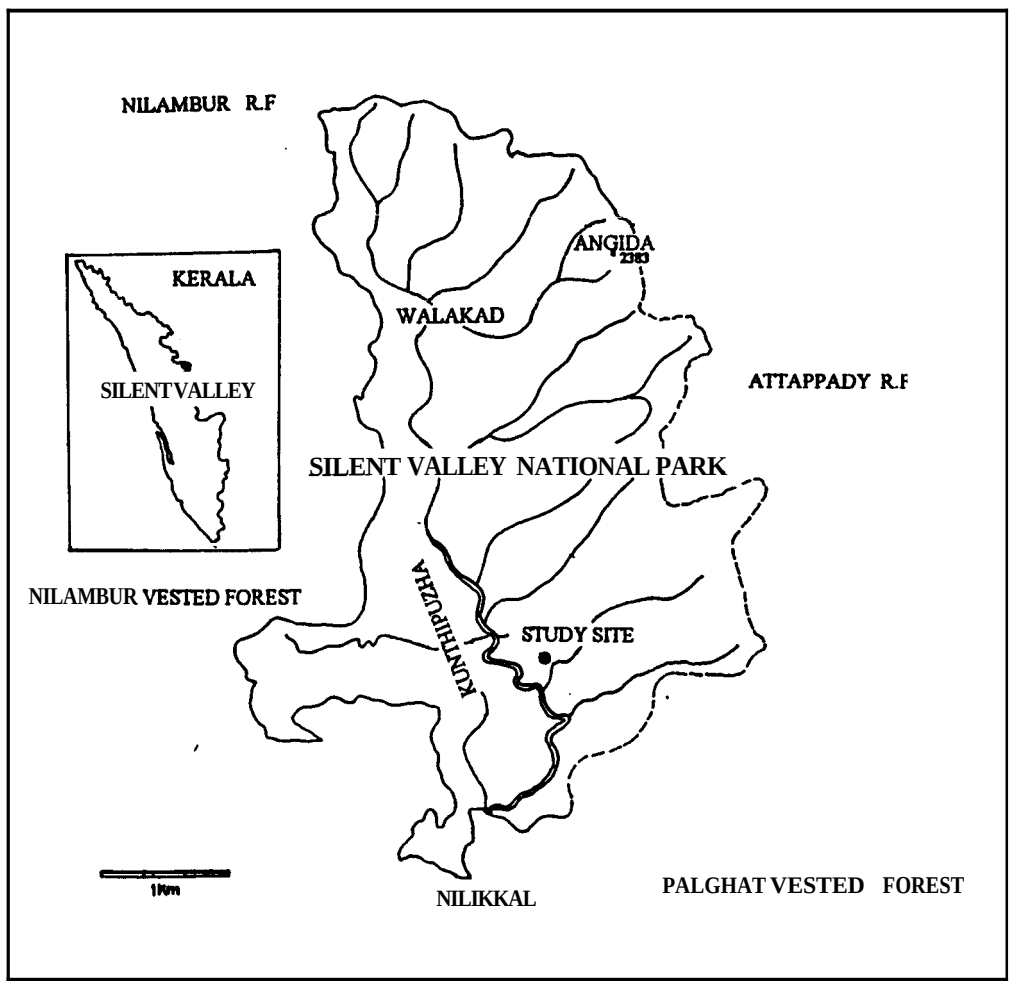

Fig. 5. Map of Silent Valley National Park showing the study site

Climate

This region is characterized by heavy summer rains. Mean annual rainfall is about 4400 mm spread over both south-west and north-east monsoons. However, the bulk of the precipitation, accounting for about 80%, occurs during the south-west monsoon lasting from June to September. The north-east monsoon from October to December contributes to only 12% of the rain. Pre-monsoon thunder showers during May account for about 6% of the rains and a small quantity (2%), is received during the dry season.

The mean annual temperature is 20 ^{o} C. April and May are the hottest months of the year when the mean temperature goes upto 23.5 ^{o} C. December, January and February are the coolest months when the mean temperature is around 18^{o}C. From June to December relative humidity is consistently high and is often around 95%.

Forest type

Due to climatic, edaphic and altitudinal variations, the forests of Silent Valley exhibit considerable variations in floristic composition, physiognomy and life forms (KFRI, 1990).The following types of forest are recognized *viz.,* west coast tropical evergreen forests, subtropical broad leaved hill forests, montane wet temperate forests and grasslands - low and high level. The characteristics of each type are given below.

West coast tropical evergreen forests

This climax vegetation type is commonly encountered between 600 to 1100 m. The trees are about 45m high and at least three strata of vegetation can be recognized. The trees of the top canopy have a spreading or umbrella- shaped crown. The middle stratum is candle - shaped and the lower is cha- racteristi- cally conical. Trees are often festooned with an array of orchids, ferns and mosses. Characteristic trees of these forests are *Artocarpus heterophyllus, Calophyllum elatum, Canarium strictum, Cullenia exarillata,* Dysoxylum *mala- baricum, Elaeocarpus tuberculatus, Holigarna* spp., *Mesua ferrea. Palaquium ellipticum, Persea macrantha* and *Poeciloneuron ellipticum.*

Subtropical broad-leaved hill forests

This type of forest is encountered between 1300 and 1800 m elevation. Typical species are *Calophyllum elatum, Cinnamomum* spp., *Elaeocarpus* spp., *Garcinia*

sp. and various other members of the families Lauraceae and Myrtaceae. Though floristically rich, this forest is not commercially valuable as most of the trees are dwarf and crooked, not exceeding 20m in height.

Montane wet temperate forest

This type of forest is seen in cliffs and sheltered folds above 1800 m. Because of wind and high altitude, these forests are stunted, the trees seldom attaining a height above 10 m. They are interspersed with rolling grasslands. Lauraceous and myrtaceous members constitute the bulk of the flora and as the name suggests the flora has a strong affinity towards temperate zone species.

Grasslands

Two types of grasslands are encountered in Silent Valley *viz.,* low level (<1500 m.) and high level (>1500 m.). The low level grasslands are characterized by tall grasses of *Cymbopogon* and *Themeda* spp., often reaching 3 m in height. Fire hardy tree species like, *Careya arborea, Emblica officianalis, Phoenix humilis, Wendlandia notoniana* and *Zizyphus rugosa* occur mixed with the grasses.

High level grasslands are stunted and carpet-like and are dominated by species like *Arundinella* sp.. *Bothriochloa* sp., *Heteropogon* sp.. *Gaultheria fragrantissima* and *Rhododendron nilagiricum.*

Major disturbances

The major disturbance is due to fire which frequently occurs during the summer season in the grasslands and spreads to the adjacent natural forests. Although the grasslands contain fire hardy species which may sprout with the rains, fire in the evergreen forests will affect the delicate ecosystem characteristic of such habitats leading to the disappearance of many evergreen species. The gaps formed in the forest due to burning will be subsequently colonised by various secondary species that are found in the adjacent moist deciduous forests and grass lands.

2.1.2. Nelliyampathy

Location

The Nelliyampathy forest (Fig. 6) which comes under the Nemmara Forest Division is located between 10° 20' and 10 ° 48' North latitudes and 76°30 and 7 6 ° 5 5 longitudes (Viswanathan. 1958).

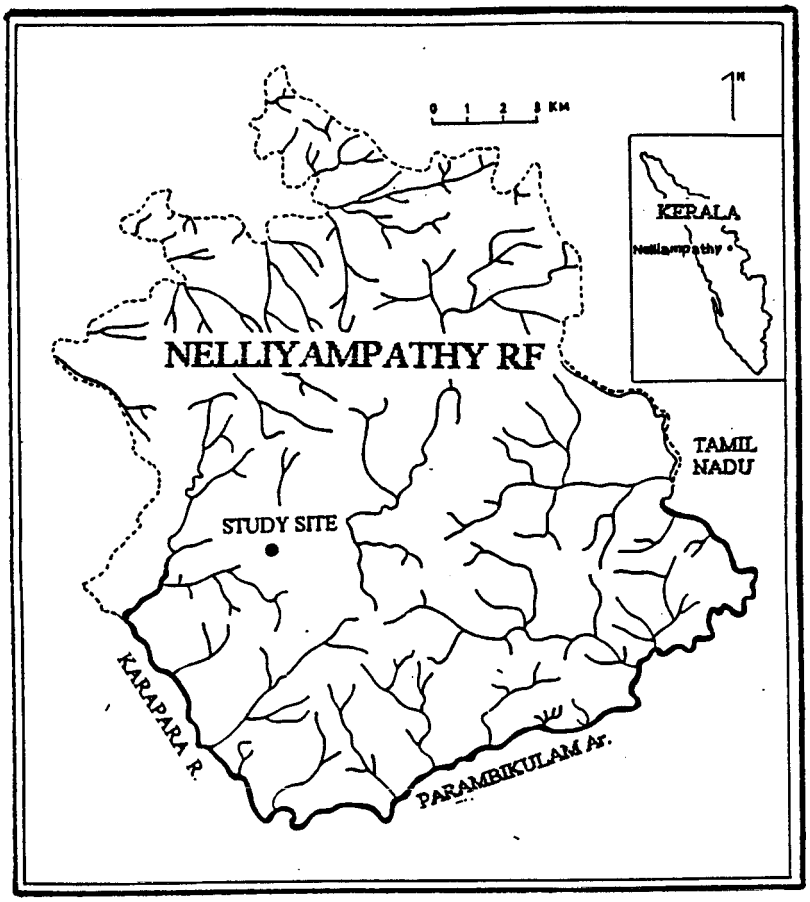

Fig. 6. Map of Nelliyampathy Reserve Forest showing the study site

Topographically the whole area is hilly in character. The ghat forests are characteristically precipitous. Padagiri ridge and Karapara Valley are the major forest bearing areas. The former runs through the northern half of the Nelliyampathy Range. The altitude of the hills ranges from 40 m to 1530 m. the highest being the padagiri ridge (1530 m).

Forest types

The major patches of forests in this region are of the wet evergreen type and are located on the western slopes. There are several rivers that drain in to these forests which include the Kuriarkutty river, the Vethiar river and the Karapara river all of which merge to form the Chalakudy river.

The top canopy is very dense and consists of *Palaquium ellipticum, Calophyllum tomentosum, Mesua ferrea, Diptermcupus indicus, Cullenia exarillata, Artocarpus hirsuta, Mangifera indica Dysoxylum malabaricum, Holigarna arnottiana , Myristica malabarica Polyalthia fragrans, Vateria indica and Eugenia jambolana.*

In the lower canopy, *Aporusa lindleyana, Canarium strictum, Hydnocarpus wightiana Mallotus philippensis, Macaranga roxburghii, Litsea* sp. and *Garcinia* sp. are commonly found.

The under-growths consist of *Antidesma* sp., *Calamus rotang, C. travancoricus. Glycosmis pentaphylla. Ixora* sp., *Laportia crenulata, Pavetta* sp. etc.

The ground vegetation is composed of wild arrowroot. *Curcuma* sp.. and *Strobilanthus* sp. Epiphytes like mosses, ferns and orchids are present in large nummbers. Canes are seen in the evergreen patches. Climbers like *Entada scandens, Dioscorea* sp.. and *Derris* sp., are also present.

Major disturbances

Nelliyampathy Reserve has a number of estates all along its boundary and it is quite likely that these estates would have encroached into the Reserve. The total area of the Reserve comes to about 20,005 ha, of which 3956 ha of land are leased out to private agencies for raising plantations of cardamom, coffee and tea. In order to provide partial shade to these crops. the trees in forest lands have been selectively removed. The under storey is also completely eliminated.

2.1.3. Sholayar

Location

The tract dealt with (Fig. 7) falls between north latitudes 10°-15' and 10°-30' and east longitudes 26°-20 and 76°-55'. The altitude varies From- 30 m at the

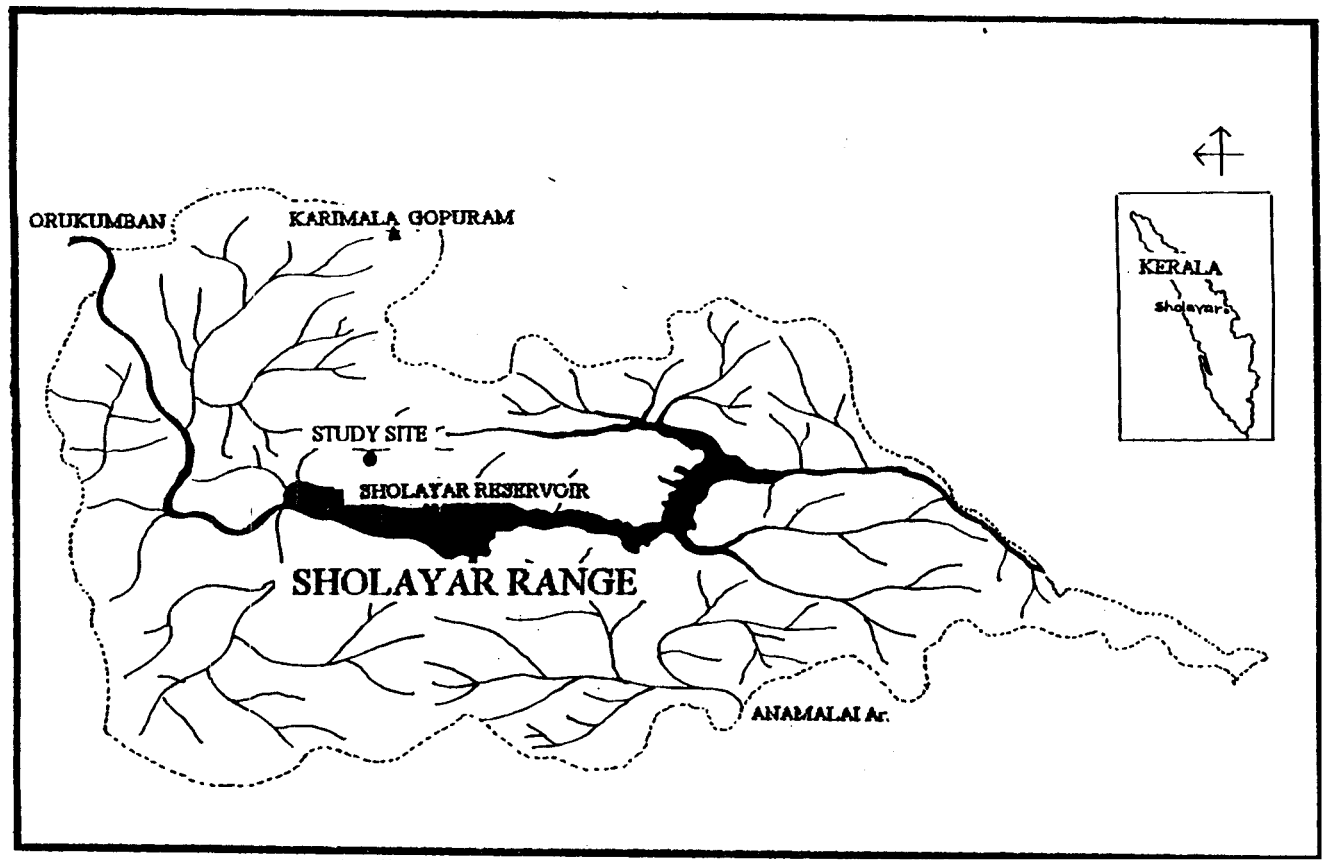

Fig. 7. Map of Sholayar Range:showing the study

foot of the hills to over 1200m on the hills. The highest peak is Karimalagopuram with an elevation of 1439 m above sea level. The latter is situated on the ridge which separates Parambikulam and Sholayar valleys. The whole area is hilly in character and the surface of the ground is mostly undulating (Viswanathan. 1958).

Climate

In the down hills it is hot and humid whereas it is fairly cool on the hills. The area gets the benefit of both the south-west and north-east monsoons and has an average rainfall of over 3500 mm annually.

Forest types

The evergreen forests represent the most luxuriant type of forest vegetation in this region and are characterised by the presence of a relatively large number of species which grow to a height of up to 45 m. The canopy is extremely dense and unbroken.

Top canopy

The main species found in the top canopy are *Anacolosa densiflora Antiaris toxicaria, Artocarpus hirsuta, Bombax malabaricum. CulIenia exarillata, Dipterocarpus bourdillonii D. indicus, Dbspyms assimilis, Dysoxylum malabaricum, Hopea parviflora, Palaquium indicum, Polyaltia fragrans, Vateria indica, Mesua ferrea,* and *Myristica malabarica.*

In the lower canopy, the major species are *Actinodaphne hookeri, Aporusa lindleyana, Canarium strictum, Cinnamomum* spp. *Dbspyms microphylla Holigarna arnottiana, Hydnocarpus wightiana, Litsea* sp., *Macaranga roxburghii* and *Garcinia* sp,

In addition to these, there are several species of twiners and stragglers forming an understorey vegetation. The major species include *Calamus rotang. C. travencoricus, Clausena wildenovit Croton malabaricum, Glycosmis pentaphylla. Ixora* sp., *Entada scandens, Diascorea* sp., *Derris* sp., *Laportea crenulata Strobilanthes* sp., *Curcuma* sp., *Selaginella* sp., and Cardamom. Various kinds of mosses, ferns and orchids are also seen in abundance.

Major disturbance

The major disturbance in this area is due to human interference involving cutting of trees for firewood and fodder. Although the number of families in this

region are rather limited. the disturbance is more or less continuous and confined to the more accessible areas surrounding human settlements which suffer maximum degradation.

2.1.4. Parambikulam

Location

The Parambikulam Wildlife Sanctuary (Fig. 8) is located in the Palghat district of Kerala State and lies between 76°35' and 76° 50' E and 10 °20' and10° 26' N at an elevation of 600 m above sea level (Uniyal, 1987).

The Sanctuary came into existence in 1962 when an area of 69.8 km2 of Sungam Range of Nemmara Forest Division was declared as a Sanctuary. Later, in 1973 the Parambikulam Range was also added to this. The Sanctuary as of now was formed in 1985, and has an area of 270 km2. The boundaries include the Indira Gandhi Wildlife Sanctuary of Tamil Nadu on the east, the Nelliyampathy Reserve Forests on the north-west as well as the Vazhachal and Sholayar forests on the south. Many streams originate in this region which later merge to form the Karappara-Kuriarkutti river systems which finally drain into the Chalakudi river at Orukombankutty.

Topography

The Sanctuary exhibits hilly terrain with characteristic distribution of undulating plains interspersed with marshy fields in the valleys. The altitude varies between 300 m and 1400 m. and the highest peak is the Karimala gopuram which has an elevation of 1438.96 m. The mountain slopes are non-symmetrical and non uniform, spread throughout the area in different directions. The mountain ridges which have well defined valleys, slope down straightly to streams which permit denser growth of vegetation in those regions. The ridges of the Sanctuary are of sheet rock and are exposed at the top. Some of the hill tops have a thin crust of soil favoring stretches of grasslands.

Inside the Sanctuary, three dams have been constructed in the year 1960 - Parambikulam, Thunacadavu, and Peruvarippalam - as part of Parambikulam - Aliyar project. The total water- spread area of these dams comes around 29 sq.km of which Parambikulam is the largest (21.22 sq km).

Climate

The climate in general is pleasant. The maximum temperature ranges between 24 °C to 33°C and minimum 20°C to 25°C. The average precipitation is

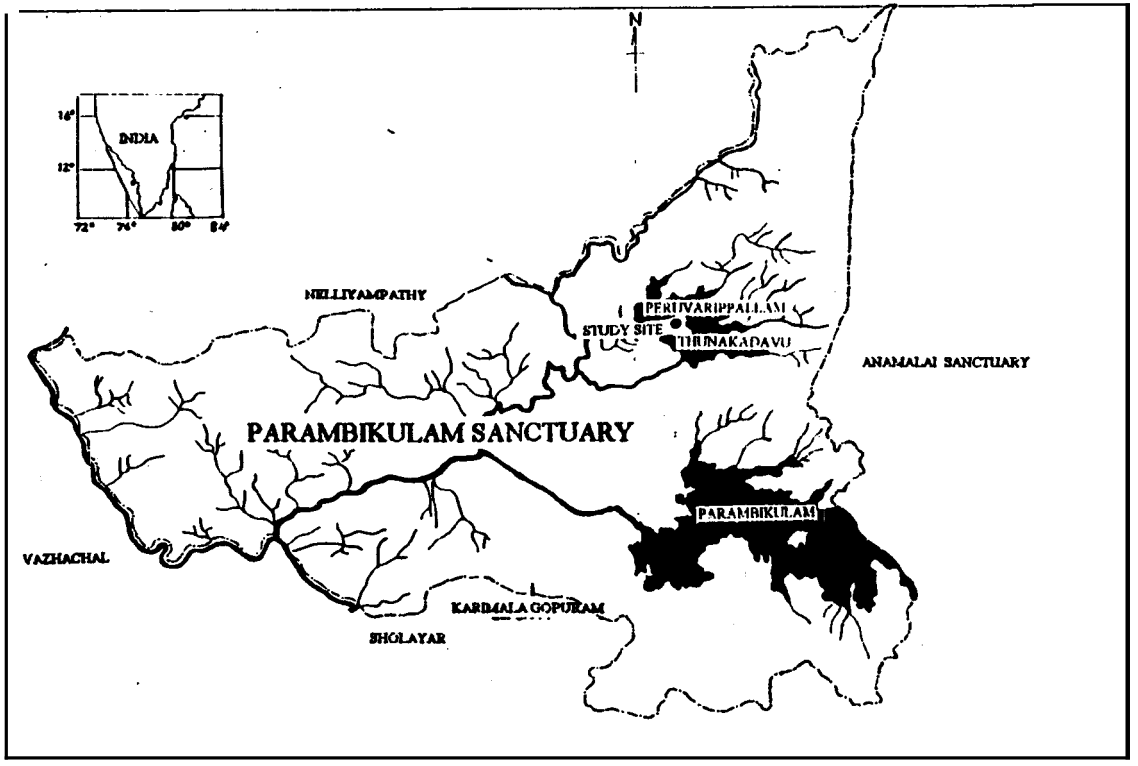

Fig. 8. Map of Parambikulam Wildlife Sanctuary showing the study site

1800 mm varying between 1200 mm to 2300 mm. The area gets both the south - west and north - east monsoons, the south - west monsoon being more active. When compared to the eastern portion, western parts of the Sanctuary receives higher precipitation. Monsoons last from June to December and as such two seasons could be distinguished in the area- dry and wet. January to May with low or no rainfall is considered as dry and the remaining months of the year as wet. February to April are the hottest months and the Sanctuary becomes dry and fire prone during these months.

