KFRI Research Report No. 206 ISSN 0970-8103

INSECT FAUNA OF THE SHOLA FORESTS OF MUNNAR AND WYNAD

George Mathew
K. Mohanadas

Kerala Forest Research Institute
Peechi - 680653, Kerala, India

February, 2001

KFRI Research Report No. 206

INSECT FAUNA OF THE SHOLA FORESTS OF MUNNAR AND WYNAD

[Final Report of the Research Project KFRI/297/98;
April 1998 - March 2000]

George Mathew
K. Mohanadas

Division of Entomology

Kerala Forest Research Institute
Peechi - 680653, Kerala, India

February, 2001

ABSTRACT OF THE PROJECT PROPOSAL

1.	Project No.	:	KFRI/297/98
2.	Tittle of the project	:	Insect fauna of shola forests of Munnar and Wynad
3.	Objectives	:	1. To document the insect fauna (of major groups), and 2. To study their diversity and distribution
4.	Date of commencement	:	April 1998
5.	Scheduled date of completion	:	March 2000
6.	Funding Agency	:	Kerala Forest Department
7.	Project Team		
	Principal Investigator	:	George Mathew
	Investigator	:	K. Mohanadas
	Research Fellow	:	C.M. Brijesh
8.	Study Area	:	Munnar and South Wynad Forest Divisions
9.	Duration of Study	:	2 years

ABSTRACT

A study was carried out on insect diversity at Mannavan shola (Munnar Forest Division) and Chembra hills (South Wynad Forest Division). Sampling of insects was carried out for 19 months (from September 1998 to March 2000) at Mannavan shola and for 12 months (April 1999 to March 2000) at Chembra hills. Three hundred and forty four species belonging to 10 orders were recorded from Mannavan shola compared to 81 species under 8 orders from Chembra hills. Because of the unequal surveys carried out, no strict comparison of faunal diversity of the two locations was made although some generalisations on the distribution pattern of fauna have been attempted. The species diversity (H) and richness (R) were highest at Mannavan shola (H=5.36; R=10.61) compared to Chembra hills (H= 4.22; R= 6.61). Species diversity and richness showed a decreasing trend with increasing altitude.

The faunal elements ranged from moist deciduous and evergreen forms to temperate species at Mannavan shola and from moist deciduous to evergreen forms in Chembra hills in accordance with vegetation and altitude. In the former, the fauna consisted mostly of arboreal feeding forms indicating a fairly undisturbed forest while in the latter, the fauna contained mostly of herbaceous feeding forms indicating a disturbed forest stand.

The faunal composition was interesting as it contained several endemic and protected species. Among butterflies, of the 11 species of endemic butterflies recorded, 5 species were having protected status in both the areas. Similarly, several butterflies like, *Athyma nefte* Doubleday, *Rohana parisatis* Cramer, *Vanessa indica* Fruhstorfer, *V. cardui* Lin. (Nymphalidae); *Mycalesis oculus* Marshall (Satyridae); *Artogeia canidia* Sparrman (Pieridae) and *Telicota acigias* Lin. (Hesperidae) recorded in this study are rather restricted in their distribution being not frequently found in other forest types. The extent of endemism present in other groups of insects was also rather high. The economic/ecological importance of most species of insects recorded in this study still remains to be worked out. Many insects could not be identified despite reference to specialists and national reference collections and it is likely that they may turn out to be new species.

CONTENTS

INTRODUCTION

The 'sholas' are essentially tropical montane evergreen forests, where trees tend to be more stunted than in the lowland rain forests. They are found in patches varying from less than a hectare to several hundred hectares in sheltered valleys, or depressions of hills surrounded by grasslands at altitudes of 1500 m and above. According to Ranganathan (1938), both sholas and grasslands are distinct climatic climaxes and their relative distribution might be controlled by frost, fire or grazing. Meher Homji (1965) who also supported the dual climax idea suggested that temperature condition that prevails during the winter months at higher elevations coupled with periodic dry spells, are responsible for confining the woody species to the sheltered areas. Champion and Seth (1968) considered the shola to be a unique type of vegetation belonging to the southern montane wet forests.

Because of the fact that the high elevation shola-grassland vegetation of the Western Ghats have apparently remained in a stable equilibrium for many decades, it was assumed that the shola vegetation is highly developed and has attained stability under the same climatic regime. Jose *et al.* (1994), based on their studies in the shola forests of Eravikulam National Park (Munnar Division), have stated that with its characteristic deep fertile soil and high moisture holding capacity, the shola may remain in the same steady climax state provided anthropogenic and other catastrophic disturbances do not destroy them. They have also reported that under the forest cover, profuse regeneration of almost all of the over-storey species occurs and that the regeneration characteristics are different along the margin and at various altitudes possibly due to the differences in the ecological conditions. Although it has been stated that the structure, composition and floristic elements of shola forests present a very high degree of richness and diversity, Swarupanandan *et al.* (1998) are of the opinion that the species diversity of shola forests is only comparable to that of moist deciduous or semi-evergreen forests and never reaches closer to that of evergreen forests.

ANIMAL LIFE IN SHOLA FORESTS

On account of isolation of shola vegetation from contiguous forests and also due to its climatic and vegetation attributes, the animal community of shola forest is highly specialised. The theories of island biogeography can be applied in the

case of animals found in the sholas (Shanker, 1996). It has been proposed that various animals, which had been overrun by competition on the mainland, survived on the islands due to the lack of predators or competition, the same situation is applicable in the case of sholas as well. McArthur and Wilson (1967) proposed that all the species that are present on islands might have come from a mainland source and that some of these species will become extinct and simultaneously others will endorse it. Therefore, the number of species on the island is an equilibrium between the number of extinctions and the number of colonisations. Islands closer to a mainland will have a better chance (*i.e.*, a higher rate) of being colonised by new species than those farther away. Also, on smaller islands species will have a greater chance of becoming extinct because smaller islands can support only smaller populations of each species and the chances of their dying out will be higher. The shola forests thus offer unique research opportunities for biogeographical research.

The sholas have been referred to as living fossils because of their inability to expand, due to the typical climatic and edaphic conditions. Prevalence of frost and extreme hot conditions prevents regeneration of plants in the grassland. However, the temperature in the sholas remains remarkably constant. The ground is usually covered with leaf litter which helps in maintaining a high level of soil moisture. As a result, there is good regeneration of tree seedlings and herbaceous flora producing very characteristic microclimatic conditions supporting a rich fauna. A variety of animals have been reported from shola forests which include several species of frogs, particularly tree frogs, burrowing snake (Uropeltidae), Nilgiri Langur, slender loris, giant squirrel, leopard, bear, sambar deer, tahr, elephant and jungle fowls. The lower groups of organisms particularly the micro-invertebrates are the least studied although they are known to out number all other groups of organisms.

REVIEW OF LITERATURE

Kerala, with its variety of ecosystems ranging from the high mountains supporting thick tropical evergreen forests, coastal plains as well as riverine and mangrove vegetations is known for its rich biodiversity. Information generated so far indicates that the forests are by far the richest in terms of diversity and the faunal elements contained therein. Insects are the major components of the animal fauna. Much of the information on Indian fauna is contained in faunal treatises such as the *Fauna of British India* series as well as the research bulletins published by agencies such as the Zoological Survey of India (ZSI), Forest Research Institute (FRI) and various University Departments. In addition to these, a number of research papers based on area specific studies have also appeared recently. These include a study of pyralid moths of Kerala by Mathew and Menon (1984), a study of insects in the hydal areas of Idukki by Cherian (1983); a survey on the butterflies of the Nilgiri mountains by Larsen (1987; 1988); a study on the butterflies and moths of Silent Valley by Mathew (1990); Mathew and Rahamathulla (1993; 1995); a survey on the insect fauna of Malayattoor (Mathew, 1993); a study of selected insect groups of Parambikulam Wildlife Sanctuary by Sudheendrakumar and Mathew (1999) as well as studies on the insect diversity of several forest areas such as Silent Valley, Nelliyampathy and Sholayar (Mathew *et al.,* 1998). In addition to these, a series of studies on soil insects (Prabhoo, 1971), parasitic wasps (Narendran, 1986; 1992; 1998) etc., have also appeared.

Very few studies have been made on the shola insects. Recently, Thomas *et al.* (1995) in a study carried out on the dynamics of insect communities at varying altitudes in the shola forests of Kodaikanal hills, reported on the patterns of changes in abundance of litter arthropods at different elevations along an altitudinal gradient. Mites, collembolans and coleopterans were the dominant faunal elements at all the elevations. Both species richness and abundance of litter faunal groups showed a pronounced decline at higher elevations. Collembola dominated the insect assemblage in all the 3 litter layers (*viz.*, freshly fallen litter, partially decomposed litter and humus layer) at the three elevations (1440 m, 1820 m and 2220 m). Thirteen species of mites were isolated at 1440 m ASL and they showed maximum abundance in the partially decomposed litter at all altitudes. The species richness at 1850 and 2220 m ASL was lesser with 11 species from the former and 9 species groups from the latter. Population density of Collembola exhibited marked differences from lower to

higher elevation forest litter habitats and exhibited increase in abundance from freshly fallen litter to partially decomposed litter followed by a fall in humus layer. The relative abundance of various groups of microarthropods along the three elevations points to the highest abundance of mites and collembolans in the partially decomposed and humus layers and their tendency to be prevalent along the lower altitudes which are rich in primary metabolites, volatiles and nutrients. Comparison of the faunal distribution patterns at three altitudinal ranges and also within and between the litter zones at each elevation shows that the low altitude litter habitat harbours large populations as against the high altitude and litter habitats at 2220 m ASL.