Habitats and vegetation

The Parambikulam Wildlife Sanctuary has a wide variety of habitats, both natural and man-made. Natural habitats include moist deciduous forests to tropical wet evergreen rain forests. Semi-evergreen forests appear where moist deciduous forests merge into evergreen forests. Grasslands are seen on the upper reaches of Karimala gopuram and Vengoli hills above 1000 m. The man made habitats are chiefly teak plantations which have an extent of about 90 km^2, and were first introduced in the year 1912. In addition to this, a small area of the Sanctuary bordering Tamil Nadu is planted with eucalyptus.

Based on Champion and Seth (1968), the natural vegetation is classified broadly as West-Coast tropical evergreen (55km^2), West- Coast semi evergreen (20km^2), the South Indian moist deciduous (65km^2), and the South Indian dry deciduous (15km^2) forests. Besides small patches of bamboo and reed are also present in certain areas.

Major disturbance

The raising of teak plantations after clear-felling of natural forests is the major disturbance to the natural ecosystem. However, being a wildlife sanctuary, the plantations are left with out much weeding or extraction of miscellaneous tree species as a result of which some areas have developed into mixed stands. The forests adjacent to teak plantations are mainly moist deciduous.

3. MTERIALS AND METHODS

The study was carried out in representative plots. At each location, eight plots were laid out at fixed intervals. The plot size was fixed at 625 m^2 and the distance between plots was 25m. The plots were taken along a transect in such a way that four plots are in the disturbed zone and the remaining in the undisturbed zone. Data on vegetation and insects were collected from all the eight plots in each locality and from this, indices of diversity, dominance, evenness, species richness etc., of plants and insects were computed separately for the disturbed and undisturbed plots. The values for disturbed and undisturbed areas were pooled for deriving the overall values for each locality.

3.1. VEGETATION STUDIES

3.1.1. Sampling methods

Vegetation was studied with a view to generate base line data on the floral elements to facilitate comparison of the relationship between the vegetation and insect community. For this, plants above 2 cm in diameter were enumerated in all the study,plots. The diameter of smalI plants was measured at about 6cm from ground. In the case of tall plants, girth at breast-height (GBH) was recorded. Based on this, the tall plants were classified into different categories viz.. mature trees (individuals with gbh more than 30.1 cm), saplings (individuals with gbh 10.1 to 30 cm). seedlings, shrubs, herbs and climbers (individuals with girth < 10 cm) (Chandrashekara and Ramakrishnan, 1994).

3.2. INSECT COMMUNITY

3.2.1. Sampling methods

Sampling of insects was done using a battery operated light trap (Fig. 9) specially fitted with a switching device to facilitate self operation at specified hours (Mathew and Rahamathulla, 1995). The trap was fitted with solar panels so as to facilitate charging of battery during the day. In order to avoid the influence of lunar phase on insect catches. the trap was operated alternately between plots in the disturbed and undisturbed areas ie.. if the trap was operated initially in plot 1 in the disturbed area, the next day, it was operated in the plot 1 of the undisturbed area and then in plot 2 of the disturbed area and so

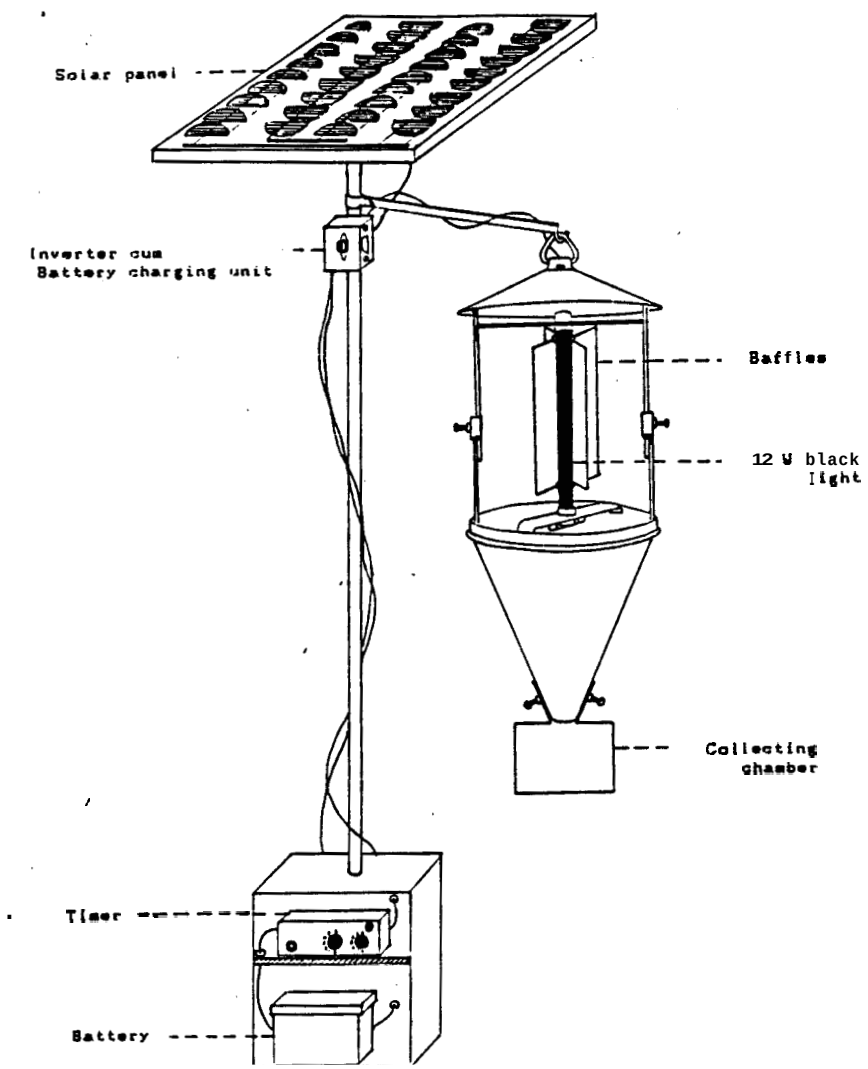

Fig. 9. A specially designed battery operated light trap used for sampling insects

on. In addition to trap catches, collections were also made during day times (8 am to 1 pm) using hand nets. At each location, collections were made for a period of one year. The insects collected were sorted out to species and the number of individuals for each species was recorded on data sheets. As it was not possible to identify all the species readily, code numbers were assigned to the various species. The insects were later identified by comparison to material available in the national collections like IARI, New Delhi and ZSI, Calcutta by the Principal Investigator himself and by referring to experts in these institutions.

3.3. ANALYISIS OF DATA

Density

Density was estimated for various plant categories such as trees, saplings, seedlings, shrubs, herbs and climbers in each locality for disturbed and undisturbed sites and the pooled values were also calculated separately.

Diversity index

The quantification of diversity must address two statistical properties common to any mixture of different objects. The first property is the number of different classes or types of objects ie.. species, genera, families, different habitats and so on. The second property is the distribution of objects among classes such as the relative abundance of individuals of different taxa or the relative area of the habitat that falls into different habitat types. In this study only species diversity was studied. For this, the Shannon-Weiner diversity index (H) was used (Margalef. 1968):

$$H = - \sum_{i} P_i \log_e (P_i)$$

where 'H' is the Shannon's index of species diversity and Pi is the proportion of individuals in the 'i' th species.

in order to find out whether any significant differences existed in the insect diversity between the two localities or between the disturbed and undisturbed areas within a locality, a 't' test was done (Magurran. 1988) using the following formula:

$$t = \frac{H_1 - H_2}{[\text{var}\ (H_1) + \text{var}\ (H_2)]^{1/2}}$$

where 'Hi' and 'H2' are diversity indices of first and second locality, and var (Hi) and var (H2) are their variances. Variance of diversity index (Magurran, 1988) is defined as follows:

$$\text{Var}\ (H) = \frac{\sum_i [P_i\ (\log_e\ (P_i)]^2 - [\sum_i (P_i \log_e\ (P_i)]^2}{N} - \frac{S-1}{2N^2}$$

Distribution models

Another way of describing diversity in a community is through species- abundance or distribution models (Fisher *et al* .1943). A species- abundance model utilizes all the information gathered in a community and is the most complete mathematical description of the data (Magurran. 1988).

The frequency distribution of insects per collected species was studied for all the localities separately. The data were described using truncated log-normal distribution (Pielou,1975). which will indicate whether the locality contain any rare species or not and also, the number of species which had not been possibly included in the sample collection.

Similarity measures

Modified Sorensen's coefficient of similarity was used to calculate the similarity between the four localities and between disturbed and undisturbed areas within each locality. The following formula was used:

$$C_N = 2N_J/(N_A + N_B)$$

Where,

N_A = the total number of individuals in site A

N_B = the total number of individuals in site B and

N_J = the sum of the lower values of individuals recorded for species nd in both sites

Dominance index

Patterns of relative abundance of species determine the dominance component of diversity. In this study, the relative dominance of each insect Order in a locality was determined by calculating the dominance index using the following formula:

$$\text{Relative dominance} = n_i \times \frac{100}{N}$$

Where n_i = number of insects in the 'i' th order, and N = the total number of insects in all the orders collected during the study period.

Evenness or equitability index

This index which measures the evenness of species abundance is complimentary to the diversity index concept and it indicates how the individuals of various species are distributed in the community.

For estimating evenness, Shannon's evenness index was calculated (Pielou, 1975). Mathematically, the evenness of frequency distribution of species abundance in a community with 's' component species, is the degree to which it approximates the uniform distribution for 's' species ie., equal abundance of all species in the sample or community (Pielou. 1977).

In a collection or in a community with 's' component species, diversity will be greater if all 's' species are well represented. In this condition, there is high evenness and low dominance. On the contrary, if a few of the species, say 't' are very common and the rest (s-t) are very rare, then it is a case of low evenness and high dominance.

The Shannon's evenness index of the community was calculated following Pielou (1975):

$$E = H/\log_e(s)$$

where 's' is the number of species recorded and 'H' is the Shannon-Weiner index of diversity.

Species richness

In the ecological literature, the number of species at a site, in a region or in a collection is called species richness which is the simplest and most useful measure of species diversity. In this study, the total number of insect species collected in each month from each locality was considered as species richness.

Species richness index

The index of species richness (d) was calculated using the formula given by Menhinick (1964):

$$d = s / \sqrt{n}$$

where 's' is the number of species recorded and 'n' is the total number of individuals summed over all species.

4. RESULTS AND DISCUSSION

4.1. VEGETATION STUDIES

A list of plants found in the study areas is given in Appendix-1. Details of lant species composition and vegetation diversity in each of the study plots (Tables 1 to 4) are presented here. In addition to this, an account of the overall vegetation diversity in different localities is also given in order to facilitate a comparison of these localities with respect to their vegetation diversity.

4.1.1. Silent Valley

Overall characteristics of vegetation

The study area in Silent Valley contained 3951 plants under 130 species belonging to various categories such as tree saplings, tree seedlings, mature trees, shrubs, herbs and climbers (Table 25). Of these, the highest number of species recorded was for tree saplings (73)followed by tree seedlings (66)and mature trees (49).The number of species in the categories such as herbs, shrubs and climbers'was low.

The density of plants was found to be high in the case of tree seedlings (1243) indicating very good regeneration of the forest stand. With regard to species diversity, the indices remained more or less the same for the categories of trees (seedlings. saplings, mature trees etc.) with highest index of richness recorded for mature trees. Evenness index was found to be high for mature trees and tree seedlings. The overall values of plant diversity index was 3.90. richness index 2.07 and evenness index 0.80.

Characteristics of vegetation in the undisturbed area

In the undisturbed area, out of 81 plant species recorded, 48 were represented as saplings, 46 as seedlings and 35 as mature trees (Table 1). Herbs, shrubs and climbers were sparse (Fig. 10). *Palaquium ellipticum, Aglaia* sp.. *Myristica dactyloides, Mesua ferrea, Cullenia exarillata, Dimocarpus longan. Drypetes oblongifolia, Holigarna arnottiana, Casearia bourdilonii Garcinia morella, Litsea floribunda, Persea macrantha, Syzygium cumini* and *Atrocarpus heterophyllus* were the common tree species in this area.

Table 1. Chracteristics of the vegetation in the undisturbed and disturbed1sites at Silent Valley

Community parameters	Plant categories						
	Mature trees	Tree saplings	Tree seedlings	Shrubs	Herbs	Climbers	Total
No. of species	35(33)	48(48)	46(50)	9(18)	4(11)	9(16)	81(109)
No. of plants	191(116)	488(493)	575(668)	262(711)	44(208)	48(147)	1608(2343)
Diversity	2.99(2.93)	3.22(2.54)	3.29(3.04)	1.67(1.93)	1.15(1.32)	1.84(2.19)	3.66(3.55)
Richness	2.53(3.06)	2.17(2.16)	1.92(1.93)	0.56(0.68)	0.60(0.76)	1.30(1.32)	2.02(2.25)
Evenness	0.84(0.84)	0.83(0.66)	0.86(0.78)	0.76(0.67)	0.83(0.55)	0.84(0.79)	

[1] Values for the disturbed site are given in parenthesis.

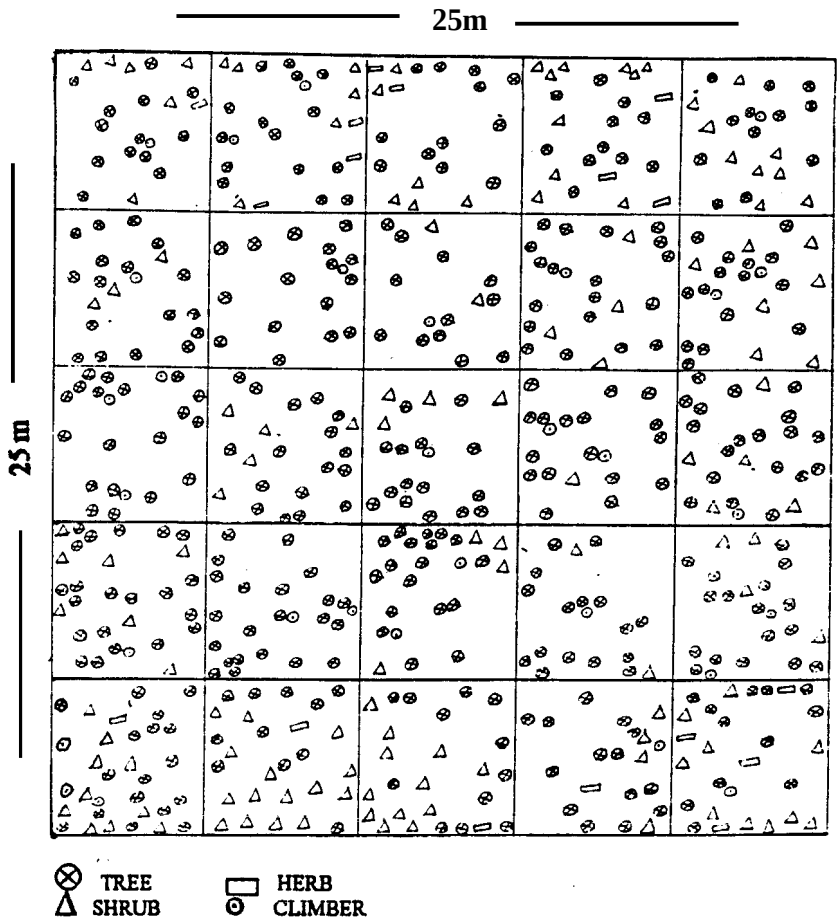

Fig. 10. Typical distribution pattern of plants in the study sites at Silent Valley (undisturbed area)

Tree seedlings showed higher species diversity (3.29) followed by tree saplings (3.22). mature trees (2.99), climbers (1.84). shrubs (1.67) and herbs (1.15). With regard to density, highest values obtained were for tree seedlings (575) followed by tree saplings (488). The index of species richness was higher for mature trees (2.53) followed by tree saplings (2.17). Evenness index was found to be higher for tree seedlings.

Characteristics of vegetation in the disturbed area

In the disturbed area, out of 109 species recorded, 33 were present as mature trees, 48 as tree saplings and 50 tree seedlings (Table 1). Shrubs, herbs and climbers were sparse (Fig. 1 1). The trees *Cullenia exarillata, Dimocarpus longan* and *Casearia bourdilloni* although not in the same density as in the undisturbed area, were present. In addition to these, secondary species like *Olea dioica, Scolopia crenata Clerodendron viscosum, Macaranga peltata* and *Zizyphus rugosa* were also present. Tree seedlings showed higher species diversity compared to all other categories. Species diversity values were low for herbs and shrubs. Highest density obtained was for shrubs (711) followed by seedlings (668). The index of species richness was found to be higher for mature trees (3.06) followed by tree saplings (2.16). Evenness index was also found to be higher for mature trees (0.84).

A comparison of vegetation in the undisturbed and disturbed areas

An examination of data on the vegetational aspects of Silent Valley indicates that shrubs, herbs and climbers were relatively more in number, both in terms of species and individuals, in the disturbed area. There was also an increase in the number of tree seedlings and saplings indicating a flourishing forest stand.

It may be noted here that the disturbed area selected in this study was affected by fire several years back and the vegetation was fast regenerating in the absence of further disturbance. The increase in the number of herbs and shrubs is attributed to the effect of lass of canpoy due to fire and subsequent colonisation of these categories from the adjoining forests and grasslands. The reduction in the density of evergreen species and subsequent colonisation by secondary species in the diisturbed area indicates the effect of disturbance on vegetation.

4.1.2. Nelliyampathy

Overall characteristics of vegetation

In Nelliyampathy. a total of 1816 plants belonging to 50 species were recorded (Table 25). The representation of various categories of plants was as follows:

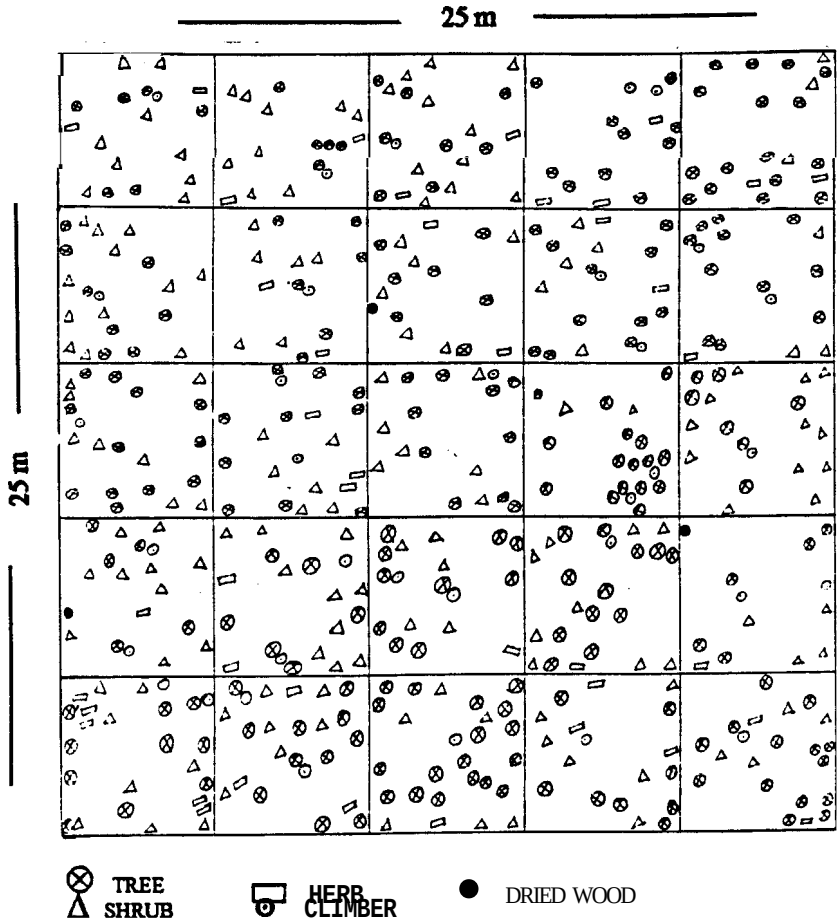

Fig. 11. typical distribution pattern of plants in the study sites at Silent Valley (Disturbed area)

mature trees - 36 species: tree saplings - 27 species: tree seedlings - 27 species: shrubs - 6 species and herbs - 5 species. The mature trees showed higher species diversity index (2.80) followed by tree saplings (2.76), tree seedlings (2.66), shrubs (1.40) and herbs (1.34). Highest density (564) was recorded for tree seedlings followed by herbs, mature trees and saplings indicating a dense, intact forest stand. The overall diversity index was 3.26, richness index 1.17 and evenness index 0.83.

Characteristics of vegetation in the undisturbed area

In the undisturbed area, 32 species were recorded. Of these, 24 were represented as mature trees, 20 as saplings and 19 as seedlings. Herbs and shrubs were sparse (Table 2). *Elaeocarpus serratus, Dimocarpus longan, Cullenia exarillata, Heritiera papilw, Litsea laevigata Mesua ferrea, Neolitsea* sp., *Palaquium ellipticum* and *Polyalthia coffeoides* were the common tree species. In addition to these, certain secondary species like *Agrostistachys meeboldi Artocarpus heterophy llus, Scolopia crenulata and Laportea crenulata* were also present indicating slight disturbance. Mature trees showed higher species diversity (2.60) followed by saplings (2.52). seedlings (2.40). shrubs (1.091 and herbs (0.69). Density was high for tree seedlings (364) followed by herbs (271) (Fig. 12). The index of species richness was found higher for mature trees followed by tree saplings. Evenness index was higher for herbs.

Characteristics of vegetation in the disturbed area

In the disturbed area, out of 42 species present, 27 were represented as mature trees, 20 as seedlings and 12 as saplings (Table 2). *Aglaia laevis. Canarium strictum, Cullenia exarillata, Dimocarpus longan. Drypetes longifolia, Heritiera papilio, Mesua ferrea, Palaquium ellipticum* and *Syzygium cumini* were the common trees. In addition to these, various secondary species like *Scolopia crenata Walsura trifolia, Celtis* sp., *Albizia chinensis, Macaranga indica and M. peltata* were also present. Shrubs and herbs were sparse and formed only a very small portion of the forest vegetation (Fig. 13). Mature trees showed higher species diversity (2.64) compared to all other categories. For herbs and shrubs, species diversity values were low. Density was highest in the case of herbs (205) followed by seedlings (200). Index of species richness was found to be higher for mature trees followed by tree saplings. Evenness index was found to be higher for saplings (0.85) and lower for herbs (0.55).