As has been stated earlier, the shola forests represent highly specialised relict vegetation, which is expected to contain interesting faunal elements. In many areas, the sholas and the adjoining grasslands have been replaced by wattle, eucalyptus, tea, pine *etc.* In Mannavan shola, the grasslands at lower altitudes (below 1750 m ASL) have been almost replaced by wattle and parts of the grassland at higher altitudes (above 2000 m ASL) by *Eucalyptus*. Similarly at Chembra, much of the sholas have been lost to tea plantations. This is the situation with regard to most of the sholas elsewhere in the Western Ghats. Grazing, fodder and fuel-wood collection, as well as poaching are the other disturbances that cause havoc to this unique ecosystem. Documentation of floral and faunal diversity is fundamental to any conservation programme. It is in this context that the present study was undertaken in order to generate baseline data on the insect faunal elements as well as their distribution patterns in two major shola forests of Kerala.

STUDY SITES

The study has been carried out at two locations *viz.*, at Mannavan shola in Munnar Forest Division and at Chembra hills in South Wynad Forest Division. Brief details of location and vegetation at each of these areas are given below.

i. Mannavan shola

Mannavan shola, located between 10^{o} 10' and 10^{o}12'18" North latitudes and 77^{o} 9' 50" and 77^{o}12' 18" East longitudes is rich in its floristic components (Fig. 1). Throughout its entire range extending from 1600 to 2150 m ASL, the forest is seen as a continuous patch. Chandrashekara *et al.* (1998), who studied the vegetation of this area has reported very high species diversity comparable to identical forests elsewhere. The RISQ (Ramakrishnan Index of Site Quality) values for tree seedling, sapling and mature trees were 1.178, 1.155 and 1.224 respectively indicating a flourishing forest stand.

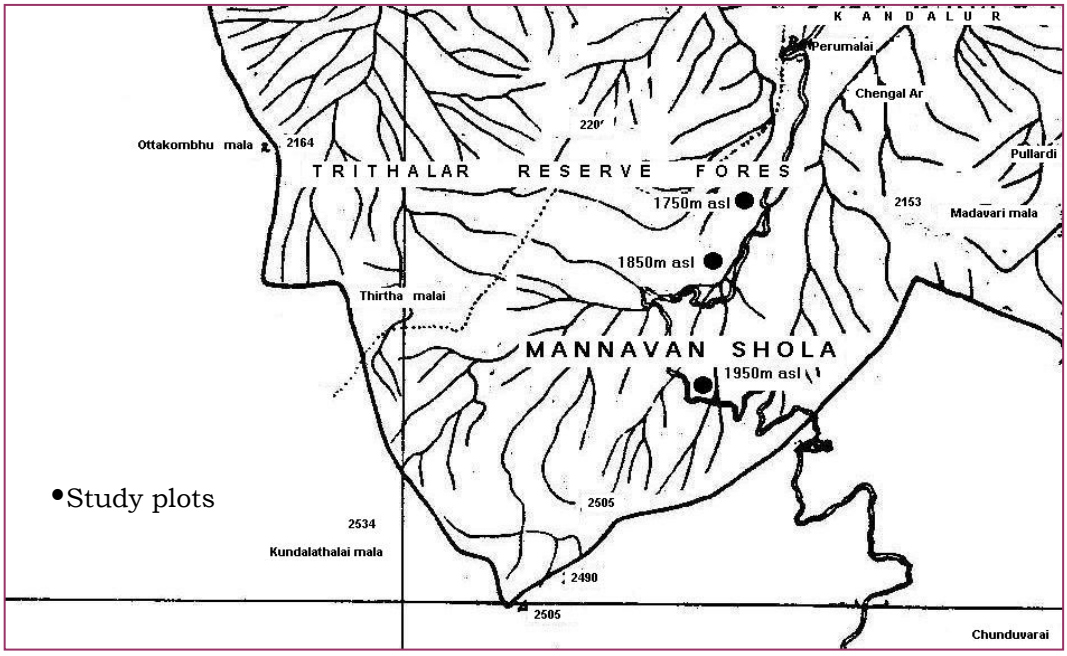

Fig.1. Map of Mannavan shola showing the representative plots at three different altitudes