A comparison of vegetation in the undisturbed and disturbed areas

The undisturbed area contained more number of tree seedlings, saplings and mature trees compared to the disturbed area where there was marked reduction

Table 2. Chracteristics of the ,vegetation in the undisturbed and disturbed[1] sites at Nelliyampathy

Community parameters	Plant categories						
	Mature trees	Tree saplings	Tree seedlings	Shrubs	Herbs	Climbers	Total
No. of species	24(27)	20(12)	19(20)	4(4)	2(3)	0(0)	32(42)
No. of plants	265(120)	201(39)	364(200)	63(88)	271(205)	0(0)	1164(652)
Diversity	2.60(2.64)	2.52(2.11)	2.40(2.42)	1.09(0.81)	0.69(0.60)	0(0)	2.92(2.85)
Richness	1.47(2.46)	1.41(1.92)	l.00(1.41)	0.50(0.43)	0.12(0.21)	0(0)	0.94(1.64)
Evenness	0.82(0.80)	0.84(0.85)	0.82(0.81)	0.79(0.58)	l.00(0.55)	0(0)	0.84(0.76)

[1] Values for the disturbed site are given in parenthesis.

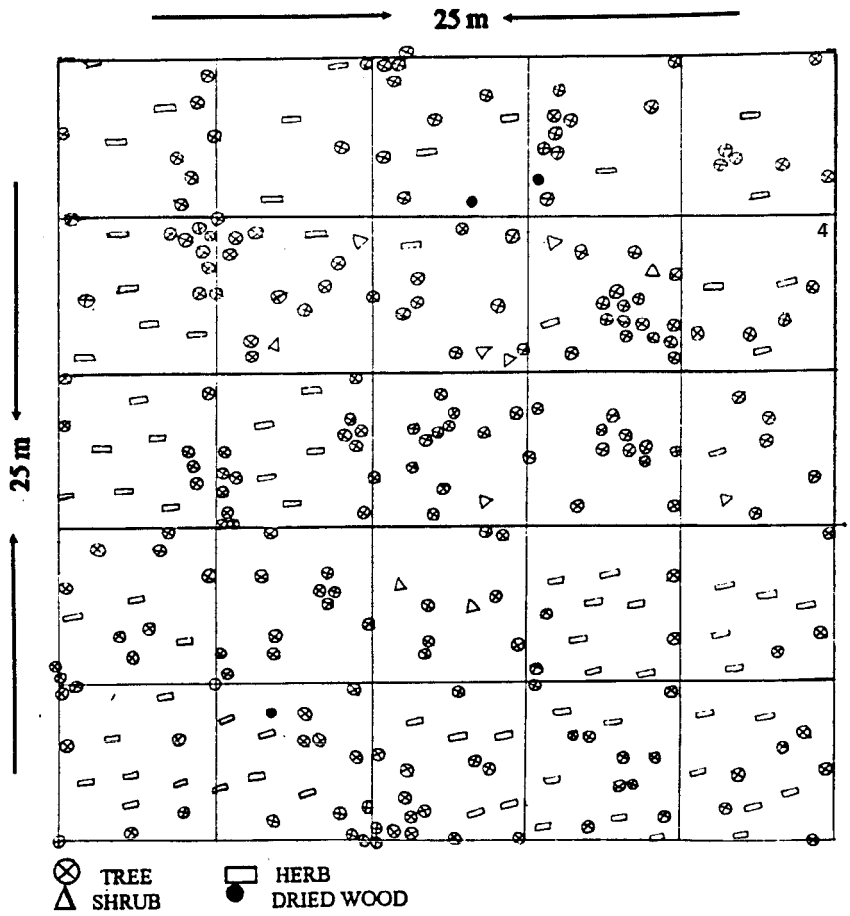

Fig. 12. Typical distributionpattern of plants in the study sites at Nelliayampathy (Undisturbed areal

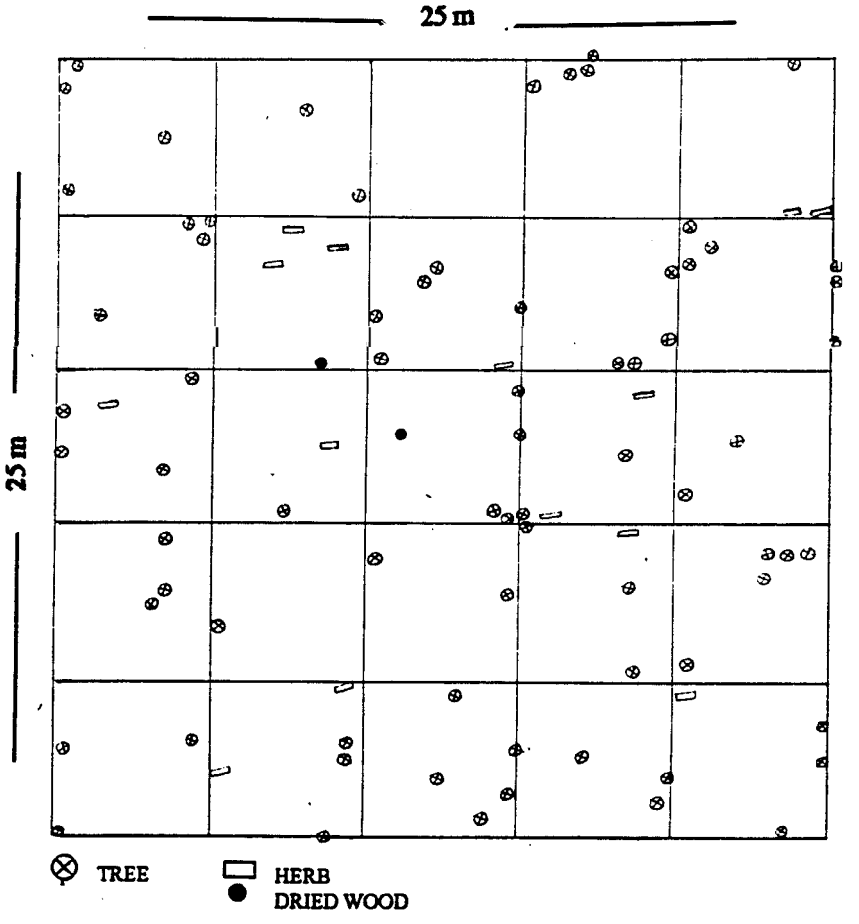

Fig. 13. Typical distribution pattern of plants in the study sites at Nelliyampathy (Disturbed area)

in the number of these categories particularly of saplings. The number of plants indicated under the category of herbs in the disturbed area are actually the cardamom plants.

4.1.3. Sholayar

Overall characteristics of vegetation

Altogether 1209 plants belonging to 32 species were present in this area (Table 26). Mature trees had the maximum representation of species (28) followed by tree saplings (23) and tree seedlings (22). Shrubs, herbs and climbers were very few. The density was found to be the highest for tree seedlings (470) followed by mature trees (272) and tree saplings (191). The diversity index was highest for mature trees (3.14) followed by tree saplings (2.91) and tree seedlings (2.85). Richness index was highest in the case of mature trees (1.70). The data gathered here shows that the forests of Sholayar are dense and well stratified. The overall index of diversity was 3.13, richness index 0.92 and evenness index 0.90.

Characteristics of vegetation in the undisturbed area

Out of the 25 tree species found in the undisturbed area, 22 species each were represented as mature trees and tree saplings and 21 as tree seedlings (Table 3). *Cycas sp., Grewia tiliaefolia, Myrtogyna parviflora Radermachera xylocarpa. Careya arborea, Cassia fistula, Cordia dicotoma, Dalbergia latifolia Dillenia bracteata Lagerstroemia microcarpa, Melia dubia Bridelia retusa, Erythrina sp., Randia sp., Tectona grandis. Terminalia paniculata, T. tomentosa Trema orientalis* and *Xylia xylocapra* were the common species. There were only 2 species of shrubs and only one species of climber. The tree species were fairly abundant in comparison to species belonging to the ground vegetation. Density was high in the case of tree seedlings (468) (Fig. 14). The diversity index was more or less the same for mature trees and tree seedlings. The species richness index was high for tree saplings (1.60) and mature trees (1.46) and low for ail the other categories suggesting that mature trees and tree saplings at Sholayar are more diverse. Evenness index was found to be high and more or less the same for mature trees, tree saplings and tree seedlings compared to that of shrubs and herbs.

Characteristics of vegetation in the disturbed area

In the disturbed area, 15 species were present of which 12 were represented as trees and one each of tree sapling. shrub, herb and climber (Table 3). *Cassia fistula, Dalbergia latifolia, Lagerstroemia microcarpa Emblica officianalis, Tectona grandis* and *Terminalia paniculata* were the common species. Density was low

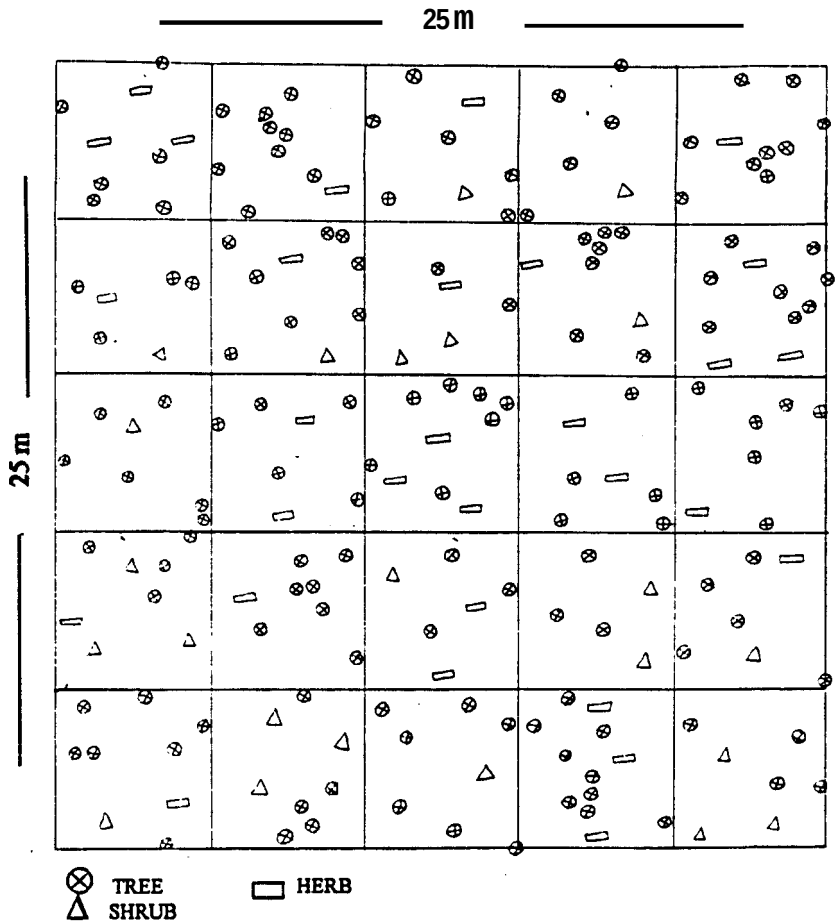

Fig. 14. Typical distribution pattern of plants in the study sites at Sholayar (Undisturbed area)

Table 3. Chracteristics of the vegetation in the undisturbed and disturbed' sites at Sholayar

Community parameters	Plant categories						
	Mature trees	Tree saplings	Tree seedlings	Shrubs	Herbs	Climbers	Total
No. of species	22(12)	22(1)	21(2)	2(1)	0(1)	1(1)	25(15)
No. of plants	226(46)	190(1)	468(2)	65(77)	0(65)	23(46)	972(237)
Diversity	2.90(2.37)	2.89(0)	2.84(0.69)	0.54(0)	0(0)	0(0)	3.03(1.85)
Richness	1.46(1.77)	1.60(1)	0.97(1.41)	0.25(0.11)	0(0)	0.21(0.15)	0.80(0.97)
Evenness	0.94(0.95)	0.93(0)	0.93(1)	0.78(0)	0(0)	0(0)	0.94(0.68)

1-Values for the disturbed site are given in parenthesis.

for all categories of plants (Fig. 15). The diversity index was 2.37 in the case of mature trees. The species richness index was high in the case of tree seedlings and tree saplings. Evenness index was nil in the case of tree saplings, shrubs, herbs and climbers. This could be due to the fact that due to extreme disturbance, most of the natural vegetation was affected leading to excessive weed growth. The weed *Mikania micrantha* was the most dominant species which suppressed the growth of other ground vegetation in the area.

A comparison of vegetation in the undisturbed and disturbed areas

The undisturbed area contained more number of trees, tree seedlings and tree saplings. In the disturbed area, there was extereme reduction in these categories as a result of disturbences and the area was colonisied by various weeds like *Lantana* sp., and *Mikania micrantha* which also prevent subsequent regeneration by species found in the adjoining natural forests.

4.1.4. Parambikulam .

Overall characteristics of vegetation

There were 623 plants belonging to 35 species, of which 22 were represented as mature trees, 17 as tree seedlings and 12 as tree saplings (Table26).Highest density recorded was for seedlings (189) followed by saplings (147) and mature trees (129). The last had the highest diversity index (2.43) followed by tree seedlings (2.05) and tree saplings (1.80).The richness index was highest for mature trees (1.94). Data gathered here indicate that the area although not as dense as the other sites, is well regenerating. The overall diversity index was 2.67. richness index 1.40 and evenness index 0.75.

Characteristics of vegetation in the undisturbed area

Out of 30 plant species recorded in the undisturbed area, 21 were represented as mature trees, 14 as tree seedlings, and 11 as tree saplings (Table 4).*Aglaia lawii, Cullenia exarillata, Dimocarpus longan, Dypetes elata, D. oblongifolia, Elaeocarpus serratus. Gomphandra coriacea. Haldina cordifolia, Heritera papilio. Holigarna arnottiana. Litsea floribunda, Mastixia arborea, Messua,ferra Myristica dactyloides, Neolitsea sp., Palaquium ellipticum and Polyalthia coffeoides* were the common species. In addition to these, secondary species like *Agrostistachys meeboldii. Scolopia crenata* and *Laportea crenulata* were also present indicating slight disturbance. Shrubs, herbs and climbers were sparse. Density was high for tree seedlings (127) (Fig. 16). Mature trees showed high species diversity (2.36) followed by seedlings (2.10) and saplings (1.71). Species richness

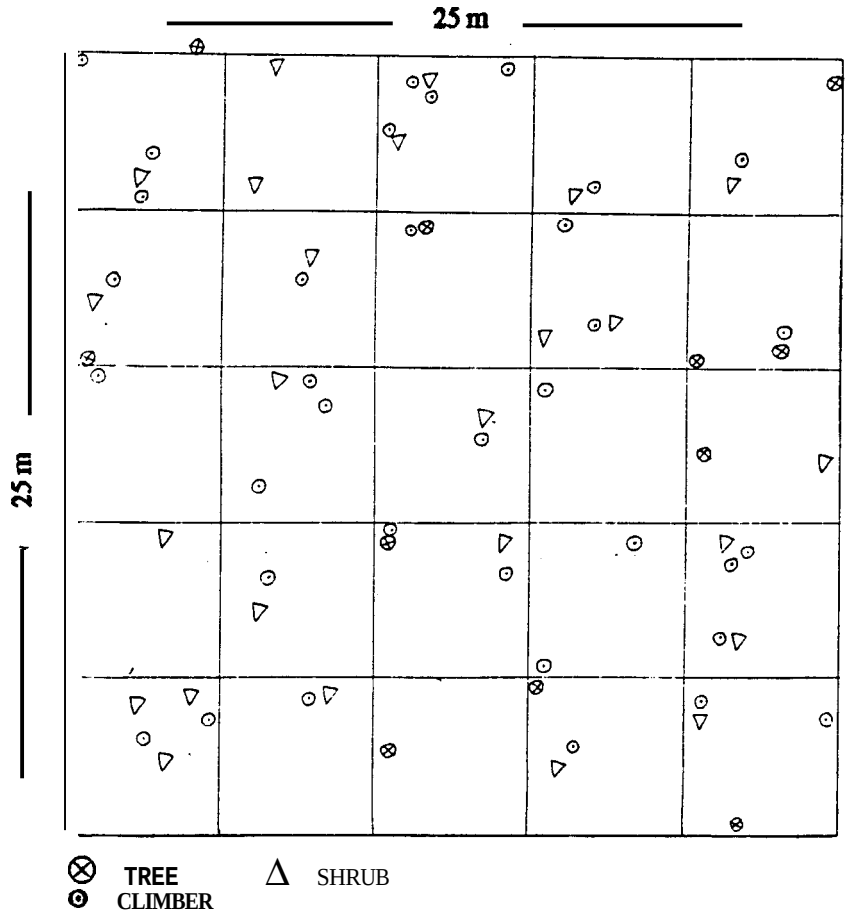

Fig. 15. Typical distribution pattern ofplants in the study sites at Sholayar (Disturbed area)

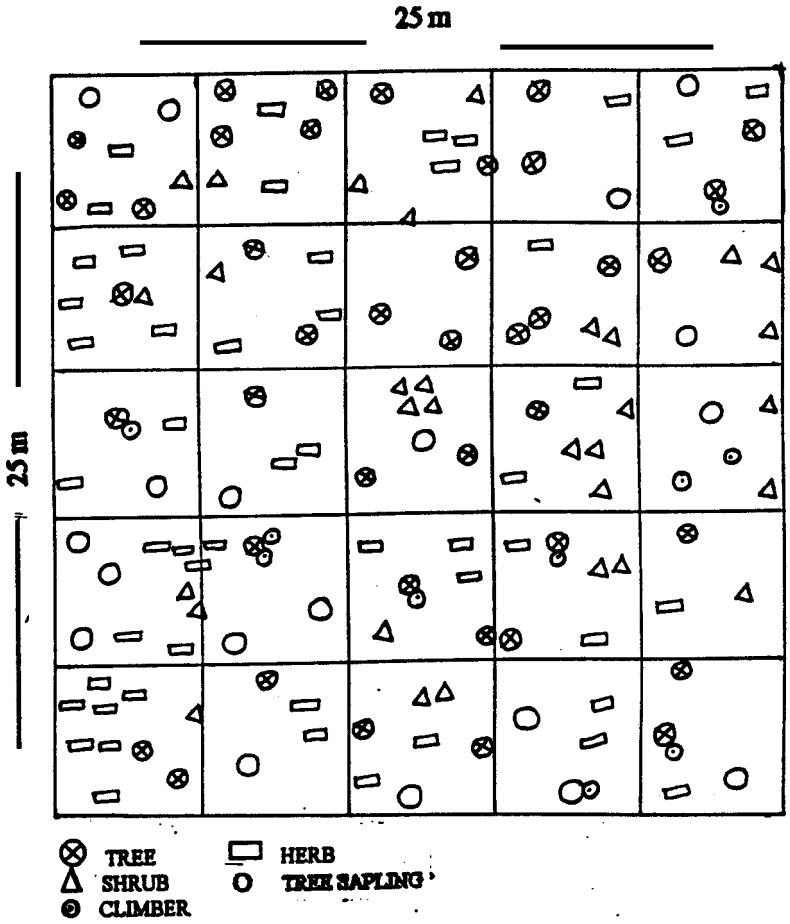

Fig. 16. Typical distribution pattern of plants in the study sites at Parambikulam (Undisturbed area)

index was found to be higher for mature trees (2.13) followed by tree seedlings (1.24). Evenness index was high for tree seedlings (0.80).mature trees (0.78) and shrubs (0.78).

Characteristics of vegetation in the disturbed area

In the disturbed area, only 19 species were recorded, of which 5 were represented as mature trees, 9 as tree seedlings and 8 as tree saplings (Table 4). *Heritiera papilio, Holigarna* sp., *Mastixia arborea, Mesuaferrea Neolitsea* sp., and secondary species like *Artocarpus heterophyllus. Alstonia scholaris. Celtis* sp., *Erythrina* sp., and *Macaranga indica* were present. Shrubs and herbs were sparse and no climber was present. Highest diversity was noticed for shrubs (2.10). Density was low for all categories (Fig. 17). Species richness index was found to be higher for tree saplings (1.49).Evenness index was highest for tree saplings (0.74) and nil for herbs and climbers.

A comparison of vegetation in the undisturbed and disturbed areas

At Parambikulam. the disturbed areas showed greatest reduction in the number of species due to raising of teak plantation. The miscellaneous species present in the plantations were through natural regeneration from the adjacent moist deciduous forest patches. It may also be added here that typical undisturbed patches are carfoined to the high hills which due to inaccessability could not be selected for this study.

4.2. INSECT COMMUNITY

Based on data generated from the four localities, collector'scurves were plotted to find out whether the collections have adequately covered the insect fauna of these areas. The curves (Figs. 18 and 19) showed an upward trend indicating that further studies are needed to take stock of the entire fauna in these regions.

4.2.1. Silent Valley

Occurrence of species

Altogether 578 species belonging to 13 Orders and 67 Families were collected from Silent Valley. Of this, 449 species were from the undisturbed and 417 species from the disturbed areas. In the former, the insects collected belonged to 13 Orders and 61 Families and in the latter to 12 Orders and 60 Families.

Table 4. Chracteristics of the vegetation in the undisturbed and disturbed' sites at Parambikulam

Community parameters	Plant categories						
	Mature trees	Tree saplings	Tree seedlings	Shrubs	Herbs	Climbers	Total
No.of species	21(5)	1 l(8)	14(9)	3(6)	3(1)	l(0)	30(19)
No. of plants	97(32)	1 18(29)	127(62)	80(30)	27(18)	3(0)	452(171)
Diversity	2.36(1.05)	1.71(1.54)	2.10(1.14)	0.86(2.10)	0.42(0.00)	0(0)	2.68(2.24)
Richness	2.13(0.88)	1.07(1.49)	1.24(1.14)	0.34(1.10)	0.58(0.24)	0.58(0)	1.41(1.45)
Evenness	0.78(0.65)	0.71(0.74)	0.80(0.52)	0.78(1.17)	0.38(0)	0(0)	

'-Values for the disturbed site are given in parenthesis.

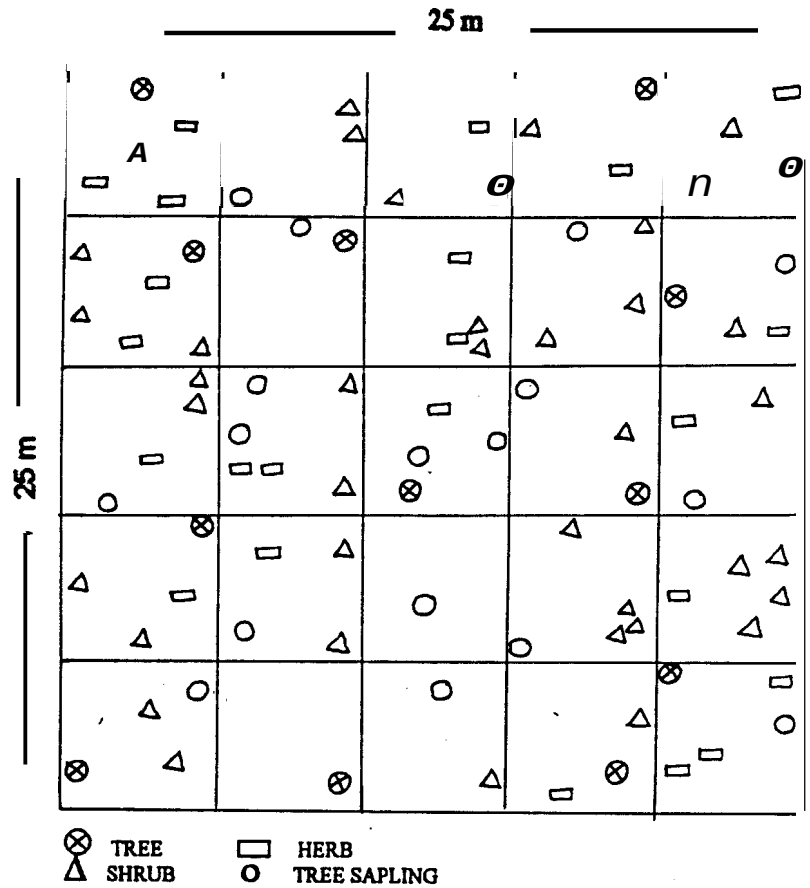

Fig. 17. Typical distribution pattern of' plants in the study sites at Parambikulam (Disturbecd area)

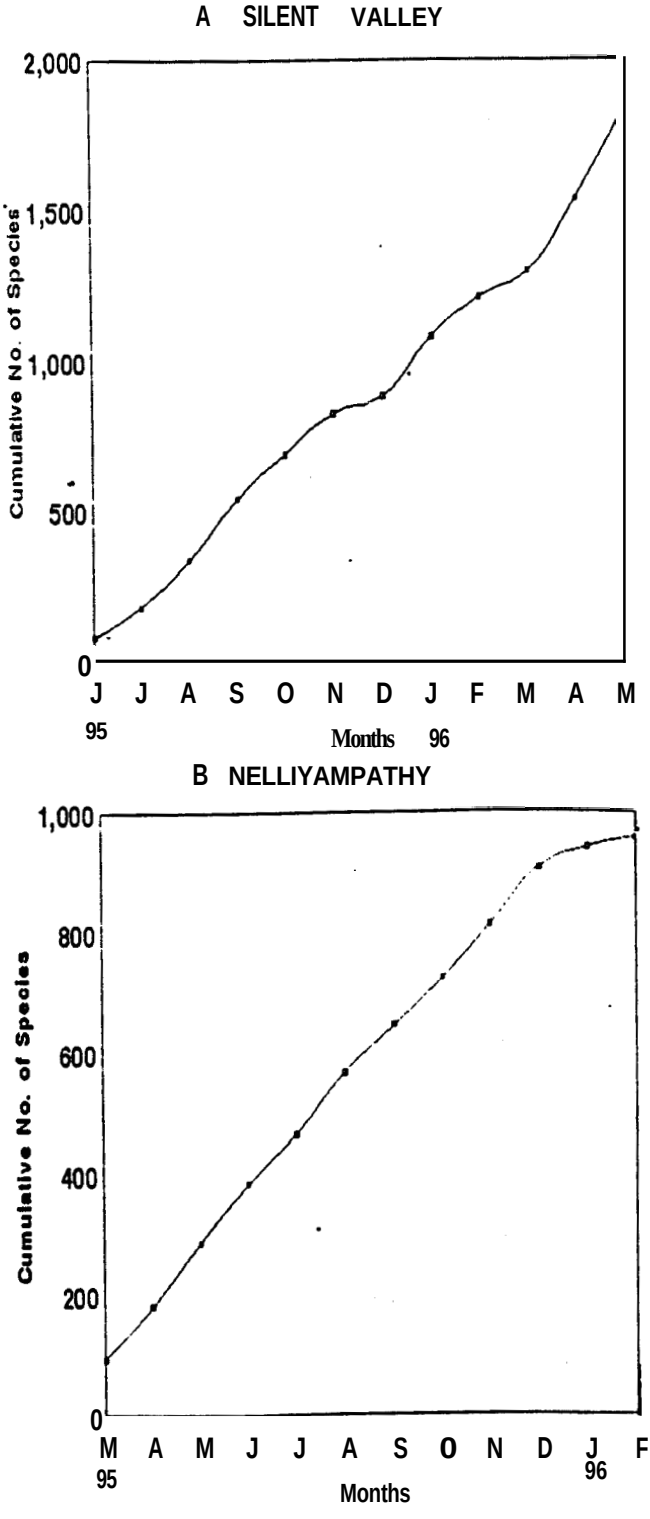

Fig. 18. Collector's curve lor the study areas a. Silent Valley, b.

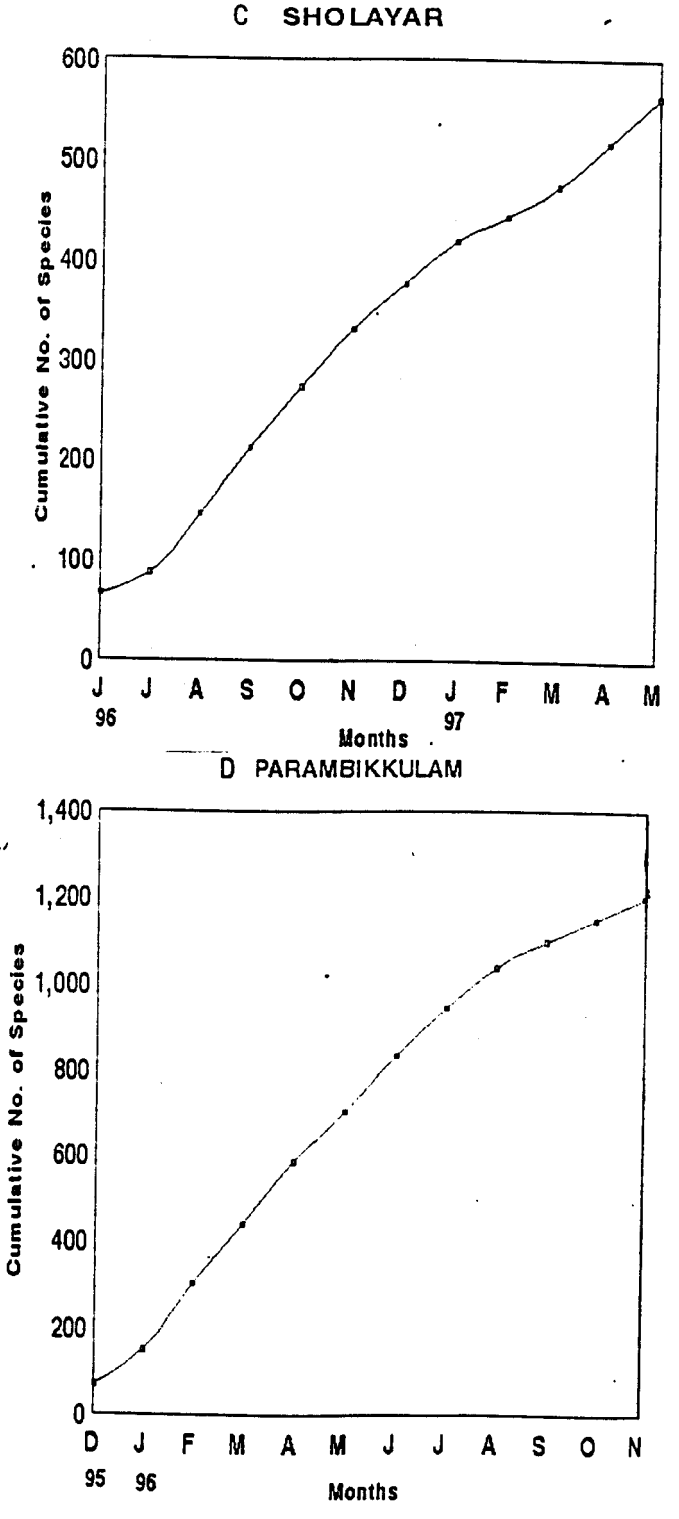

Fig. 19. Collector's curve for the study areas a. Sholayar. b. Parambikulam

Data on the number of species collected in each month from the disturbed and undisturbed areas are given in Table 5.

Area	1995							1996					Total
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
Undisturbed area	42	48	112	136	125	94	37	155	88	38	161	218	449
Disturbed area	52	74	91	131	56	73	34	122	68	66	166	207	417

Species richness

In both the areas, maximum collection was during May and least collection in December. There was a reduction in the catches during June, July 1995 in both the areas.

In the chi-square test, significant difference was found in the number of species collected in various months from the undisturbed ($x^2 = 347.89$) and disturbed areas ($x^2 = 3,07.47$).

Species richness index

The values for the undisturbed and disturbed areas were 5.91 and 6.10 respectively. The index was found to be higher for the disturbed area which indicates that there was no reduction in species diversity due to disturbance. This could probably be due to the stabilization of the habitats following recolonization by species from the adjacent areas. is also possible that as the regenerating vegetation is in its early phase, the canopy which is still open allows more dispersion of light from the light traps to greater distances enabling relatively higher number of species to be caught. In the dense forests where the canopy is closed, the dispersal of light is rather restricted which in turn might have affected the trap catches.

Dominance index

The dominance index for insect groups collected from Silent Valley is given in Table 6.

Table 6. Dominance index of insect Orders at Silent Valley

Order	Domninance Index	
	Disturbed area	Undisturbed area
Coleoptera	16.13	14.75
Hymenoptera	12.90	15.01
Hemiptera	3.61	6.08
Orthoptera	0.34	0.51
Dictyoptera	0.73	1.31
Dermaptera	0.54	0.64
Diptera	32.87	30.84
Ephemeroptera	0.19	0.09
Isoptera	3.66	0.99
Lepidoptera	23.59	25.25
Mecoptera	0.02	0.02
Neuroptera	0.04	0
Trichoptera	5.39	4.52

The dominant insect Orders with respect to number of individuals, in both the areas at Silent Valley were Diptera and Lepidoptera followed by Coleoptera and Hymenoptera. The dominance indices were more or less similar for both localities (disturbed and undisturbed) and showed only slight differences.

Maximum number of species collected belonged to Lepidoptera (49.67%)in the undisturbed and 46.28% in the disturbed areas) followed by Coleoptera (22.27% in the undisturbed and 24.2% in the disturbed areas) (Figs. 20 and 21).

Species abundance

The number of insects collected during the various months ranged from 73 to 1398 in the undisturbed area and from 63 to 1248 in the disturbed area. The number of individuals collected was less during June and December, 1995 and highest in April - May, 1996 (Table 7).

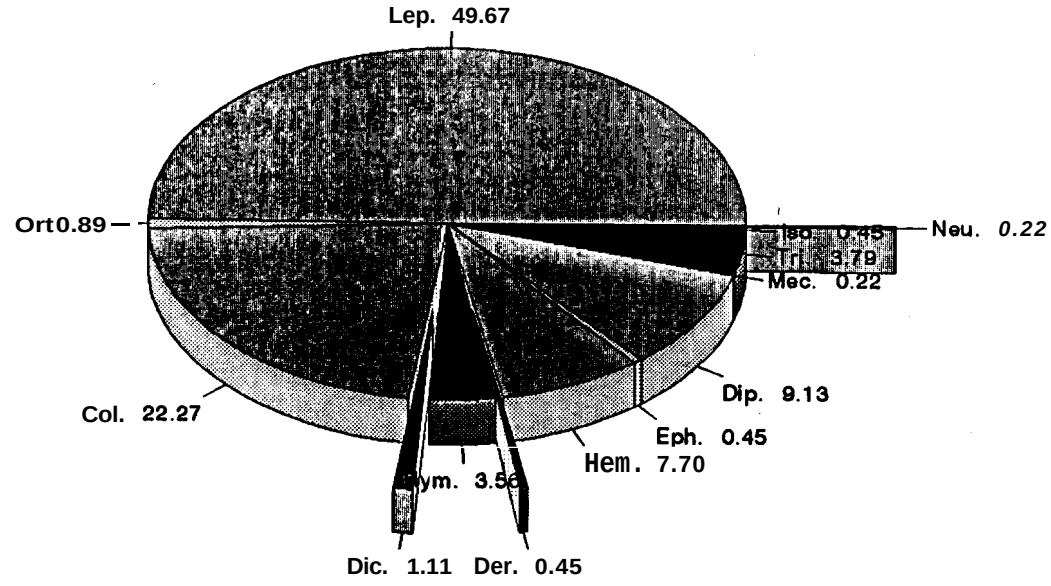

Fig.20. Representation of percentage of insect species belonging to various groups in Silent Valley (Undisturbedarea)

Lep-Lepldoptera; Iso-lsoptera; Tri-Trichoptera; Mec-Mecoptera; Dip-Diptera; Eph-Ephemeroptera; Hem-Hemiptera; Der-Dermaptera; Hym-Hymenoptera; Dic-Dictyoptera; Col-Coleoptera; Ort-Orthoptera

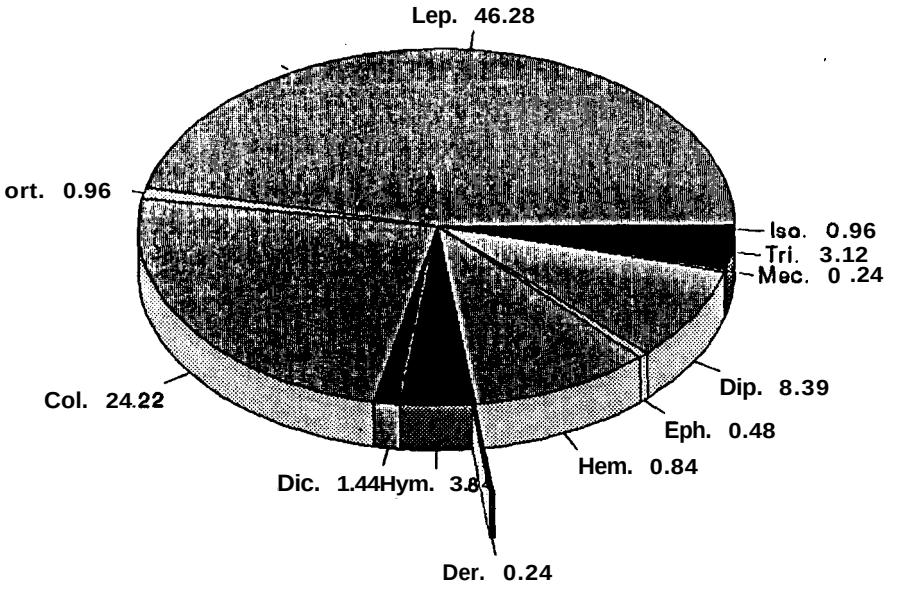

Fig. 21. Representation of percentage of insect species belonging to various groups in Silent Valley (Disturbed area)

Lep-Lepidoptera; Iso-Isoptera; Tri-Trichoptera; Mec-Mecoptera; Dip-Diptera; Eph-Ephemeroptera; Hem-Hemiptera; Der-Dermaptera; Hym-Hymenoptera; Dic-Dictyoptera; Col-Coleoplera; Ort-Orthoptera

Table 7. Monthly collection of insects from the study areas in Silent Valley

Area	1995							1996				
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Undisturbed area	73	152	406	923	428	314	73	760	269	109	877	1398
Disturbed area	102	230	326	472	149	167	63	467	175	215	1057	1248

The Chi-square test showed significant difference in the number of insects in various months for the undisturbed ($x^2 = 4009.78$) and disturbed ($x^2 = 4105.99$) areas.

Species diversity

Even though species abundance model provides full description of diversity, it cannot be used for comparison of diversity. For this, the Shannon's index of diversity was calculated which is a measure of diversity.

Monthly variations in Shannon's index of diversity in the undisturbed and disturbed areas are presented in Table 8.

Table 8. Species diversity index for insects at Silent Valley

Area	1995							1996					Total
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
Undistur-bed area	3.51	3.48	4.08	3.41	4.26	3.98	3.35	4.03	3.89	3.13	4.11	4.15	4.76
Disturbed area	3.50	3.68	3.83	4.22	3.46	3.71	3.34	3.80	3.58	3.52	4.11	3.92	4.65

The diversity index remained more or less in the same range through out the period of study although there was a slight increase in the undisturbed area in August and October 1995 and January, April and May, 1996. In the disturbed area, it was lowest in December, 1995.

A t-test was done to determine the significant difference between the disturbed and undisturbed areas in terms of species diversity. The t-value was found to be highly significant (2.29) which shows that the species present in the undistu-bed area is more diverse than those in the disturbed area.

Distribution model

A truncated lognormal distribution was fitted to the data (pooled data from undisturbed and disturbed areas) from Silent Valley. The observed and expected number of species was compared using x^2 goodness of fit test. The test showed no significant difference between the observed and expected distribution (Table 9) This shows that the distribution pattern of species is following truncated lognormal distribution at Silent Valley (x^2 = 11.47). This shows that a large number of rare species occur in Silent Valley. There were 202 species which were not covered in the survey.

Table 9. Truncated lognormal distribution at Silent Valley

Class	Upper class boundary	Observed species	Expected species	χ^2
Behind vail line	0.5	-	202.17	-
1.	2.5	248	236.58	0.55
2.	4.5	88	86.81	0.02
3.	8.5	73	81.54	0.89
4.	16.5	57	66.72	1.42
5.	32.5	49	47.34	0.06
6.	64.5	25	29.60	0.71
7.	128.5	25	16.18	4.81
8.	256.5	5	7.89	1.06
9.	512.5	6	3.42	1.95
10.	∞	2	1.92	0.003
Total	-	578	780.17	11.47

Evenness or equitability index

The evenness indices obtained for the undisturbed area was 0.78 and for the disturbed area it was 0.77 indicating that the undisturbed area contains more species and that they are uniformly distributed.

Similarity measures

Similarity index was calculated using modified Sorenson's formula and the value obtained was 0.65. It indicates that there is 65% similarity between the undisturbed and disturbed areas.

4.2.2.Nelliyampathy

Occurrence of species

Three hundred and twelve insect species belonging to 1 1 Orders and 79 Families were recorded from the undisturbed area and 119 belonging to 10 Orders and 53 Families were recorded from the disturbed area. Data on the number of species collected during the study period from Nelliyampathy are reported in Table 10.

Area	1995										1996		Total
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Undisturbed area	**47**	**51**	**89**	**88**	**72**	**68**	**51**	**56**	**47**	**51**	**21**	**10**	**312**
Disturbed area	**55**	**42**	**19**	**11**	**15**	**44**	**28**	**33**	**49**	**52**	**14**	**7**	**119**

Species richness

Maximum number of species collected from the undisturbed area was in May and June 1995. In the undisturbed area maximum collection was in March and December 1995. In both areas collections showed a declining trend from January (1996) onwards which may be due to the dry conditions with the onset of summer.

Species richness index

Species richness index was calculated using Meinhinick formula and the values were found to be higher for the undisturbed area (8.13) and low for the disturbed area (3.26) indicating richness in species in the undisturbed area.

Dominance index

The values obtained are given in Table 11. The dominant insect Orders with respect to the number of individuals in the undisturbed area were Coleoptera (55.50) and Lepidoptera (22.18) and in the disturbed area, Coleoptera (28.05).

Trichoptera (26.99). Lepidoptera (20.38) and Heimiptera (16.62). It may be noted here that there was an increase in the dominance index for groups like Hemiptera and Trichoptera in the disturbed area while in the undisturbed area, there was an increase in Diptera and Hymenoptera. The last two groups have economical significanceas they contain parasitoids of several pest insects which may have an application in biological control in future.

Table 11. Dominance index of insect Orders at Nelliyampathy

No.	Order	Dominance index	
		Undisturbed	Disturbed
1.	Coleoptera	55.50	28.05
2.	Dermaptera	-	0.15
3.	Dictyoptera	3.26	2.33
4.	Diptera	3.05	0.90
5.	Hemiptera	7.53	16.62
6.	Hymenoptera	3.87	1.80
7.	Lepidoptera	22.18	20.38
8.	Neuroptera	0.88	0.68
9.	Odonata	-	0.30
10.	Orthoptera	1.15	1.05
11.	Trichoptera	2.24	26.99
12.	Plecoptera	0.27	-

Maximum number of species collected belonged to Coleoptera (35.26% in the undisturbed and 38.66% in the disturbed area).

Least value obtained was for Plecoptera (0.32%) in the undisturbed area followed by Hymenoptera (0.84%) in the disturbed area (Figs. 22 and 23).