The compositional type of vegetation of this region was of the *Cinnamomum stocksii* type, as the latter species was 100 percent constant in all the stands between 1,600-2,100m ASL (Swarupanandan *et al.*, 1998). The vegetation is characterised by trees, tree saplings, seedlings, ferns and grasses. Among trees, *Hydnocarpus alpina*, *Isonandra stocksii*, *Gomphandra coriacea*, Lasianthus alpina, *Chionanthus ramiflorus* and *Mastixia arborea* are the first five dominant species. *L. alpina* and *C. ramiflorus* dominates tree sapling population. In the case of tree seedling population, *L. acuminatus* is the dominant species followed *by Beilschmedia wightii*, *C. ramiflorus*, *Ardisia rhomboidea* and *H. alpina*. It may be noted here that species like *L. acuminatus*, *A. rhomboidea* and *C. ramiflorus* which are understorey species of small girth class, showed higher values of IVI (Importance Value Index) in the seedling and sapling populations (Chandrashekara *et al.*, 1998).

Much of the lower parts of Mannavan shola, starting from 1600 m ASL have been converted to wattle plantations that extend up to 1700 m ASL. From 1700 to 1750m ASL is shola-grassland ecotone with rich diversity of herbaceous flora although no appreciable increase is observed at high elevations (Swarupanandan *et al.*, 1998). The dominant tree species are *Isonandra candolleana*, *H. alpina*, *G. coriacea*, *Syzygium* sp., *Isonandra* sp., and *Litsea* sp.

The forest at 1850 m ASL is fairly undisturbed. The dominant species are *H. alpina*, *I. candolleana*, *Syzygium* sp., *G. coriacea*, *Litsea* sp., *Persea macrantha* and *M. arborea.* The number of species showed a decrease from 1850 m ASL onwards as elevation ascended further up to 2100 m ASL (Swarupanandan *et al.*, 1998).

At 1950 m ASL also, the forests are undisturbed with *M. arborea*, *H. alpina*, *Syzygium densifolia*, *S.caryophyllatum, G. coriacea*, *Scolopia crenata*, *I. candolleana*, *Litsea* sp., *Pygeum gardneri* and *Turpinia nepalensis* being the most dominant species.

The dominance spectrum indicated by Simpson's index is highest at lower elevation and least at 2100 m ASL. Evenness of species (plant) population decreased from 1850 m ASL upwards indicating an increase in rarity (sparseness) of species population with increasing elevation (Swarupanandan *et al.*, 1998).

ii. Chembra hills

A part of the study was carried out in Chembra hills at Meppady. Meppady is located between 76^{o} 4' and 76^{o} 7' East latitudes and 11^{o} 31' and 11^{o} 35' North

longitudes (Fig. 2). The altitude ranges between 1100 to 1800 m ASL. The forest type of Chembra hills ranges from tropical wet evergreen to montane subtropical forest, associated with vast areas of grassland. The shola patches are seen from about 1500 m ASL extending up to 1800 m ASL. The vegetation is characterised by trees, shrubs, ferns and orchids. Some of the common tree species found in this area are *Myristica* sp., *Litsea* sp., *Cinnamom* sp., *Syzygium* sp., *Elaeocarpus* sp., *Memecylon* sp., *Agrostistachys* sp., *Oreocnide integrifolia*, *Euonymus indicus* and *Aporusa ligustrum*. Shrubs that are found in this area include *Psychotria sp.*, *Lasianthus* sp., *Clerodendron* sp., *Maesa indica*, *Ardisia pauciflora, Saprosma* sp., *Claoxylon* sp. and *Eurya* sp. Herbs included *Justicia* sp., *Ophiorrhiza* sp., *Pilea melastomoides*, *Anaphalis* sp., *Plectranthus* sp., *Impatiens* sp., *Commelina* sp., *Pogostemon* sp., *Osbeckia* sp., *Sonerila* sp., *Christisonia tubulosa* and *Peliosanthus* sp.

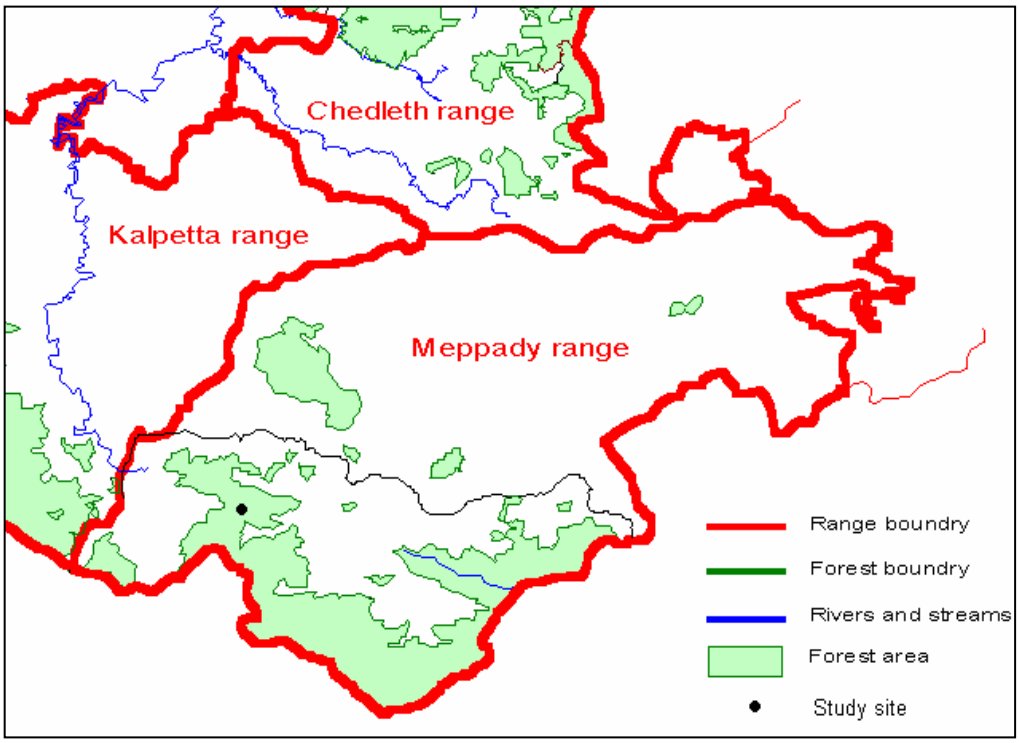

Fig. 2. Map of Meppady Forest Range showing study site at Chembra hills

In addition to the above, climbers such as *Calamus* sp., *Piper* sp., *Smilax* sp., and orchids like *Oberonia* sp., *Bulbophyllum* sp., *Sirhookera* sp., and *Habenaria* sp. are also present on the trunks of mature trees.

MATERIALS AND METHODS

At Mannavan shola, the study was carried out in the semi-permanent plots (50 m x 50 m) already established at three different altitudes (1750 m, 1850 m and 1950 m) by KFRI. At Chembra hills, the study was carried out in a forest patch (50 x 50 m) at 1700 m ASL.

Sampling of insects was carried out at each of the collection sites using a battery operated light trap specially fitted with a switching device to facilitate automatic operation at specified hours (Mathew and Rahamathulla, 1995). In order to avoid the influence of lunar phase on insect catches, the trap was operated in a cyclic order in different altitudes. In addition to trap catches, collections were also made during day times (8 am to 1 pm) using hand nets. The insects collected were sorted out to species and the number of individuals for each species was recorded on data sheets. From the data collected, indices of diversity, dominance, evenness, species richness etc., were computed separately for different altitudes. As it was not possible to identify all the species in the field, code numbers were assigned to the various species. The insects were later identified by comparison to material available in KFRI collection and by referring to experts in various institutions.

ANALYSIS OF DATA

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 *i.e.*, 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; Magurran, 1988):

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

Where 'H' is the Shannon's index of species diversity and P_i is the proportion of individuals in the i^{th} species.

Dominance index

Patterns of relative abundance of species which determine the dominance of each insect Order in a locality was estimated 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 i.e., equal abundance of all species in the sample or community (Pielou, 1977).

The Shannon's evenness index of the community (E) 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.

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.

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. Coefficient of correlation was worked out in order to show the effect of increasing elevation on the species diversity of insects and plants.

RESULTS

Information generated on insect diversity at each of the study sites is presented below:

i. Mannavan shola

Occurrence of species

Altogether, 1051 insects belonging to 344 species under 10 orders and 73 families were recorded from Mannavan shola. The distribution patterns of insects at various altitudes is presented in Table 1.

Table 1. Data on insects collected from Mannavan shola

Location	No. of orders	No. of families	No. of species	No. of individuals
1750 m	8	51	187	368
1850 m	8	42	175	366
1950 m	8	41	147	317
Pooled data	10	73	344	1051

From the sample plots at 1750 m ASL, 368 insects belonging to 187 species of insects under 51 families and 8 orders were collected. The plots at 1850 m ASL also had more or less similar number of insects (366) although there was a reduction in the number of families and species. Plots at 1950 m elevation had still lesser number of families and species. The representation of taxa was different in the plots at various altitudes.

Dominance index

The dominance index worked out for various groups of insects is given in Table2.