Species abundance

In both the areas, least collection obtained was during February and January, 1996. Maximum collection in the undisturbed area was in June (183) and August (243 spp.) in 1995 in both the disturbed areas. Least collection obtained in both the areas was in February (11 spp.) (Table 12)

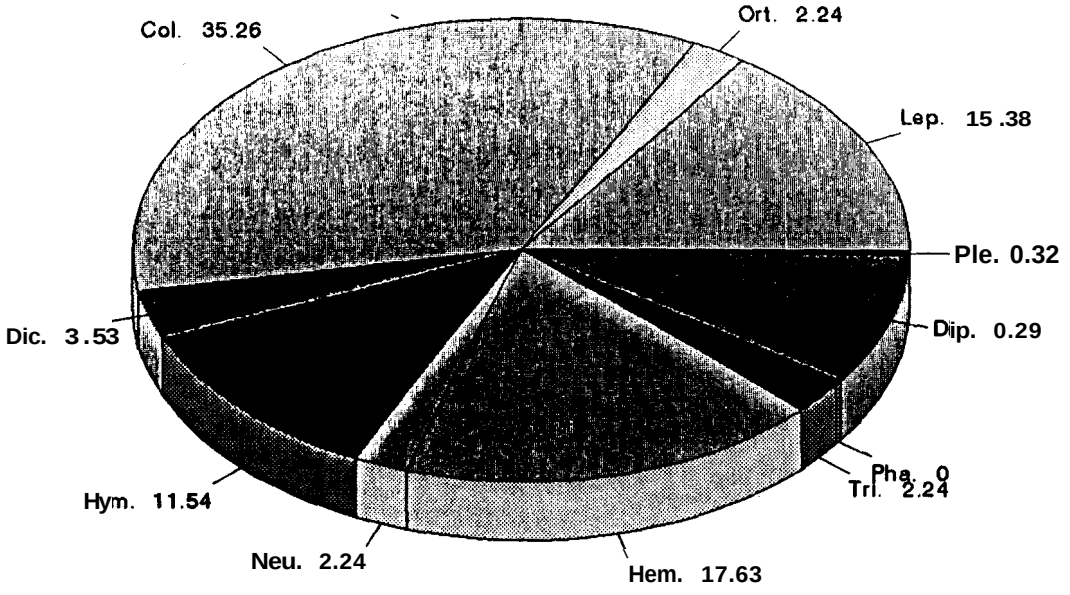

Fig. 22. Representation of percentage of insect species belonging to various groups in Nelliyampathy (Undisturbed area)

Col-Coleoptera; Ort-Orthoptera; Lep-Lepldoptera; Ple-Plecoptera; Dip-Dlptera; Pha-Phasmlda; Td-Trlchoptera; Hem-Hemiptera; Neu-Neuroptera; Hym-Hymenoptera; Dlc-Dlctyoptera

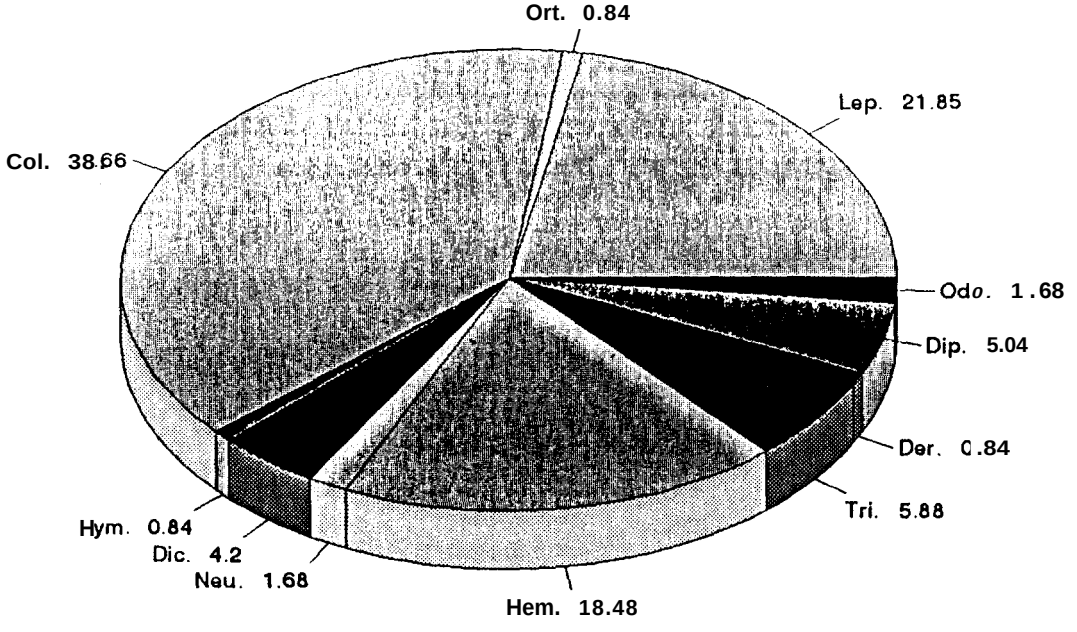

Fig. 23. Representation of percentage of insect species belonging to various groups in Nelliyampathy (Disturbed area)

Ort-Orthoptera; Lep-Lepidoptera; Odo-Odonata; Dip-Diptera; Der-Dermaptera; Tri-Trichoptera; Hem-Hemiptera; Neu-Neuroptera; Dic- Dictyoptera; Hym-Hymenoptera; Col-Coleoptera

Area	1995										1996		
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Undisturb area	133	118	162	183	141	163	22	144	115	132	49	11	1474
Disturbed area	156	120	62	213	73	243	82	99	105	138	29	11	1330

The results of chi-square test indicated significant difference in number of insects collected during various months in the undisturbed ($x^2 = 214.53$) and disturbed ($x^2 = 471.06$) areas.

Species diversity

Shannon's index of species diversity calculated month - wise for the disturbed and undisturbed study areas at Nelliyampathy are given in Table 13.

Table 13. Species diversity indices for insects at Nelliyampathy

Area	1995										1996		Total
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Undis-turbed area	3.58	3.71	4.33	4.31	4.11	3.95	3.64	3.78	3.68	3.67	2.75	2.27	5.21
Disturbed area	3.52	3.29	2.61	1.04	2.09	2.65	2.85	3.26	3.64	3.65	2.49	1.77	3.91

The number of insect species in the community was found to be variable. In order to find out whether there existed any significant difference in the insect species diversity between undisturbed and disturbed areas, a 't' test was done. It was found that the two areas were significantly different ($t = -29.94$) in terms of the diversity of insects occurring in these areas and that the undisturbed area is more diverse than the disturbed area.

Distribution models

A truncated lognormal distribution was fitted to the data (pooled data from undisturbed and disturbed areas) from Nelliyampathy. The observed and expected number of species was compared using x^2 goodness of fit test. The test

showed no significant difference between the observed and expected distribution (Table 14). This shows that the distribution pattern of species is following truncated lognormal distribution at Nelliyampathy ($x2 = 9.082$). It indicates that there are more rare species to be collected from Nelliyampathy. There were 29 species which were not covered in the survey.

Table 14. Truncated lognormal distribution at Nelliyampathy

Classes	Upper class boundary	Observed species	Expected species	X^2
Behind veil line	0.5	-	29.04	-
1.	2.5	158	144.88	1.18
2.	4.5	55	74.49	5.09
3.	8.5	76	69.17	0.67
4.	16.5	49	47.64	0.03
5.	32.5	20	24.04	0.67
6.	64.5	9	8.84	0.002
7.	128.5	4	2.39	1.08
8.	∞	1	0.55	0.36
Total		372	401.04	9.082

Evenness or equitability index

The evenness indices for the disturbed area was 0.82 and for the undisturbed area it was 0.91. This shows that the species are uniformly represented in the undisturbed area.

Similarity measures

Modified Sorenson's similarity index was calculated to find the similarity between undisturbed and disturbed areas at Nelliyampathy and the value obtained was 0.14. It indicates that the undisturbed and disturbed sites are not similar with regard to the species present.

4.2.3. Sholayar

Occurrence of species

Data on the number of species collected from various sites at Sholayar are given in Table 15.

Table 15. Number of insect species collected at Sholayar in different months

Area	1996							1997					Total
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
Undisturbe-darea	53	16	48	58	51	46	38	31	10	17	27	36	163
Disturbed area	15	6	13	20	12	16	9	11	15	14	18	13	63

One hundred and sixty three species belonging to 9 Orders and 27 Families and 63 species of insects belonging 27 Families of the same Orders were collected from the undisturbed and disturbed areas respectively.

Species richness

Data on the number of species collected from the undisturbed area have indicated that the highest number of species obtained was in September 1996(58) and October 1996(51), and the least in February 1997(10). In the disturbed area maximum number of species collected was in September 1996(20) followed by April 1997(18) and the least in July 1996(6).

Significant differences were noted in insect species richness during various months in the undisturbed ($x^2 = 70.76$) and disturbed areas ($x^2 = 11.79$).

Species richness index

The species richness index was found to be higher for the undisturbed area (5.49) compared to the disturbed area. This could be due to the extreme simplification of the floral elements in the disturbed area as a result of heavy disturbance of anthropogenic origin. As a result, there were only a few trees and the ground flora was mostly occupied by weeds, mostly *Mikania macrantha,* Lantana as well as low grasses.

Dominance index

The dominance indices of insect Orders at Sholayar is given in Table 16.

The dominant insect Orders with respect to number of individuals in the undisturbed area were Lepidoptera (65.01) and Coleoptera (27.29) and in the disturbed area, Isoptera (34.52). Lepidoptera (26.95) and Coleoptera (22.93) vere the dominant groups.

Table 16. Dominance indices of insect Orders collected from Sholayar

Order	Dominance indices	
	Undisturbed area	Disturbed area
Coleoptea	27.29	22.93
Dictyoptera	0.91	0.71
Diptera	-	0.47
Hemiptera	1.59	8.99
Hymenoptera	1.25	0.7 1
Isoptera	0.79	34.52
Lepidoptera	65.01	26.95
Neuroptera	0.9 1	-
Orthoptera	1.70	2.60
Plecoptera	0.57	2.13

Maximum number of species collected belonged to Lepidoptera (7 1.17%) in the undisturbed and disturbed areas (34.92%) (Figs. 24 and 25). Least number of species collected belonged to Plecoptera (0.61%) and Orthoptera (0.61%) in the undisturbed area and to Diptera (1.59%) and Dictyoptera (1.59%) in the disturbed area.

Species abundance

The monthly collection of insects is presented in Table 17. The number of insects recorded ranged from 17 to 152 in the undisturbed area and from 9 to 136 and in the disturbed area. Maximum number of insects recorded from the undisturbed area was in September 1996(152) and lowest in February 1997(17) and for the disturbed area maximum collection was in Aug 1996 (136) and least during July 1996(9).

Table 17. Number of insects recorded at Sholayar in various months

Area	1996							1997					Total
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
Undisturbed area	73	18	114	152	133	92	70	63	17	31	74	46	883
Disturbed area	30	9	136	32	32	26	29	29	21	18	41	20	423

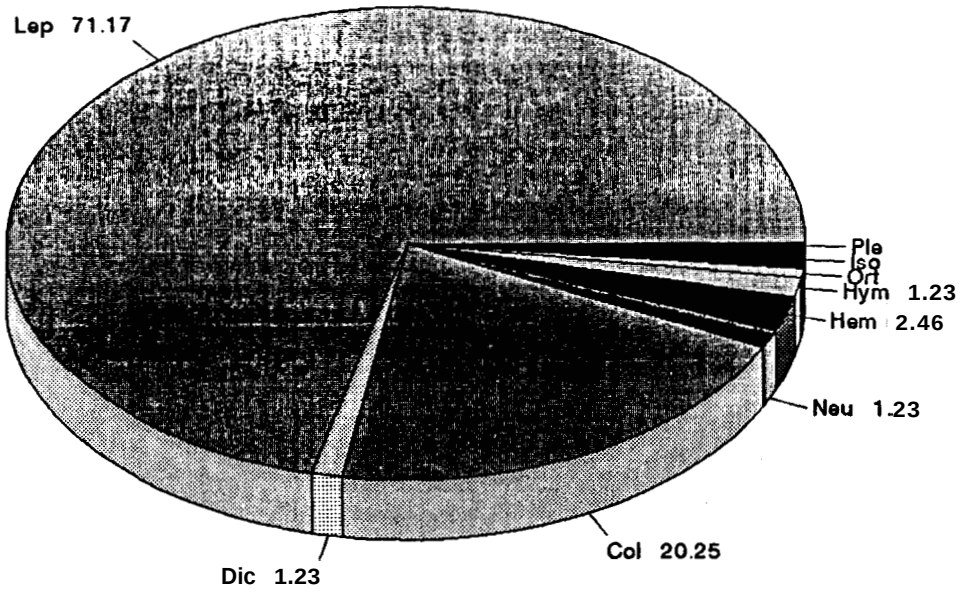

Fig. 24. Representation of percentage of insect species belonging to various groups in Sholayar (Undisturbed area)

Lep-Lepidoptera; Ple-Plecoptera; Iso-Isoptera; Ort-Orthoptera; Hym-Hymenoptera; Hem-Hemiptera; Neu-Neuroptera; Col-Coleoptera; Dlc-Dictyoptera

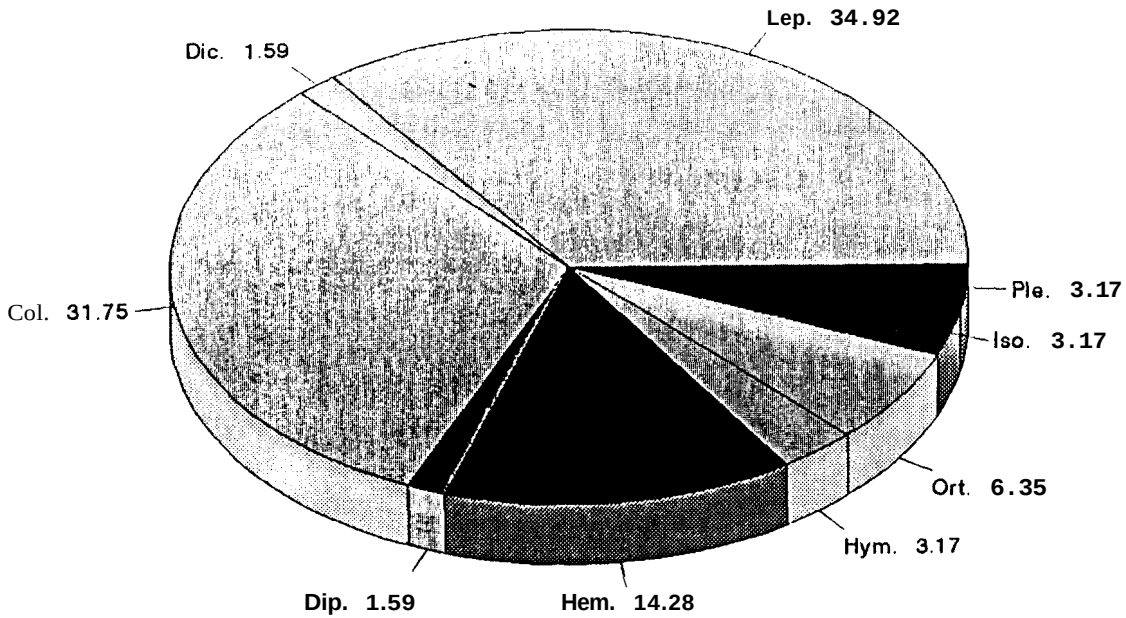

Fig. 25. Representation of percentage of insect species belonging to various groups in Sholayar (Disturbed area)

Lep-Lepidoptera; Ple-Plecoptera; Iso-Isoptera; Ort-Orthoptera; Hym-Hymenoptera; Hem-Hemiptera; Dip-Diptera; Col-Coleoptera: Dic-Dictyoptera

Chi-squire test showed highly significant differences in the number of species over various months in the undisturbed (x^2 = 287.49) and disturbed (x^2 = 335.25) areas

Species diversity

Month-wise Shannon's index of diversity for various study sites at Sholayar are presented in Table 18.

Table 18. Species diversity index for insects collected from Sholayar

Area	1996							1997					Total
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
Undis-turbed area	3.86	3.74	2.72	3.80	3.83	3.71	3.53	3.34	2.15	2.77	2.36	3.52	4.79
Disturbed area	2.27	1.68	0.68	2.76	1.96	2.66	1.58	2.31	2.62	2.58	2.40	2.32	3.13

Maximum diversity (4.79) was recorded in the undisturbed area compared to the disturbed area (3.13). When the month-wise diversity was compared highest diversity index recorded was 3.86 during June, 1966 in the case of undisturbed area and 2.76 during September, 1996 in the case of disturbed area. Least values obtained were 2.15 during February, 1997 in the undisturbed area and 0.68 during August, 1996 in the case of disturbed area.

Significant difference was obtained in diversity of insects between undisturbed and disturbed areas at Sholayar (t=14.03) which shows that the undisturbed area is thus more diverse than the disturbed area.

Distribution model

A truncated lognormal distribution was fitted to the data(poo1ed data from undisturbed and disturbed areas) from Sholayar. The observed and expected number of species was compared using x^2 goodness of fit test. The test showed no significant difference between the observed and expected distribution (Table 19). This indicates that the distribution pattern of species is following truncated lognormal distribution (x^2 = 13.96). This shows that there are not many rare species of insects to be collected from Sholayar and that there were just 2 species that were not covered in the survey.

Table 19. Truncated lognormal distribution at sholayar

Class	Upper class boundary	Observed species	Expected species	x^2
Behind vail Line	0.5	-	1.57	-
1.	2.5	53	54.59	0.05
2.	4.5	45	51.12	0.73
3.	8.5	70	59.56	1.83
4.	16.5	21	22.01	0.05
5.	32.5	8	9.8	0.33
6.	∞	2	1.92	0.003
Total		199	200.57	2.993

Evenness or equitability index

Shannon's eveness index was calculated for the study areas and the index was found to be high (0.94) for the undisturbed area and less for the disturbed area (0.76). indicating rich species diversity in the undisturbed area.

Similarity measures

Modified Sorenson's similarity index was also calculated for disturbed and undisturbed areas and the value obtained was 0.38. This shows that there exists only weak similarity between disturbed and undisturbed areas at Sholayar.

4.2.4. Parambikulam

Occurrence of species

Three hundred and fifty one species of insects were recorded from the undisturbed and 292 species from the disturbed areas at Parambikulam. Species collected from the former belonged to 11 orders and 62 families and to 9 orders and 56 families in the latter.

Species richness

Data on the number of species collected from the disturbed and undisturbed areas at Parambikulam are given in Table 20.

Table 20. Number of species of insects collected at Parambikulam in different months

Area	'95	1996											Total
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
Undis-turbed area	52	67	115	118	71	67	77	75	63	41	24	32	351
Disturbed area	47	53	92	57	95	80	95	51	51	31	30	25	292

It may be noted that in the undisturbed area, maximum number of insects was collected in March 1996 (118) followed by February 1996 (115) and least in October 1996 (24). In the disturbed area, the number of species collected was higher in April and June 1996. (95 each) and June 1996 (95) and least in November 1996 (25).

Distinct seasonal changes in species composition were observed during the study period in both the undisturbed as well as the disturbed areas. There was also a reduction in the number of species during the monsoon months (July-November). During the summer months (January-May).the number of species collected was relatively high.

It was found that there was significant difference in insect species richness in various months from the undisturbed ($x^2 = 144.45$) and disturbed ($x^2 = 122.45$) areas.

Species richness index

Species richness index showed high values for undisturbed area (5.62) compared to the disturbed area (4.46) indicating that the undisturbed areas are more diverse.

Dominance index

The dominance indices for various insect groups at Parambikulam are given in Table 21.

Table 21. Dominance index of insect Orders at Parmabikulam

Order	Dominance indices	
	Undisturbed area	Disturbed area
Coleptera	50.15	60.03
Dictyoptera	0.67	0.91
Diptera	14.16	9.44
Ephemeroptera	0.23	-
Hemiptera	12.17	7.08
Hymenoptera	8.04	17.02
Isoptera	1.97	0.61
Lepidoptera	11.37	4.55
Odonata	0.05	-
Orthoptera	0.74	0.16
Trichoptera	0.44	0.19

The dominant insect groups in the undisturbed area were Coleoptera (50.15), Diptera (14.16) and Hemiptera (12.17) while in the disturbed area, Coleoptera (60.03), Hymenoptera (17.02) and Diptera (9.44) were the most abundant groups.

Maximum nhmber of species collected belonged to Coleoptera (41.88% in the undisturbed area and 41.1% in the disturbed area) folowed by Lepidoptera (19.37% in the undisturbed and 19.18% in the disturbed area) (Figs. 26 and 27). Least number of species collected belayed to (0.28) in the undisturbed area and Trichoptera (0.34) puther disturbed area.

Species abundance

The number of insects recorded in each month in the undisturbed and disturbed areas are presented in Table 22.