Table 2. Dominance index of insect orders with respect to number of individuals

ORDER	Elevation (in m. ASL)							
	1750		1850		1950		Pooled	
	I	D	I	D	I	D	I	D
Lepidoptera	245	66.58	246	67.22	228	71.93	719	68.41
Trichoptera	22	5.98	46	12.57	22	6.94	90	8.56
Coleoptera	33	8.97	28	7.65	19	5.99	80	7.61
Diptera	32	8.70	17	4.65	18	5.68	67	6.38
Hymenoptera	14	3.80	9	2.46	22	6.94	45	4.28
Hemiptera	18	4.89	16	4.37	5	1.58	39	3.71
Mecoptera	2	0.54	2	0.55	2	0.63	6	0.57
Dictyoptera	2	0.54	-	-	-	-	2	0.19
Plecoptera	-	-	2	0.55	-	-	2	0.19
Orthoptera	-	-	-	-	1	0.32	1	0.10

I – No. of individuals
D - Dominance index

At 1750 m elevation, Lepidoptera had the highest dominance index (66.58). The values for all other groups were relatively low (Fig.3). Coleoptera and Diptera had more or less similar values (8.97 and 8.70 respectively). At 1850m elevation, Lepidoptera had slightly higher values (67.21) followed by Trichoptera (12.57), Coleoptera (7.65) and Diptera (4.65). Similarly, at 1950m elevation, the values for Lepidoptera showed an increasing trend (71.92) and the values for Trichoptera, Coleoptera and Diptera were more or less in the same range. Of the 18 families of Lepidoptera represented in this study, Geometridae was the most dominant family followed by Pyraustidae, Noctuidae, Lymantridae and Arctiidae. The dominance index of Lepidoptera at all elevations remained high probably due to their diversified habits and adaptability to various habitats although similar trends were not observed for other groups such as Coleoptera and Hemiptera which are also highly adapted to diverse ecological conditions.

Certain groups such as Orthoptera, Plecoptera and Dictyoptera which are more specific in their habits were found to be present only in certain plots.

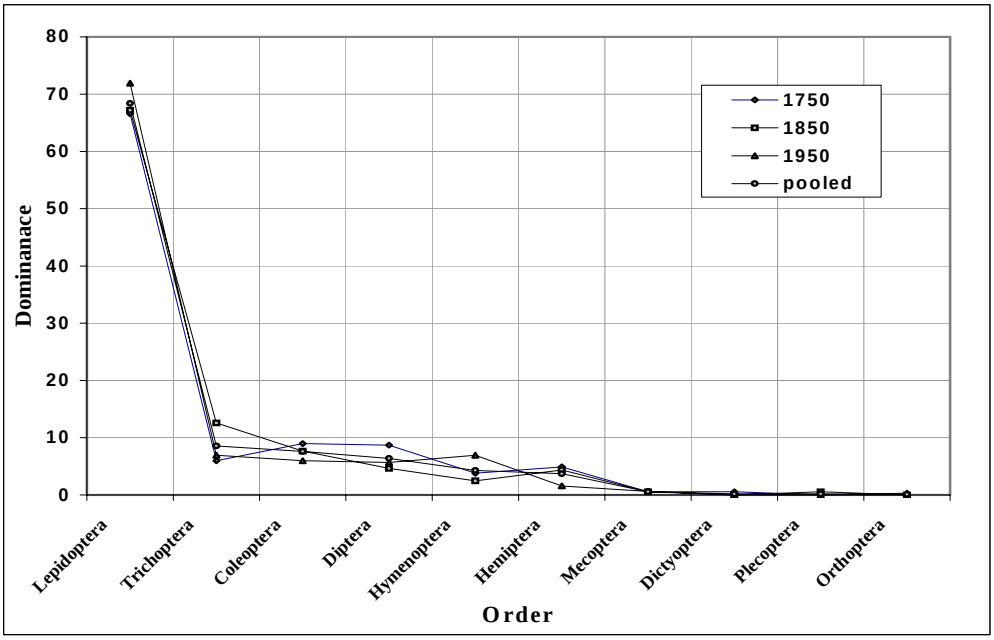

Fig. 3. Relative dominance of various insect groups at Mannavan shola

Species richness index

Species richness index for various altitudes calculated using Menhinick formula, are given in Table-3. The species richness showed a decline with increasing altitude, being 9.75 in the plot situated at 1750 m ASL and 8.2563 at 1950 m ASL.

Table 3. Characteristics of insect community at various altitudes in Mannavan shola

Location (in m ASL)	No. of species	No. of individuals	Diversity index	Richness index	Evenness index
1750	187	368	4.87082	9.75	0.93
1850	175	366	4.78539	9.15	0.93
1950	147	317	4.62545	8.26	0.93
Pooled data	344	1051	5.36357	10.61	0.92

Species diversity

Shannon's index of species diversity calculated for different altitudes are given in Table 3. The diversity index showed a decreasing trend with the increasing altitude. The diversity was maximum in the plot at the lowest altitude (1750 m) and minimum in the plot selected at the highest altitude (1950 m).