Table 22. Number of insects recorded in each month at Parambikulam

Area	'95	1996											Total
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
Undis-turbed area	358	473	488	681	397	389	303	247	344	93	64	67	3904
Disturbed area	156	255	550	325	1308	555	511	188	262	85	41	52	4288

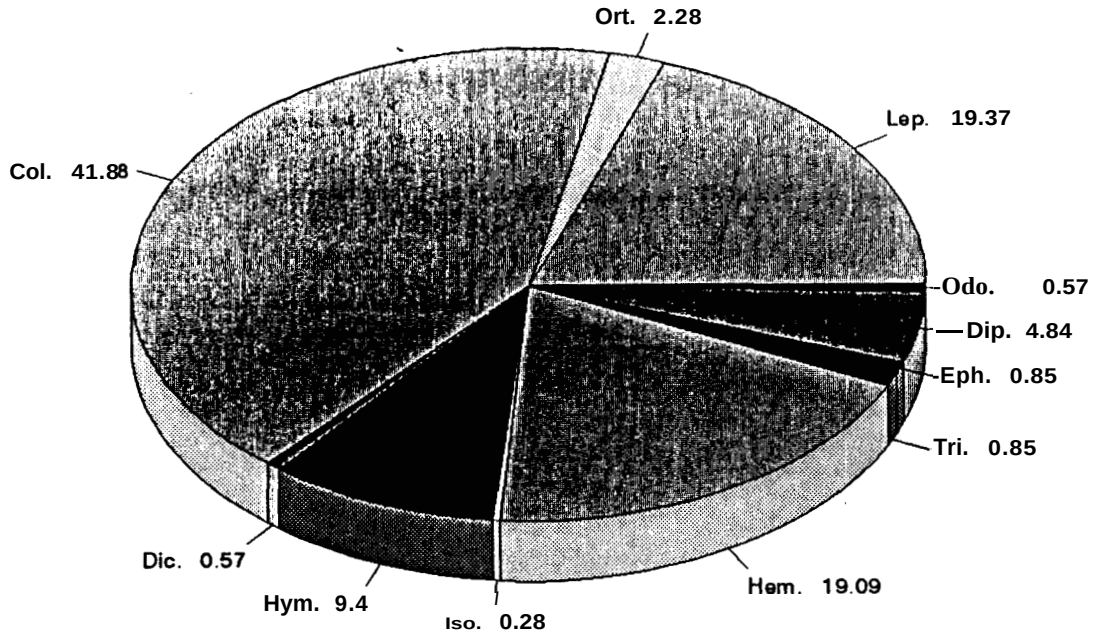

Fig. 26. Representation of percentage of insect species belonging to various groups in Parambikulam (Undisturbed area)

Ort-Orthoptera; Lep-Lepidoptera; Odo-Odonata; Dip-Diptera; Eph- Ephemeroptera; Tri-Trichoptera; Hem-Hemiptera; Iso-Isoptera; Hym- Hymenoptera; Dic-Dictyoptera; Col-Coleoptera

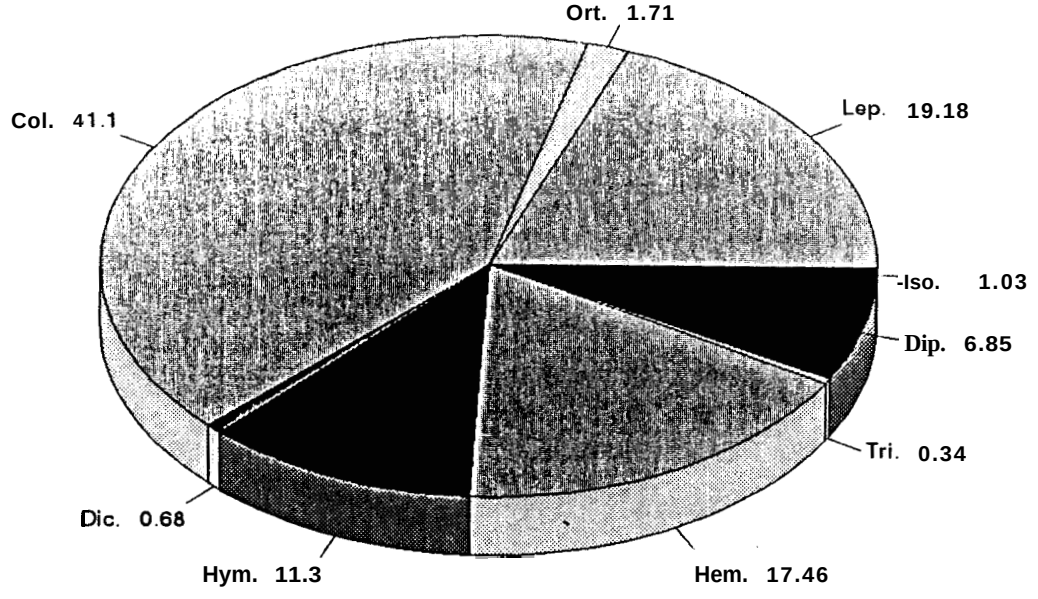

Fig. 27. Representation of percentage of insect species belonging to various groups in Parambikulam (Disturbed areal

Ort-Orthoptera; Lep-Lepidoptera; Iso-Isoptera; Dip-Diptera; Tri- Trichoptera; Hem-Hemiptera; Hym-Hymenoptera; Dic-Dictyoptera; Col-Coleoptera

The number of insects collected ranged from 64 (October 1996) to 681 (March 1996) in the undisturbed area and from 41 (October 1996) to 1308 (April 1996) in the disturbed area. Least number of insect collectd was from September to November 1996 in both the areas.

A chi-square test showed highly significant difference in the number of insects in various months in undisturbed (x^2 = 1171.16) and disturbed (x^2 = 3808.37) areas.

Species diversity

Shannon's index of diversity was calculated monthwise for various study sites as presented in Table 23.

Table 23. Species diversity indices for insects collected from Parambikulam

Area	'95	1996											Total
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
Undisturbed area	**2.59**	**2.91**	**4.00**	**3.53**	**3.56**	**3.61**	**3.73**	**3.60**	**3.20**	**3.52**	**2.89**	**3.31**	**4.64**
Disturbed area	**3.46**	**3.36**	**3.13**	**2.80**	**2.54**	**2.86**	**2.93**	**3.10**	**2.48**	**2.84**	**3.32**	**2.99**	**3.99**

In the undisturbed area, the highest diversity obtained was 4.00 (February 1995) and the least 2.59 (December 1995). For the disturbed area, the highest diversity obtained was 3.46 (December, 1995) and least 2.48 (August, 1996).

A t-test was carried out to find out whether any significant difference existed in the insect species diversity between disturbed and undisturbed areas. Significant difference was obtained in the insect diversity between undisturbed and disturbed areas (t = 11.98) indicating that the undisturbed areas were more diverse than the disturbed areas.

Distribution model

A truncated lognormal distribution was fitted to the data (pooled data from undisturbed and disturbed areas) from Parambikulam. The observed and expected number of species was compared using x^2 goodness of fit test. The test

showed no significant difference between the observed and expected distribution (Table 24). This shows that the distribution pattern of species is following truncated lognormal distribution at Parambikulam ($x^2 = 2.993$). This shows that there are rare species to be collected from Parambikulam. There were 53 species that were not covered in the survey.

Table 24. Truncated lognormal distribution at Parambikulam

Class	Upper class boundary	Observed species	Expected species	χ^2
Behind veil line	0.5	-	52.82	-
1.	2.5	144	137.94	0.26
2.	4.5	66	66.20	0.00
3.	8.5	73	68.59	0.28
4.	16.5	50	58.86	1.33
5.	32.5	45	41.87	0.23
6.	64.5	17	24.81	2.45
7.	128.5	13	12.22	0.04
8.	256.5	3	5.07	0.84
9.	512.5	5	1.77	5.89
10.	1024.5	2	0.67	2.64
Total		418	470.82	13.96

Evenness of equitability index

Shannon's evenness index for the undisturbed area was 0.79 and for the disturbed area, it was 0.70 indicating rich species diversity in the latter.
Similarity measures

Modified Sorenson's similarity index obtained was 0.48. This shows that there is 48% similarity between disturbed and undisturbed areas at Parambikulam. This is in support of the findings that there is significant difference in species diversity between disturbed and undisturbed areas.

4.3. General characteristics of insect fauna

Faunal elements

Insects belonging to only 15 Orders were collected. Of the 1250 species collected from the study areas, 586 species could be identified as indicated (Appendix II

and 111). Out of these, 368 species were found in Silent Valley. 290 species in Nelliyampathy, 147 species in Sholayar and 271 species in Parambikulam. In all the areas Lepidoptera and Coleoptera were the most dominant groups. At Silent Valley and Sholayar maximum number of species collected belonged to the order Lepidoptera (49.14% and 66.37%) while at Nelliyampathy and Parambikulam maximum number of insects collected belonged to Coleoptera (34.14% and 39.7 1%). An examination of species recorded under these orders show that the families Pyralidae, Noctuidae, Geometridae and Arctiidae (Lepidoptera)as well as Chrysomelidae, Cerambycidae and Tenebrionidae (Coleoptera) contained maximum number of species recorded under this study. Species belonging to most of these families are phytophagous in habits and hence their distribution is dependent on the vegetation. Certain families like Lymantriidae. Saturnidae, Limacodidae and Hepialidae (Lepidoptera)and Lucanidae, Cicindelidae and Lariidae (Coleoptera)were collected only in small numbers.

While the economic importance of certain species collected in this study is already known. for several species such information is not available and detailed biological studies are required to assign their significance and role in the sustenance of tropical forest ecosystems.

Distribution of insects

Appendix II shows the occurrence of various species in different study areas. Although the four localities included in this study are located more or less in the same geographical region, the insects occurring in these areas were found to be distinct. Based on the presence or absence of any particular species in any of these localities alone, we may not be able draw any conclusion regarding the occurrence and distribution pattern of insects in these areas since as has been shown by the Collector's curve and the distribution models, these areas contain more species which remain to be collected. The t-test also showed significant difference between various sites except Silent Valley and Sholayar (1.78). In fact, the study was made in sample plots along a transect. Considering the extent of the forest area in relation to the sample plots, the insects collected in this study may not be enough to make any broad generalisations on the insects fauna of this region. Also, for samplings, we had used only two methods viz., sweeping with hand nets and collection by setting up light traps, wherein we used 8 V UV/fluorescent tubes of 22 cm length. Actually using 20 V tubes of 60 cm length would have been much more effective as shown by studies carriedout elsewhere. We couldn't go for this, because of difficulties in using a generator for this purpose. The operation of generator was difficult on account of difficulty in carrying this equipment to the various plots and also due to the

sound it produces which will be disturbing for various wild animals like monkeys, bison and elephants. The present study has however, provided baseline data on the major insect groups present in different locations and further studies required for getting a complete picture of the overall distribution pattern of insects in this area.

5. GENERAL DISCUSSION

5.1. PATTERNS OF PLANT DIVERSITY

Of the four areas (Tables 25 and 26). Silent Valley registered the highest plant diversity (3.90). This area was also found to be rich in the number plant species (130) and individuals (3951). Then comes Nelliyampathy with a diversity index of 3.26. This area contained 18 16 plants belonging to 50 species. Sholayar with a diversity index of 3.13 had 1209 plants belonging to 32 species. Least values obtained was for Parambikulam where only 623 plants belonging to 35 species were present. The diversity index was 2.67.

These ratings of plant diversity, although based on data generated from arbitrarily selected study plots-covering just 5000 sqm in each location may not be enough to make any generalisations on vegetational diversity considering the small sample size in relation to the vast forest area present in each of these localities. In fact, our intention was only to rate the different areas on the basis of vegetational characteristics in order to allow a fairly reasonable comparison of these areas with regard to plant diversity. As insect diversity is expected to be dependent on plant diversity, a comparison could be made between the two so as to indicate the possible attributes of plant composition on insect abundance.

Excepting Silent Valley, in all locations the disturbed areas contained less number of plants. The disturbed area in Silent Valley contained more number of plants (2343) and species (109) compared to the undisturbed area (1608 plants belonging to 81 species). The number of tree seedlings and saplings in the disturbed area was more or less comparable to that in the undisturbed area and the increase in the floral elements was mainly due to the presence more number of plants belonging to the categories shrubs, herbs and climbers which have invaded the disturbed patch from the adjacent forests and grasslands.

However, the above trend was not found in other areas. For example, the disturbed area in Nelliyampathy contained only 652 plants while the undisturbed area contained 1164 plants. While the flora in the undisturbed areas contained a high proportion of mature trees, tree seedlings and saplings, the disturbed areas contained lesser number of these elements and there was an increase in shrubs and herbs.

Table 25. Characteristics of the vegetation in the different study areas

Silent Valley							
Community Parameters	Plant categories						
	Mature trees	Tree saplings	Tree seedlings	Shrubs	Herbs	Climbers	Total
No. of species	49	73	66	2	13	19	130
No. of plants	307	981	1243	973	252	195	3951
Diversity	3.37	3.38	3.48	2.08	1.46	2.43	3.90
Richness	2.80	2.33	1.87	0.71	0.82	1.36	2.07
Evenness	0.85'	0.79	0.83	0.67	0.57	0.83	0.80
No. of species	36	27	27	6	5	0	50
No. ofplants	385	240	564	151	476	0	1816
Diversity	2.80	2.76	2.66	1.40	1.34	0	3.26
Richness	1.83	1.74	1.14	0.49	0.23	0	1.17
Evenness	0.78	0.84	0.81	0.78	0.83	0	0.83

Table 26. Characteristics of the vegetation in various study areas

Sholayar							
Community Parameters	Plant categories						
	Mature trees	Tree saplings	Tree seedlings	Shrubs	Herbs	Climbers	Total
No. of species	28	23	22	2	1	1	32
No. of plants	272	191	470	142	65	69	1209
Diversity	3.14	2.91	2.85	0.34	0.00	0.00	3.13
Richness	1.70	1.66	1.01	0.17	0.12	0.12	0.92
Evenness	0.94	0.93	0.92	0.49	0.00	0.00	0.90
No. of species	22	12	17	12	3	1	35
No. of plants	129	147	189	110	45	3	623
Diversity	2.43	1.80	2.05	1.53	0.29	0	2.67
Richness	1.94	0.99	1.24	1.14	0.45	0.58	1.40
Evenness	0.79	0.72	0.72	0.62	0.26	0	0.75

At Sholayar, where there was heavy disturbance due to human interference (fire wood collection, cattle grazing etc.), the disturbed area contained only 237 plants belonging to just 15 species. There was an extreme reduction in the number of plants belonging to tree categories. The ground vegetation was also simplified due to invasion by various weeds like *Mikania macrantha, Lantana* sp., etc. The undisturbed area on the otherhand was rich in mature trees, tree saplings and seedlings and contained 972 plants under 25 species, indicating a flourising forest stand.

Least number of plants recorded was from Parambikulam. A total of 452 plants belonging to 30 species, mostly belonging to the categories of mature trees, tree saplings and tree seedlings were recorded from the undisturbed area. However the disturbed area contained only 171 plants belonging to 19 species which mostly belonged to the categories of shrubs and herbs. The reduction in venous plant categories in the disturbed area was mainly due to teak monoculture which allows only limited regeneration.

Based on a comparison of floral diversity as discussed above, it was concluded that the forests of Silent Valley are less affected by the perturbations probably because of its isolation and absence of continued disturbance. The effect of disturbance was very much pronounced in the disturbed patches of Sholayar and Nelliyampathy as these areas are under continued stress. In the case of Parambikulam. clearfelling of natural forests and raising of teak plantations had considerable impact on the vegetation as indicated by the extreme reduction in the floral elements.

5.2. PATTERNS OF INSECT DIVERSITY

The overall pattern of diversity using pooled values of diversity index (undisturbed and disturbed) showed that although Silent Valley contained a higher number of individuals and species (10451/578), the species diversity was only 4.83 whereas in the case of Nelliyampathy the index was 5.13. This area contained only 2804 individuals under 372 species. In the case of Sholayar where the diversity index was 4.74, a total of 1306 individuals belonging to 199 species were present, For Parambikulam where the diversity index was 4.50, there were 8192 insects belonging to 418 species (Table 27).

On the whole, the overall values of insect diversity for various localities were more or less similar although Nelliyampathy and Silent Valley had higher values

of diversity index. In the comparison made between the four localities using modified Soreson's similarity index, the values were found to be moderate for the pair Nelliyampathy - Sholayar (0.55) followed by Silent Valley - Parambikulam (0.28); Parambikulam - Nelliyampathy (0.25); Parambikulam - Sholayar (0.25); Parambikulam - Sholayar ((0.25); Silent Valley - Nelliyampathy (0.23) and Silent Valley - Sholayar (0.23). The t-test showed significant difference in insect species diversity for the pairs Silent Valley-Parambikulam (9.23); Silent Valley - Nelliyampathy (7.45); Nelliyampathy - Parambikulam (14.12) ; Sholayar - Parambikulam (4.28) and Nelliyampathy - Sholayar (6.56). Whereas the t-test showed non- significant difference in diversity index between the sites Silent Valley and Sholayar (1.78). the other locations were significant.

Table 27. Data on insects and plants recorded from various study sites

Study area	Plant diversity	Plant species	Plant number	Insect diversity	Insect species	Insect number
Silent Valley						
Overall values	**3.90**	**130**	**3951**	**4.83**	**578**	**10451**
Values for undist. area	**3.66**	**81**	**1608**	**4.76**	**449**	**5781**
Values for dist. area	**3.55**	**109**	**2343**	**4.65**	**417**	**4670**
Overall values	**3.26**	**50**	**1816**	**5.13**	**372**	**2804**
Values for undist. area	**2.92**	**32**	**1164**	**5.21**	**312**	**1474**
Values for dist. area	**2.85**	**42**	**652**	**3.91**	**119**	**1330**
Sholayar						
Overall values	**3.13**	**32**	**1209**	**4.74**	**199**	**1306**
Values for undist. area	**3.03**	**25**	**972**	**4.79**	**163**	**883**
Values for dist. area	**1.85**	**15**	**237**	**3.13**	**63**	**423**
Overall values	**2.67**	**35**	**623**	**4.50**	**418**	**8192**
Values for undist. area	**2.68**	**30**	**452**	**4.64**	**351**	**4288**
Values for dist. area	**2.24**	**19**	**171**	**3.99**	**292**	**3904**

5.3. A COMPARISON OF PLANT AND INSECT DIVERSITY

It may be noted from Table 27 that the number of plant (130 spp.) and insect (578 spp.) species was highest in Silent Valley. At Nelliyampathy, where 50

species of plants were recorded, the number of insect species recorded was 372. At Parambikulam. where only 35 species of plants were recorded, the number of insects was found to be fairly high (418 spp.). Lowest values of plant (32) and insect (199) species was for Sholayar.

With regard to diversity, the highest values were obtained for and Nelliyampathy (plant diversity - 3.26; insect diversity 5.13) and Silent Valley (Plant diversity - 3.90: insect diversity 4.83). followed by Sholayar (plant diversity - 3.13: insect diversity - 4.74) and Parambikulam (plant diversity - 2.67; insect diversity - 4.50). The insect and plant diversity indices were found to be significantly correlated ($r = 73.49\%$ at $P = 0.05$).

5.4. IMPACT OF DISTURBANCE ON INSECT DIVERSITY

Maximum number of insects collected was from the undisturbed area in Silent Valley (578 1 individuals and 449 species). A total of 4670 individuals belonging to 417 species have been recorded from-the disturbed area. This was followed by Parambikulam where 4288 individuals were collected from the undisturbed area and 3904 individuals from the disturbed area. The number of species recorded was also higher in the undisturbed area (351) compared to the disturbed area (292). It was surprising to note that such high number of insects have been recorded from an area that has been subject to extreme disturbance. Probably the increase in the number of insects in this area might be due to the recolonisation of the changed habitats by insects present in the surrounding patches of natural forests. In fact, the isolated high forests surrounding the plantations are more or less free from any major disturbance and hence will serve as natural reserves for many groups of insects. It may also be pointed out here that over years, the teak plantations have developed into some what mixed stands in the absence of routine silvicultural practices that will eradicate miscellaneous plant growth.

In the case of Nelliyampathy and Sholayar, the undisturbed areas were rich in insects both in the number of individuals and species. In the former. 1474 individuals belonging to 3 12 species from the undisturbed and 1330 individuals belonging to 119 species in the disturbed forest have been recorded. At Sholayar, 883 individuals belonging to 163 species in the undisturbed and 423 individuals belonging to 63 species in the disturbed forest have been recorded.

In general, the diversity index was found to be high in the undisturbed areas (Fig. 28). The highest value of 5.21 obtained for the undisturbed area in Nelliyampathy indicates that this area is very rich in insect species diversity. In

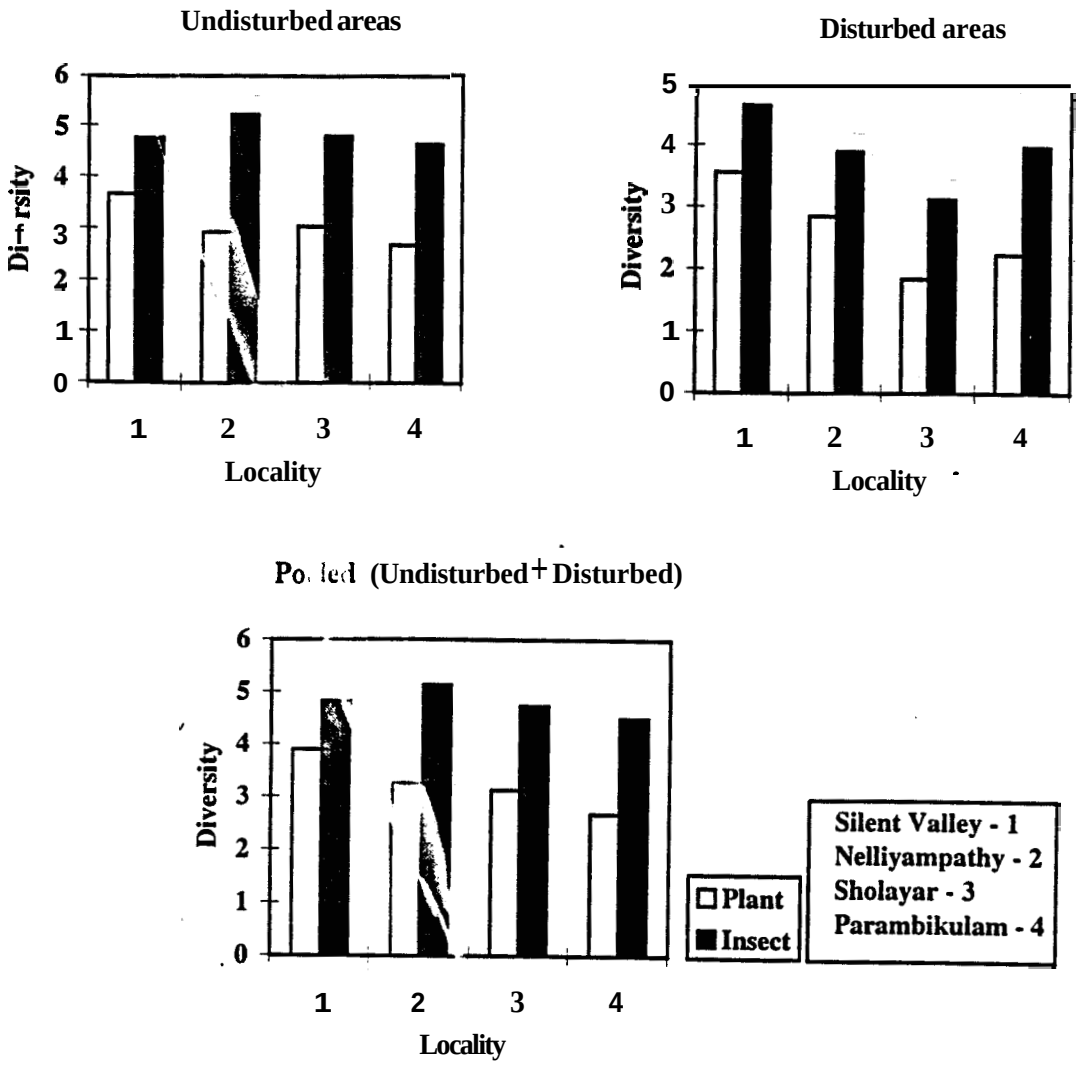

Fig. 28. Comparison of plant and insect diversity at different study sites

the disturbed area, the index was only 3.91. Despite the higher plant diversity, the insect diversity in the disturbed area of Silent Valley tended to be low (4.65) compared to the undisturbed area (4.76). Parambikulam, despite the adverse effects of monoculture, had more insect diversity which was high in the undisturbed area (4.64) compared to the disturbed area (3 99). in rhe case of Sholayar, the diversity index was 4.79 in the undisturbed area and only 3.13 in the disturbed area. This reduction in the diversity index in the disturbed areas clearly points to the drain in insect species diversity- following forest disturbance.

The floral composition in the disturbed and undisturbed areas was also interesting. In all the four localities, the undisturbed areas had good representation of primary species like *Palaquium ellipticum, Aglaia* sp., *Myristica dactyloides, Mesua ferrea, Cullenia exarillata. Holigarna arnottiana, Casearia bourdiloni, Persea macranthae*tc. In the disturbed areas, although the primary species were present, there was invasion of various secondary species like *Olea dioica, Scolopia crenata, Macaranga peltata, Zizyphus rugosa, Walsura trifolia, Celtis* sp., *Albizia chinensis* and weeds like Clerodendron viscosum, Mikania *micrantha, Lantana* sp. etc. As a result, the forest composition was affected which in turn might have affected the insect composition as certain arboreal feeding insects like Geometridae. Saturnidae, Cossidae etc., were abundant in the undisturbed area whereas herbaceous feeding families like Pyralidae. Chrysomelidae etc., were very abundantly found in the disturbed areas.

6. CONCLUSIONS

he main causes of species loss in tropical forests are degradation and fragmentation of natural habitats, over exploitation of natural resources, pollution, introduction of exotics and climate change. The manner in which the rich complexity of biosphere will respond to these global environmental changes and to the rapid pace of utilization of biological resources is yet to be studied. In this context, there is an urgent need to document diversity already existing in the various habitats as a first step for conservation.

Incidence of fire. the clearing of forest for agriculture. forest cutting for firewood and fodder as well as establishment of forest and agricultural plantations are the major factors that affect biodiversity in the Kerala part of Western Ghats. The present study has shown that there is a reduction in diversity in the disturbed forest patches compared to the undisturbed areas.

By adopting appropriate site amelioration programmes involving Are protection (at Silent Valley), favouring recolonisation of altered habitats (at Nelliyampathy and Parambikulam) and raising of fuelwood plantations and providing pasture areas in the vicinity of human settlements (at Sholayar). the existing biodiversity in these areas can be conserved. Silent Valley and Parambikulam are already protected through legislation as National Park and Wildlife Sanctuary respectively. Nelliyampathy and Sholayar, although biodiversity 'hotspots' are yet to be protected. As all these forests are located in adjacent geographical areas, disturbance to any region may affect the biodiversity in the other areas and hence it is necessary to have a collective conservation programme for the entire area.

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Appendix -I

List of Plants recorded from the Study areas

Plant Species	Silent Valley	Nelliym-Pathy	Sholayar	Parambi-kulam
Aglaia lawii Wt.)Sald.	*(2/68)	*(4/6)	*(1/16)!	-
Aglaia **sp.**	*(26/. 116)	*(-46;		
Agrostistachys meeboldii Pax & Hoffm.	*(18/68)	*(6/30)	*(0/123)-	
Albizia chinensis (Osb.) Merr.	-	*(12/-)	-	-
Albizia sp.	-	-	-	*(1/-)
Allophylus sp.	*(3/1)	-	-	-
Allophylus cobbe (Lin.) Raeusch.	*(4/-)	-	-	-
Alstonia scholaris (Lin.) R.Br.	*(1/-)	-	*(7/-)	-
Aporusa sp.	*(-/21)	-	-	-
Aphanamixis sp.	*(3/3)	-	-	-
Apollonias sp.	*(3/6)	-	-	-
Ardisia pauciflora Heyne ex Wall.	-	*(1/-)	-	
Ardisia sp.	*(-/11)	-	-	-
Artocarpus heterophyllus Lamk.	*(-/7)	*(1/8)	*(7/0)	-
Bischofia javanica Bl.	*(7/1)	*(-/2)	-	-
Boumeria sp.	*(-/2)	-	-	-
Bridelia retusa (Lin.) Spreng.	-	-	-	*(-/2)
Calamus sp.	*(1/-)	-	-	-
Callicarpa tomentosa (Lin.) Murray	*(2/-)	-	-	-
Canarium strictum Roxb.	*(6/9)	*(-/11)	*(-/27)	-
Careya arborea Roxb.				*(-/1)
caryota sp.	*(-/ 1)			
*Casearia bourdillonii*Mukherjee	*(59/69)			
cassia fistula Lin.				*(32/69)!
celtis sp.	-	*(26/-)	*(6/-)	- -
Cinnamomum malabatrum (Burm.f.) Bl.	*(9/ 17)	*(1/-)		
Citrus sp.	*(6/5)			
Clerodendrum viscosum Vent.	*(358/6)			
Cordia dichotoma Forst.f.				*(-/7)
Cullenia exarillata Robyns	'(38 /87)	*(9/45)	*(-/42)	
Cycas sp.	-	-	-	*(-/9)

Dalbergia latifolia Roxb.		-	-	*(4/6)
Debregeasia sp.	*(11/ 10)	-	-	-
Dillenia bracteata Wt.		-	-	*(-/4)
Dimocarpus longan Lour.	*(43/79)	*(7/64)	*(-/62)	-
Diospyros sp.	*(-/8)	*(6/3)	-	-
Drypetes elata Bedd.	*(1/6)	*(1/6)	*(-/35)	-
Drypetes oblongfolia (Bedd.) Airy Shaw		*(59/82)	*(7/99)-	
Elaeocarpus serratus Lin.	*(7/2)			
Emblica officinalis Gaertn.				*(2/ 10)
Erythrina sp.		*(10/-)	*(6/-)	
Erythroxylum moonii Hochr	*(/1)	-	-	-
Eugenia sp.	*(-/2)	-	-	-
Euonymus sp.	*(1/3)	-	-	-
Fahrenheitia sp.	*(3/-)	-	-	-
Ficus sp .	*(4/-)	*(2/-)	-	-
Garcinia morella (Gaertn.) Desr.	*(-/22)	*(-/7)	-	-
Glochidion sp.	*(-/ 1)		-	-
Glycosmis sp .	*(1/9)	-	-	
Gomphandra coriacea Wt.	*(7/18)	*(-/ 17)	*(-/41)	
Grewia tiliifolia Vahl.				*(-/3)
Haldina cordifolia (Roxb.) Ridsd.			*(-/ 10)	
Heritiera papilio Bedd.		*(32/126)	*(4/50)	
Holigarna arnottiana Hk.f.	*(8/37)	*(8/6)	*(-/20)	
Holigarna sp.	-	-	*(2/23)	-
Hopea glabra Wt. & Am.	*(1/3)			
Hydnocarpus sp.	*(1/-)			
Knema attenuata (Wall.ex Hk.f.& Thoms.) Warb.	*(-/ 1)			
Lagerstroemia microcarpa Wt.	-	-	-	*(5/49)
Laportea crenulata (Roxb.) Gaud.	*(39/88)	*(-/10)	*(-/17)	-
Lepisanthes sp.	*(3/12)	-	-	-
Litsea floribunda (Bl.) Gamble	*(25/10)	*(-/6)	-	-
L. laevigata (Nees) Gamble	-	*(-/58)	*(-/44)	-
Macaranga indica Wt.	-	*(45/-)	*(3/-)	-
M. peltata (Roxb.) M.-A.	-	*(108/1)	*(11/-)-	
Mallotus philippensis (Lamk.) M.-A.	*(8/-)	-	-	-
Mangifera indica L.	*(2/-)	-	-	-
Mastixia arborea (Wt.) Bedd. ssp.*arborea*	*(1/1)	*(18/17)	*(4/42)-	

Meiogyne sp.	*(1/2)	*(28/-)	-	-
Melia dubia Cav.				*(-/1)
Meliosma pinnata (Roxb.)Maxim.	*(54/-)	*(1/3)		-
Mesua ferrea auct. non Lin.	*(9/38)	*(23/59)	*(5/54)	-
Microtropis ovalifolia Wt.	*(1-/7)	-	-	-
Mitragyna parvifolia (Roxb.) Kunth	-	-	-	*(-/3)
Myristica dactyloides Gaertn.	*(6/91)	*(-/2)	*(-/24)	-
Neolitsea sp.	-	*(3/83)	*(2/30)	-
Olea dioica Roxb.	*(36/-)	-	-	-
Orophea sp.	*(5/7)	-	-	-
Palaquium ellipticum (Dalz.) Engl.	*(111/97)	*(30/76)	*(-/33)	
Persea macarantha (Nees) Kosterm.	*(37/28)			
Pinanga dicksonii (Roxb.)Blume	*(-/15)			
Polyalthia coffeoides (Thw.) Benth. ex Hk. f. & Thorns.	-	*(0/32)	*(0/10)	-
Polyalthia fragrans (Dalz.) Bedd.	*(43/2)			
Radermachera xylocarpa (Roxb.) K. Schum.				*(1/9)
Randia sp.oleosa (Lour.)Oken				*(35/79)
Schleichera sp.	*(1/-)			-
Scolopia crenata (Wt. & Am.) Clos.	*(42/-)	*(3/40)	*(0/36)	
Sterculia sp.	*(1/-)			
Symplocos sp.	*(34/33)			
Syzygium cumini (Lin.)Skeels	*(10/16)	*(10/31)		
Syzygium sp.	*(8/10)			
Tectona grandis Lin. f.				*(41/54)
Terminalia paniculata Roth.				*(2/18)
T. tomentosa w & A	-	-	-	*(-/3)
Trema orientalis (Lin.) Bl.	*(1/-)			
Trichilia sp.	*(13/5)			
Turpinia malabarica Gamble	*(2/3)			-
Vateria indica Lin.	*(1/2)	-	-	-
Vernonia arborea Ham.	*(1/-)	*(-/1)	-	-
Walsura trifolia (Juss.)Harms		*(2/-1		
Xylia xylocarpa (Roxb.)Taub.			*(2/-1	*(-/15)
zanthoxylum sp.	*(2/-)			
Zizyphus rugosa Lamk.	*(3/-)	-	-	-
Unidentified sp.1	•			
Unidentified sp.2	•			

Unidentified sp.3	•	-	-	-
Unidentified sp.4	*	-	-	-
Unidentified sp.5		*	-	-
Unidentified sp.6		•	-	-
Shrubs				
Ageratina adenophora (Spreng.) King & Robins.	*	-	-	-
Amomum sp.	*	-	-	-
Artabotrys zeylanicus Hook. f. & Thoms.	•	-	-	-
crotalaria sp.				•
Chromolaena odorata (Lin.) King & Robins.		•		•
Flemingia sp.	•	-	-	-
Isonandra sp.	*	-	-	-
Ixora sp.	•		-	-
Jasminum sp.	•	-	-	-
Lasianthus sp.	*	-	-	-
Leea indica (Burm.)f. Merr.	*	-	-	
Ligustrum sp.	*	-	-	-
Maesa indica (Roxb.) A. DC.	•	-	-	-
Pandanus thwaitesii Mart.	•	-	-	-
Pavetta sp.	*		-	-
Psychotria curviflora Wall.	•		-	-
Saprosma fraarans Bedd.	•	*	-	-
Sarcandra sp.	•			
Sauropus sp.	•			
schumannianthus sp. *virgatus* (Roxb.) Rolfe.	•	•		
solanum sp.		•		
Strobilanthus sp.	•			
Thottia siliquosa (Lam.) Ding Hou	•			
Unidentified sp.1	*			•
Unidentified sp.2	•			•
Unidentified SD.3		*		•
Unidentified sp.4		*		•
Unidentified sp.5			•	•
Unidentified sp.6			*	•
Unidentified sp.7				•
Unidentified sp.8				•
Unidentified sp.9				•

Unidentfied sp.10	-	-	-	*
Herbs				
Amorphopalum sp.	*	-	-	-
Argostemma sp.	*	-	-	-
Blumea sp.	-	*	-	-
Bolbytis sp.		*		-
Commelina sp.	*			
Costus speciosus (Koen.)Smith	*			
Crotalaria sp.	*	-	-	-
Centella asiatica(Lin.) Urban		*	-	-
Eletteria cardamomum (Lin.) Maton	*		-	-
Ophiopogon intermedius D. Don	*		-	-
Ophiorrhiza hirsutula Wt.x Hook.f.	*	-	-	-
Pteris sp.	•			
scleria sp.				-
Synedrella nodiflora (Lin.)Gaertn.	*	*		-
Unidentified sp.1	*	-	*	*
Unidentified sp.2	*	-	-	*
Unidentified sp.3	*	*	-	*
Climbers				
Ancistrocladus heyneanus Wallex Graham	*	-	-	-
Caesalpinia cucullata Roxb.	*	-	-	-
Calamus sp.	*	-	-	-
Cayratia sp.	*			
Diplocyclos sp.	*			
Lea sp.	*			
Mucuna sp.	•			
Piper sp				
Polygonum chinense Lin.	*			
Rubia cordifolia Lin.	•			
Rubus sp.	•			
Smilax wightii A.DC.	*	-	-	-
Smilax sp.	•			
Smythea bombaiensis (Dalz.) Banerjee and Mukerjee	•			
Tetrastigma sp.	*			
Toddalia asiatica (Lin.) Lamk.	•			
Thunbergia bicolor (Wight) Manilal & Suresh	•			

Unidentified sp.1	*			
Unidentified sp.2	*			
Unidentified sp.3			*	
Unidentified sp.4				*

* Species present

- Species absent

(Figures in parenthesis indicate the number of plants in the undisturbed and disturbed areas).

Appendix -II

List of insects recorded from the study areas

Order / Family / Species	Study areas			
	Silent Valley	Nelliya-mpathy	Sholayar	Parambi-kulam
LEPIDOPTERA				
RHOPALOCERA				
PAPILIONIDAE				
Chilasa clytia Lin.	*	*		
Troides minos Cram.	*	*	*	*
Papilio helenus Lin.	*	*	*	*
P. polymnestor parinda Moore	*	*	*	*
P. budha Westwood	*	*	-	*
P. liomedon Moore	*	*	-	-
P. dravidarum Wood-Mason *	*		*	
Graphium sarpedon teredon Felder	*	*	*	*
G. agamemnon agamemnon Lin.	*	*	*	*
G. doson doson Felder	*	*	*	*
Pachliopta aristolochiae Lin.	*	*	*	*
P. hector Lin.,	*	*	*	*
P. pandiyana Moore	*			
Papilio polytes thesus Cramer	*	*	*	*
P. polytes romulus Cramer	*			-
P. demoleus dernoleus Lin.	*	*	*	*
P. paris tamilana Moore	*	*	*	*
Pathysa antipathes(Fb.)	*	*		*
NYMPHALIDAE				
Vindula erota soloma de Niceville	*	*	*	*
Parthenos sylvia virens Moore	*	*		*
Moduza procris Cramer	*			*
Tanaecia lepidea (Butler)	*	*		*
Cupha erymanthis maja Fruhstorfer	*	*	*	*
Charaxes bernardus imna Butler				*
Charaxes schreiberi (Godart)		*		
Cyrestis thyodamas ganescha Kollar	*	*		
Junonia heirta Fb.	*	*		*

J. almana Lin.	*			*
J. orithiya Lin.	*		-	-
J. atlites Lin.	*	*	*	*
Cirrochroa thais thais Fb	*	*	•	*
Euthalia lubentina (Cramer)		*	*	*
E. aconthea Fruhstorfer -	*			
Precis iphita pluvialis Fruhstorfer	*	*	*	•
Phalanta phalanta Drury	*	*		*
Euploea core core Cramer	*	*	*	*
Vanessa cardui Lin.	*			*
V: indica nubicola Fruhstorfer	*	*	*	*
Ergolis merione Cramer	*	*		
Hypolimnas bolina Lin.	*	*	*	*
H. missipus Lin.	*	*	*	*
Neptis hylas varmona Moore	*	*		•
N.perius perinus F'ruhstorfer	*	*		*
Kaniska canace haronica Moore	*	*		•
Junonia stygia	-	*	*	-
J. lemonias vaisya Fruhstorfer	*	*	-	*
Ergolis ariadne (Johanssen)	*	*	-	*
Pantoporia ranga (Moore)	*	*	-	-
Argynnis hyperbius (Johannsen)	*	-	-	-
DANAIDAE				
Tirumala limniace leopardus Butler	*	*	-	*
T. sepentrionis dravidarum Fruhstorfer	*	*	*	*
Parantica aglea Stoll	*	*		*
P. nilgiriensis Moore	*	*		*
Danaus genuita genuita Cramer	*	*	*	•
D. chrysippus (Lin.)	*	*	*	*
Idea malabarica malabarica Moore	•	*		*
PIERIDAE				
Delias eucharis Drury	*	*		*
Appias libythea Fb.	*	*	•	*
A. albina Boisduval	*			
A. indra Moore	*	*		*
A. lagela Moore	*			

Catopsilia florella(Fb.)	*	-	-	*
C. pomona Fb.	*	*	*	*
C. pyranthe (Lin.)	*	*	*	*
Cepora nadina Moore	*	-	-	*
Eurema brigitta Stoll	*			
E. laeta Boisduval	*			*
E. hecabe Lin.	*	-		*
Hebomoia glaucippe (Lin.)	*	*	*	*
Appias paulina galene Felder	*	*	*	*
Appias wardi (Moore)		*		
Appias lyncida (Cramer)	*	*		*
Parenonia ?valeria (Cramer)		*		
Eurema lacteola Dist.	*	*		
Cepora nerissa Fb.	*			*
Eurema blanda Boisd.	*	-	-	*
Leptosia nina Fb.	*	-	-	*
Ixias *marianne* (Cramer)				*
I. pyrene Lin.				*
Colotis fausta (Olivier)				*
SATYRIDAE				
Mycalesis anaxias Hewitson	*	*	*	*
M. perseus Fb.	*			
M. igilia Fb.	*	-	-	*
M. patnia Moore	*	*		*
Lethe rohria Frushstorfer	*			•
L. europa Fb.	*			•
L. neelgheriensis Guerin	*	*	-	8
Ypthima ceylonica Hewitson	*	-	-	*
Y: baldus	*			-
Ypthima sp.	*	*	*	-
Elymnias caudata **Butler**	*	-	-	-
Zipoetis saitis Hewitson	*	*	*	*
Melanitis leda Lin.	*	*	*	*
M. phedima varaha Moore	*	*		*
HESPERIIDAE				
Celaenorrhinus leucocera (Kollar)	*	*		*
C. ambareesa (Moore)	*	*	8	*

Tagiades litigiosa Moschler	*	-	-	*
Odontoptilum angulata (Felder)	*	-	-	*
Spialia galba Fb	*	-	-	*
Badamia exclamationis Fb	*	-	-	-
Taractrocera ceramas (Hewitson)	*	-	-	-
Telicota acigias Lin.	*	*	*	-
Potanthus pava pava Fruhstorfer	*	-	-	-
Pelopidas mathias Fb.	*	-	-	-
Udaspes folus Cram.	*	*	*	*
Iambrix salsala (Moore)	*	-	-	*
Tagiades obscurus Mabille	-	*	-	-
Coladenia dan (Fb.)	-	*	-	-
LYCAENIDAE				
Castalius rosimon (Fb.)	*	*	•	*
Caleta caleta Hewitson	*	-	-	*
Thalicada nyseus (Guerin.)	*	*	-	*
Curetis thetis Drury	*			*
Loxura atymnus Cramer	*			
Cheritra freja (Fb.)	*	*		*
Jamides alecto (Felder)	*	*		•
J. celeno (Cramer)	*			*
Jamides sp.	*			
Celastrina lavendularis Moore	*	-	-	*
Chilades pandava	*	-		
Udara akasa Horsfield	*			•
Spindasis lohita lazularia Moore		*		-
Megisba malaya (Moore)		*	•	-
Euchrysops cnejus (Fb.)		*		-
Catochrysops strabo (Fb.)		•	*	-
Arhopala centaurus Moore	*	-	-	-
Arhopala amantes (Hewitson)	*	-	-	-
RIODINIDAE				
Abisara echerius Stoll	*	-	-	-
LIBYTHEIDAE				
Libythea myrrha Godart.	*	-	-	-
ACRAEIDAE				
Acraea violae (Fb.)	*	*		*

HETEROCERA				
NOCTUIDAE				
Achaea janata Fb.	-	*	-	-
Anomis figlina Butler	-	*	-	-
A. flava (Fb.)	-	*	-	-
Arcte modesta Van der Hoev.	*	*	*	-
Athetis renalis Moore	-	*	-	-
Banisia myrtaea Drury		*	-	-
Bocana manifestalis Walker	*	-	-	-
Callopistria pulchrilinea Walker	*			*
C. rivularis Walker		*		
Carea endophaea Hamp.	-	-	-	*
C. subtilis Walker		*	*	
Chalciope hyppasia Cram.	*	*	*	*
Chasmina rejecta Fb.	-	*	*	*
Condica illecta Walker	*	-	-	-
Dactylioglypha tonica Meyrick	-	*	-	-
Dichromia orosia Cram.				*
Dierna strigata Moore		*	*	-
Egnasia khasiana Moore	*			-
Elygea materna (Lin.)		*	*	-
Erebus caprimulgus Fb.	-	*	-	*
E. ephesperis	-	*	-	-
Ericeia inangulata Guen.	-	*	*	*
Eumonodia sp.	-	-	-	*
Heliothis obsoleta	-	-	-	*
Heliothis sp.	-	-	-	*
Hyblaea puera Cram.	-	-	-	*
Hypena biplagiata Butler	*	-	-	-
Hypocala deflorata Fb.	-	-	-	*
Ischyja inferna		-	-	*
Ischyja sp.	*	-	-	-
Laphygma exigua Hb.		*	*	*
Lophoptera sp.	*	-	-	-
Maceda mansueta Walker	*			
Masalia bimaculata Moore	*			
Melipotis cyllaria Cram.			*	