Evenness or equitability index

The evenness index for all the plots was found to be above 0.93, indicating uniform distribution of insects in all the plots. This shows that the species are uniformly represented in the area irrespective of elevation.

Faunal elements

The insects collected and identified from the study areas at Mannavan shola are given in Appendix-I. The fauna contained species mostly found in moist deciduous and evergreen forests along with certain elements found in the temperate zone. An analysis of faunal elements was attempted in the case of Lepidoptera for which ecological and biogeographical data was available. The butterflies for instance, contained species found in moist deciduous forests - *Neptis hylas*, *Junonia lemonias*, *Argynnis hyperbius* (Nymphalidae), *Euploea core*, *Danaus genuita* and *D. chrysippus* (Danaidae), *Catopsilia pomona*, *Eurema hecabe and Leptosia nina* (Pieridae); species found in evergreen forests - *Cupha erymanthis maja, Cirrochroa thais*, *Kaniska canace* (Nymphalidae), *Zipoetis saitis* and *Elymnias caudata* (Satyridae) as well as *species* found in temperate forests - *Vanessa cardui, V. indica (Nymphalidae), Telicota acigias* (Hesperidae) and *Colias erata* (Pieridae). Certain endemic species such as *Tirumala septentrionis dravidarum*, *Parentica nilgiriensis* (Danaidae), *Lethe neelgheriensis* (Satyridae), *Delias eucharis* (Pieridae) as well as certain protected species such as *Hypolimnas missipus*, *Euthalia lubentina* (Nymphalidae), *Appias libythea* (Pieridae), *Zipoetis saitis, Mycalesis oculus* (Satyridae) and *Udara akasa* (Lycaenidae) have also been recorded (Fig. 4). Similarly, the moth fauna was also specalised having more number of arboreal feeding forms such as *Pingasa* sp., *Semiothisa emersaria* sp., *Abraxes poliaria*, *Hypomecis* sp. (Geometridae), *Bochoris onyclinalis*, *Euclasta* sp. (Pyraustidae), *Eupterote* sp. (Eupterotidae) and *Sahyadrassus malabaricus* (Hepialidae). The identity of a number of species collected in this study still remains to be established and many of these are likely to be new species.

A number of insects mostly belonging to Coleoptera, Hymenoptera and Hemiptera have also been recorded. Among beetles, the passalid, *Pleurarina brachyphyllus* recorded in this study was of interest as it was found only at altitudes of around 1850 m. The hymenoptera recorded contained an ichneumon, *Ericospilus* sp., besides several species of bees (*Xylocopa* spp., *Apis cerana*), wasps and ants (*Camponotus* spp.). The bugs collected, represented several families covering Cercopidae, Eurybrachyidae, Fulgoridae, Cicadellidae and Delphacidae. Of these, the cicadellid, *Traigume* sp. nr. *verticalis* was of interest as this insect is restricted to the south Indian forests. This insect was found to be rather rare and we could collect only a single specimen.

ii. Chembra hills

Sampling was carried out only at one altitude *i.e.,* 1700 m ASL. Eighty one species grouped under 8 orders were collected from this area (Table 4).

Table 4. Characteristics of insect community at Chembra hills

Location	No. of species	No. of Individuals	Evenness index	Diversity index	Richness index
Chembra hills (1700 m ASL)	81	150	0.96	4.22	6.61

Occurrence of species

One hundred and fifty insects belonging to eighty one species under eight orders were recorded in this study (Tables 4 and 5).

Dominance index

The number of insects belonging to various insect groups and their dominance index is given in Table 5. The Order Lepidoptera registered the highest value (72.67) followed by Coleoptera (7.33) and Orthoptera (6.00). The dominance of Lepidoptera might be due to their high degree of adaptive radiation within the habitat.

Table 5. Dominance index of various insect orders at Chembra hills

Order	I	D
Lepidoptera	109	72.67
Coleoptera	11	7.33
Orthoptera	9	6.00
Hymenoptera	7	4.67
Diptera	5	3.33
Hemiptera	4	2.67
Trichoptera	4	2.67
Mecoptera	1	0.67

I – No. of individuals
D – Dominance index

Species richness

Species richness index calculated using Menhinick formula was found to be 6.61 which is low compared to the value obtained for Mannavan shola (10.61).

Species diversity

The Shannon's index of diversity was 4.22 (Table 4). The coefficient of correlation (r) between insect diversity and plant diversity was found to be 0.94 and that for insect diversity and altitudinal change was found to be -0.99.