Mocis frugalis Fb.	*	*	*	*
M. undata Fb.	-	-	-	-
Mythimna curvilinea Hamp.	-	-	-	*
M. vittata Hamp.	*	*	*	*
Nycteola grisea Hamp.	*	-	-	-
Nyctipao macrops Lin.	*	-	-	-
Olethreutes paragramma Meyrick	-	*	-	-
Ophideres materna Lin.	*	*	*	*
O. fullonica Lin.	-	*	*	-
Othreis ancilla Cram.		*	*	
Oxyodes scrobiculata Fb.		•	*	*
Ozarba sp.	*			
Parallelia jouiana Stoll.	*	*	*	
P. crameri Moore	*	*	*	
Polytela gloriosae Fb.				*
Prodenia litura Fb.	*	*	*	*
Pterogonia cardinalis	-	-	*	-
Raparna undulata Moore		*	*	
Rhynchina curvilinea Hamp.	*	*		
Rhynchina sp.				•
Simplicia? butesalis Walker				
Spiredonia retorta Cram.				•
S. suffusoma Guenee			*	
Sphetta apicalis Walker	*	*	*	
Spodoptera litura (Fb.)		*		•
S. mauritia Boisduval	*	•	*	*
Tarsolepis rufobrunnea malayana Naka.	*	*		
Tiracola plagiata Walker	•	*		
Tinolius eburneigutta Walker	-	-	-	*
Westermannia superba Hubn.		*	*	•
LYMANTRIIDAE				
Aroa sp. of plana Walker Complex	*	*	*	*
Caissa gambita Hering	-	-	-	*
Cispia charma Swinhoe	*	*	-	-
Dasychira mendosa Hb.	-	-	-	*
D. cerigoides Walker	-	*	-	-
D. bhana Moore	*	*	-	-

Euproctis fraterna Moore				*
E. percnogaster Collenette	*			
E. bipunctapex Hamp.				*
E. bigutta Walker	*	*		
E. scintillans Walker	*			*
Euproctis sp.	*			*
Laelia colon Hamp.	*			*
Lymantria todara Moore	-	*	-	-
Lyrnantria sp.		*		*
Miresa argentifera Walker		*		*
Orgyia sp.	-	-	-	*
Penicillifera sp.	-	*	-	*
Redoa sp.	*	*		*
Susica himalayana Holloway	*	*		*
Teldenia sp.				*
EUPTEROTIDAE				
Eupterote testacea Walker	-	-	-	*
E. hibisci Fb.	-	*	*	*
E. flavida Moore	*	*	*	*
E. mollis Moore	-	*	*	*
ARCTIIDAE				
Amata extensa Walker	*	-	-	-
Argina syringa Cram.	*	*	*	-
A. argus Koll.	-	*	*	*
A. astrea Drury	*	-	-	-
A. cribraria Clerck	-	*	*	*
Argina sp.	-	-	-	*
Asura metamelus Hamp.	*	-	-	-
A. conferta Walker	-	-	*	*
A. obsoleta Moore	-	-	-	*
A. rubricosa Moore	*	*	*	-
Asura sp.	*	*	-	-
Chionaema peregrina Walker	-	*	*	*
Creatonotus gangis Lin.	-	-	-	*
Diacrisia obliqua Walker	*	-	-	-
Eilema tetragona Walker	*	*	*	*
E. tumida Walker	*	-	-	-

Eligma narcissus Cram.	*	-	-	*
Euschema percota Swinhoe	-	-	-	*
Estigmene perotetti	*	*	*	-
Hypsa alciphron Cram.	*	*	*	-
Macotasa sp. *?nubecula* Moore	*	-	-	-
Neochera dominia Cram.	*	*	-	-
Nyctemera baulus Boisd.	-	-	-	*
N. coleta Cram.	-	*	*	*
Paraona splendens Butler	*	*	*	-
Paraplastis hampsoni Swinhoe	*	*		
Pericallia ricini Fb.		*	*	*
Rhodogastria astreas Drury		*		*
spilosoma sp.	*	*	*	
Utethesia pulchellale Walker	*			*
TORTRICIDAE				
Adoxophyes revoluta Meyrick	*	*	*	*
Bostra indicator Walker	*	-	-	-
Thylacoptila paurosema Meyrick	*	-	-	-
Udea ferrugalis Hubner	*	-	-	-
YPONOMEUTIDAE				
Atteva fabriciella Swed.	*			•
GEOMETRIDAE				
?Catoria sp.	•		-	-
Abraxas sp. nr. *latizonata* Hamp.	*	*	-	-
Abraxas poliaria Swinhoe	*	-	-	-
Agathia lycaenaria Koll.				•
Agathia laetata Fb.				•
Amblychia angeronaria Guen.		*		
Aualacodes peribocalis Walker		*	*	
Anisodes apogona Prout	*			
Anisozyga sp.	•	*	*	*
Aplochlora vivilaca Walker	*	•		
Boarmia infixaria Walker	*			*
Borbacha sp. nr. pardonica Guen.			*	
Buzura ?suppressaria Walker				
Cleora sp. prob. alienaria Walker	•	*	*	
Comibaena ?integranota Hamp.	•			

Comostola sp. prob. *virago* Prout				
Cusiala raptaria Walker	*	*	*	*
Dirades theclata Guen.	*			
Ecliptopera dissecta Moore	*	*		
Ectropis breta Swinhoe		*	*	*
Epiplema quadricaudata Walker	*			
E. fulvilinea Hamp.	*			
Eumelea rosalia Cram.	*			*
Eumelea sp.		*	*	*
Euytaphria sp.	*			
Gnamptoloma aventiaria Guen.	*			
Heterosteqane subtessellata Walker		*	*	
Heterostegane sp.	*			
Hypochrosis sp. *?abstractaria* Walker	*			
H. hyadaria Guen.	*			
Hypomcis pallida Hamp.	*	*	*	*
Hypomcis sp.	*	*	*	*
Hyposidra talaca Walker	*	*	*	
Lomographa sp. *?simpliciaria* Walker	*	*	*	
Luxiaria hypaphanes Hamp.	-	*	-	-
Medasina dissimilis Moore				
Menophra sp. *?inouei* Sato				
Naxa sp		*		•
Noreia ajaia Walker	*			
Ourapteryx marginata Hamp.	*	*	*	
Petelia? medardaria Herrich-Schaff.	*			
Pingasa chlora Cram.		*	*	
Polynesia sunandava Walker	*			
prasinocyma sp.				*
Racotis boarmiaria Guen.		*	*	
R. ?inconclusa Walker		*	*	
Ruttellerona cessaria Walker		*	*	
Sabaria sp.nr. *rondelaria* Fb.	*			
Scopula opicata (Fb.)	*			
scapula sp.	*			
Semiothisa ?khasiana Moore		*	*	
S. ?triangulata Hamp.	*	-		*

S. fasciata Fb.			*	
S. ?eleonora Stoll	•	*	*	*
S. honoria Hamp.				*
S. emersaria Walker	•			
S. quadraria Moore	•			•
Symmacra solidaria Guen.	*			
Thalassodes sp.	•	*	*	*
Timandra sp. ?nelsoni Prout	*			*
Uliocnemis biplagiata Moore	*	-	-	-
Xanthorhoe sp. *?molata* Felder	•			-
Zamarada excisa Hamp.				•
PYRALIDAE				
Acigona sp.	*		- -	*
Acrobasis olivalis Hamp.	*			
Agathodes ostentalis Hubn.	•	*		
Agrotera basinotata Hamp.	•			
Antigastra catalunalis Swinh.	*			
Botyodes asialis Guen.				•
Bocchoris inspersalis Zell.	*			•
Bostra vibicalis Leder.	•			
Bradina admixtalis Walker	*			
Charltona consociella Walker	•			
Cirrhochrista fumipalpis Feld.	*			
Cnaphalocrocis medinalis Guen.	*			
Conogethes suralis Guen.'	*			
Diasemia literata Scop.	*			
Dichocrocis evaxalis Walker	•		*	•
D. plutusalis Walker	•	•		
Endotricha sp.	*			
Epicrocis hilarella Rag.				•
Etiella zinckenella Treit.	•			
Eutectona macheralis Walker	•			
Eurrhyparodes tricoloralis Zell.	•			
Filodes fulvidorsalis Hubn.	•			•
Galleria mellonella Lin.	-	-	-	*
Glyphodes celsalis Walker	*		-	
G. bicolor Swains.				*

G. laticostaiis Guen.	*	-	-	-
G. vertumnalis Guen.	*	*		
G. glauculalis Guen.		*		
G. indica Saund.		*	*	*
G. itysalis Walker		*		
G. marginata Hamp.	-	*	-	-
Goniorhynchus plumbeizonalis Hamp.	*	-	-	-
Hellula undalis Fb.				*
Herculia marthalis Walker	*			*
Homoeosoma sp.	*			-
Hyalobathra opheltesalis Walker	*			*
Hypsipygia mauritialis Boisd.	*			
Isocentris filalis Guen.	*			
Lamprosema sp.	*			*
Lepyrodes geometralis Guen.				*
Loxostege sp.		*	*	
Lygropia amyntusalis Walker	*			*
L. orbinusalis Walker	*	*		*
Marasmia trapezalis Guen.	*			-
Myleopsis sp.	*			*
Nacoleia diemenalis Guen.	*			
Nephoteryx atrisquamella Hamp.	*			*
Nymphula crisonalis Walker	*			
N. fluctuosalis Zell.	*	-	-	-
N. foedalis Guen.	*	-	-	-
Omphisa repetitalis Snell.		*		•
Pardomima distorta Moore	*			
Patissa fulvosparsa Butl.	*			
Phlyctaenia massalis Walker	•			
Phryganodes ?unitalis Guen.	*		-	*
Pilocrocis barcalis Walker	*	-	-	-
Pionea brevialis Walker	*			
Polygrammodes spilosomoides Moore	*			
Protrigonia zizanialis Swinh.	*	-	-	-
Psara bipunctalis Fb.	*	-	-	-
Pycnarmon caberalis Guen.	*	-	-	-
Pygospila tyres Cram.	*	*	*	*

Pyralis manihotalis Guen.	*	-	-	*
Pyrausta sp. nr. signatalis Walker	*	*	*	*
P. tetraplagialis Hamp.	*			
Sammeodes cancellalis Zell.	*			
Schoenobius minutellus Zell.	*			
Scirpophaga sp.	*			*
Stenia minoralis Snell	*			
Sylepta arctalis Guen.	*			*
S. balteata Fb.		*	*	-
S. derogata Fb.	*	*	*	-
S. lunalis Guen.				*
s.quadrimaculalis Koll.				*
S. tibialis Moore	*			
Syngamia abruptalis Walker	*			*
S. latimarginalis Walker	*			*
Syngamia sp.	*			
Terastia egialealis Walker		*		
Tryporiza incertulas Walker	•			
Vitessa suradeva Moore		*	-	-
CRAMBIDAE				
Chilopartellus Swinh	*			
TINEIDAE				
Limnoecia sp. nr. *peronodes* Meyr.	*			
Setomorpha rutella Zell.	*			
AMATIDAE				
Eressa confinis Walker	*			•
E. sp. nr. asperiens Walker				*
NOTODONTIDAE				
Phalera procera Feld.Walker	*	•	*	
SPHINGIDAE				
?Rhagastis albomarginatus Roths.	*			
Acherontia lachesis Fb.		*		
Acherontia sp.		*	*	
Herse convolvuli Lin.		*	*	
Hippotion boerhaviae Fb.		*	*	
Macroglossa aquila Boisd.				*
Macroglossa sp.				*

Theretra castanea Moore	*			
T. nessus Drury		*	*	
Theretra sp.				*
SATURNIDAE				
Attacus atlas Lin.	*	*		*
Loepa sikkima Moore		*	*	*
Tropea luna Lin.	*	*	*	*
COSSIDAE				
Alcterogystia cadambae Moore	-	-	-	*
COLEOPTERA				
HYDROPHILIDAE				
Hydaticus ieechi Sato	*	*	-	-
H. vittatus Fb.	*	-	-	-
CICINDELIDAE				
Cicindela sexpunctata Fb.	*		-	-
Neocollyris sp.	*	*	-	-
LUCANIDAE				
Odontofabis cuvera Hope	*		*	-
Odontolabis sp.			*	-
ANTHRIBIDAE				
Baryrrhynchus planicollis Walker	*	*	-	-
PASSALIDAE				
Pleurarina brachyphyllus Stal.	*	*	*	
CARABIDAE				
Chlaenius tenuelimbatus Ball.	*	*	*	
Omphra sp.	*	*		*
COCCINELLIDAE				
Aspidornorpha sp.	*			
Coelophora bissellata Mus.			*	
Coccinella septempunctata Lin.		*		
C.transversalis Fb.				
Epilachna septima Dieke		*		
E. vigintioctopunctata Fb.	*	*		*
Synonycha grandis (Thun.)		*		
SCARABAEIDAE				
Anomala ruficapilla Burmeister		*	*	

Anomala sp.	*	*	-	*
Catharsis sp.	-	*	-	-
copris sp.	*	*		*
Gymnopleurus sinuatus (Olivier)	*	*	*	
Heliocopris dominus Bates	*		*	*
Heteromhina sp.	*	*		
Holotrichia rufoflava Brenske	*	*	*	*
H. fessa Brenske		*	*	*
H. serrata Fb.	*	*	-	*
Holotrichia sp.	*	*		*
Macronota sp.	*	*		
Maladera sp.		*	*	
Mimela sp.	*	*		*
Oryctes rhinoceros Lin.	*	*	*	*
Popillia complanata Newm.	*	*	*	
Trigomophosus sp.		*		
CURCULIONIDAE				
Sternochaetus mangiferae Fb.	*	*		*
Myllocerus viridanus Fb.	*			*
M. dorsatus Fb.				*
Mecistocerus concretus Faust				*
Peltotrachelus cognatus Mshl.	*			
Esamus albomarginatus Gyll.	*			
LAMPYRIDAE				
Epicauta sp.		*		-
Lissomus sp.	-	*	-	-
ALLICULIDAE				
Allecula punctatissima Mak.		*	*	
TENEBRIONIDAE				
Amarygmus purpureofossus Fairm.		*		
Lyprops curticollis Fairm.	*	*	*	*
Lyctoxylon ambigum Les.	*			
Strongylium macrops Wied.	*	*	*	*
BUPRESTIDAE				
Campsosternus sp.	*	*		
Chrysochroa sp.	*	*		
Pachylanguria elongata Fb.		*		

Ptiloctaenus rubroaureus De Geer				
Sphenoptera cyaniceps Kerr:	*			*
CHRYSOMELIDAE				
Aulacophora cincta (Fb.)	*	*	*	*
Aulacophora unicolor Illig.		*	*	
Basilepta fulvicornis Jac.	*	*	*	*
Calopepla leayana Latr.	*			*
Cryptocephalus malabaricus Clav.	*			*
Derectina collina Weise	-	*		
Diaprornorpha turcica Fb.	*			
Hoplasoma unicolor Illig.	*	*	-	-
Lilioceris ?laosensis (Pic.)		*	-	-
Monolepta longitarsis Jac.	*	-	-	-
Sagra femorata Drury		*		-
Sagra sp.	*	*		
ATTELABIDAE				
Attelabus sp.	*	*		-
Colasposorna rufipes Jac.	*			*
Ophrida marmorea Wied.				
CERAMBYCIDAE				
Aeolesthes holocericea Fb.	*			
Acalolepta rusticatrix Fb.		*		-
Asticosterna alternata Fairm.		*		-
Acanthophorus serraticornis Oliv.	*			*
Batocera sp.		*		*
Chelidonium argentatum (Dalm.)	-	*		-
Cerosterna scabrator (Fb.)	*			*
Derolus dernissus Pasc.		*		
Epepeotes uncinatus Cah.		*		
Logaeus subopacus Wat.		*		
Macrochenus tigrinus Ol.		*		
Morimus inaequalis Waterh.	-	*	-	-
Nupserha madurensis Pic.	*	*	*	*
N. malabarensis Pic.	-	-	-	*
Prionomma atratum Gmelin.	-	-	*	*
Plocaederus obesus		*	*	
Rhaphipodus subopacus Gahan		*		

Rhodopina ?nilghirica (Breun.)	-	*	-	-
Stromatium barbatum Fb.	*	*	-	-
Xystrocera globosa Oliv.				*
HEMIPTERA				
EURYBRACHIDAE				
Eurybrachis sp.	*		*	*
Messena pulverosa (Hope)	*	*		
Messena sp.	*	-	-	-
Nicidus sp.	*	-	-	-
RICANIIDE				
Apachnas nobilis Dist.		*		*
Ricania sp.	*			
Varcia sp. nr. *kandyiana* Dist. .		*	-	-
BELOSTOMATIDAE				
Diplonychus molestus (Dufour)	*	-	-	-
NOTONECTIDAE				
Enithares sp.		*		
GERRIDAE				
Jenagogonus (= Limnometra) longispinu- lus Thirumalai	*	-	-	-
Metrocoris variegans Thirumalai	*			
ptilomera (= *Ptilomera) argroides* Schmidt	*			
FLATTIDAE				
Flata ?ocellata Fb.	*			
Phormnia sp.	*			
Seliza ?partita Melicher		*		
DICTYOPHARIDAE				
Dictyopharina ?viridissima Melicher	*			•
CERCOPIDAE				
Cosmocarta relata Dist.				
Cosmocarta sp.	*	*	•	
Eoscorta sp.				
LYGAEIDAE				
Dindymus lanius Stal.		*		
D. sanguineus				•
Macropes sp.	*			

Melamphaus fulvomarginalis				
Odontopus nigricornis	*	*	*	*
REDUVIDAE				
Androclus granulatus Stal	*			
Canthesancus qulo Stal		*		
FULGORIDAE				
Kalidasa lanata Drury				*
Melicharia sp. -	-	*	-	
Pochazia fuscata Fb.	-	-	*	-
CICADIDAE				
Cryptotympana varicolor Dist.	-	-	*	*
Dichoptera hampsoni Dist.	*	-	-	-
Gaeana atkkinsoni Dist.	*	-	-	-
Platylomia amicta Dist.	-	*	*	-
P. sp. nr. *larus* Walker	-	-	-	*
Platypleura insignis Dist.	*			-
Purana tigrina Walker				-
CICADELLIDAE				
Bothrogonia ferruginea Fb.		*	*	
Krishna strigicollis Spinola	-		*	-
Tettigoniella indistincta Walker		*	*	-
PENTATOMIDAE				
Cantao ocellatus Thunb.	*			*
Degonatus serratus Dist.				-
Nezara viridis Lin.		*	*	
Plautia fimbriata Fb.			*	
Sabaeus humeralis Dall.	*	*	*	
Tipulparra trivandera producta Ghauri	*			
Placosternum taurus (Fb.)	*	*		
ACANTHOSOMATIDAE				
Elasmostethus sp.				
COREIDAE				
Anacanthocoris strucornis Scott.	-	*	*	-
Anoplocnemis curvipes		*		
Dysdercus cingulatus Fb.	*	*	*	*
Notobitus sp.	*	*		*
Physomerus grossipus Fb.				

Riptortus linearis Fb.		*		
Serinatha augur Fb.	*	*		
HYMENOPTERA				
APIDAE				
Apis dorsata Fb.	*	*	*	*
A. *indica* Fb .	*	*	*	*
XYLOCOPIDAE				
Xylocopa verticalis Lepel.	*	*	*	*
EUMENIDAE				
Eumenes conica Fb.	*	*		*
SCOLIIDAE				
Megascolia sp.	•	•	-	-
POMPILIDAE				
Salius aureosericeus Guer.	*	*	-	-
SPHECIDAE				
Ammophila laevigata Smith.	*	*	-	*
Chalybion bengalense Dahl.	*	*		*
Sceliphron javanum Lepel.	*	*		*
Sphex argentatus	*	*	-	-
CHRYSIDIDAE				
Stilbum cyanurum Forster	*	*	*	*
VESPIDAE				
Vespa sp. nr.*cincta* Fb.	*	*	*	*
ODONATA				
Orthetrum pruinesum neglectum (Ramb.)	*	*	*	•
Macromia sp.	*	*		•
Nemothemis fulvia Drury	*	*		*
N. intermedia (Ramb.)	*	*	•	*
Palpopleura sexmaculata Drury				*
Trithemis aurora (Burm.)	•	*		*
T.festiva (Ramb.)	*	*		*
ORTHOPTERA				
ACRIDIDAE				
Catantops henryi Bol.	*			*
catantops sp.	*			*
Onomarchus sp.		•		*

DICTYOPTERA				
BLATTIDAE				
Placoblatta asymmetrica Bey-Bienko	*	*	-	
Rhabdoblatta SP.	*	*		*
Thoras porcellana Sauss.		*	*	
MANTIDAE				
Deroplatys desicata West		*		
Humbertiella indica Sauss.	*	*	-	*

• Species present

- Species absent

Appendix 111

List of unidentified insects

Order / Family	No. of species
LEPIDOPTERA	
Amatidae	1
Geometridae	11
Lymantriidae	33
Noctuidae	39
Pyralidae	26
Cossidae	4
Saturnidae	3
Sphingidae	10
Arctiidae	21
Microlepidoptera	20
COLEOPTERA	
Chrysomelidae	14
Curculionidae	10
Buprestidae	4
Cicindelidae	5
Staphylinidae	4
Rutelidae	3
Scarabaeidae	7
Carabidae	8
Lycidae	6
Meloidae	2
Tenebrionidae	9
Cetoniidae	5
Elateridae	12
Hydrophilidae	2
Dytiscidae	4
Coccinellidae	5
Cerambycidae	12

Lucanidae	2
Paussidae	1
Lampyridae	5
HYMENOPTERA	
Vespidae	10
Scoliidae	1
Apidae	3
Xylocopidae	2
Ichneumonidae	8
Ichneumonidae	15
Bracibudae	3
Formicidae	8
Pompilidae	17
Sphecidae	2
DIPTERA	
Tabanidae	5
Syrphidae	9
Asilidae	21
Tipulidae	8
Dolichopcjdidae	5
Tephritidae	3
Tachinidae	3
Unidentified	9
HEMIPTERA	
Derbidae	1
Lygaeidae	11
Coreidae	7
Reduviidae	16
Corixidae	1
Scutelleridae	1
Dictyopharidae	2
Cicadidae	6
Pentatomidae	13

Fulgoridae	11
Belostomatidae	1
Cercopidae	8
Acanaloniidae	7
Flatidae	5
Gerridae	3
Nepidae	1
Notonectidae	4
ORTHOPTERA	
Acrididae	20
Tettigonidae	9
Gryllidae	3
Gryllotalpidae	1
DICTYOPTERA	
Phasmida	10
Blattidae	7
Mantidae	8
ODONATA	
Libellulidae	22
Coenagrionidae	15
TRICHOPTERA	8
NEUROPTERA	7
ISOPTERA	3
EPHEMEROPTERA	3
PLECOPTERA	1