Evenness or equitability index

The evenness index was 0.96 indicating a more or less uniform distribution of various insects in this study area. This value was slightly higher than that for Mannavan shola (0.93).

Faunal elements

The insects collected and identified from Chembra hills are given in Appendix-I. The faunal elements were of the moist deciduous and evergreen types, since this study was carried out only at one altitude, *viz.*, 1700 m ASL. The study area

which is surrounded by tea estates was partially disturbed due to human interference. In spite of this, the area was found to be rich in fauna, particularly the butterflies which included several colourful and rare ones such as *Graphium sarpedon*, *Papilio helenus*, P. polymnestor, *P. paris tamilana, Troides minos* (Papilionidae), *Cirrochroa thais thais*, *Cupha erymanthis*, *Cyrestis thyodamas*, *Hypolimnas bolina*, *H. missipus* (Nymphalidae), *Tirumala sepentrionis* (Danaidae), *Appias indra siva, A. libythea, Delias eucharis* (Pieridae*), Udara akasa (*Lycaenidae) as well as *Lethe rohria* and *Ypthima avanta* (Satyridae). Of these, *P. paris tamilana, P. polymnestor, T. minos, T. sepentrionis, D. eucharis* and *U. akasa* are south Indian endemics while *H. missipus, A. indra siva* and *A.libythea* are having protected status under the Indian Wildlife Act (GOI, 1982).

The moths collected included mostly of herbaceous feeding forms *Euproctis* spp. (Lymantridae), *Psara* spp., and *Syngamia* spp. (Pyraustidae). Other insects collected included several species of Chrysomelidae which generally thrive on various weeds found in the forest. A major share of insects collected from this area are yet to be identified (Appendix 2).

DISCUSSION

A comparison of faunal diversity at Mannavan shola and Chembra hills

While 1051 insects belonging to 344 species under 73 families were recorded from the study plots laid out at 3 altitudes in Mannavan shola, just 150 insects belonging to 81 species could be collected from the study plots at Chembra hills. It may be noted here that at Mannavan shola, sampling was carried out for 19 months (from September 1998 to March 2000) whereas at Chembra hills, sampling was carried out only for 12 months (from April, 1999 to March, 2000). Hence, a strict comparison of fauna of these two areas was not possible and only the major characteristics and broad similarities are discussed here.

The overall diversity of insects at Mannavan shola was 5.36 while that of Chembra was only 4.22. The richness index was also higher at Mannavan shola (10.61) compared to Chembra hills (6.61). Data generated for various biodiversity 'hotspots' in Kerala such as Silent Valley, Nelliyampathy, Sholayar and Parambikulam are presented in Table 6. The values obtained for Mannavan shola and Chembra hills were found to be fairly comparable to those of other forest areas in the Kerala part of Western Ghats. The value obtained for Mannavan shola (5.36) is higher than the values so far recorded. With regard to Chembra hills, for which the value was low (4.22), the area surveyed was much less and plots were taken at only one altitude and the period of sampling was also short.

Table 6. Insect species diversity in selected forests in the Kerala part of Western Ghats

Locality	Species diversity	Richness	Reference
Silent valley	4.83	5.91	Mathew *et al.*, 1998
Nelliyampathy	5.13	8.13	Mathew *et al.*, 1998
Sholayar	4.74	5.49	Mathew *et al.*, 1998
Parambikulam	4.50	5.62	Mathew *et al.*, 1998
Mannavan shola	5.36	10.61	Present study
Chembra hills	4.22	6.61	Present study

Both small and large sized sholas are known to have their own characteristics as indicated by Ganeshaiah *et al.* (1997), who stated that small sholas were less similar and shared fewer species among themselves compared to medium and large sized sholas. The species assemblage diversity among sholas appeared to converge towards a common assemblage of species. According to them, small fragments add structural and functional heterogeneity to the ecosystem and hence are as important as are the large fragments in conserving biodiversity. The large sholas may contain twice the number of species found in small sholas. The small fragments though individually may not be species rich compared to large fragments, together they add substantially to the spatial and structural heterogeneity of the ecosystem that might be important for its functional diversity particularly considering invertebrates that require small areas for their survival. As we could not make a very comprehensive survey of the insect fauna of the Chembra hills, we were not able to make a more realistic comparison of the faunal specialties of the two locations.

Patterns of insect diversity in different habitats in the shola forests

The diversity patterns of different habitats was another aspect covered in this study. At Mannavan shola, where sampling was done at three altitudes, the floral and faunal elements as well as species diversity showed pronounced variations at different altitudes. At lower elevation, the vegetation was typically the evergreen type comprising of trees such as *Hydnocarpus*, *Gomphandra*, *Litsea* and *Cinnamomum*. At an Altitude of 1850m the flora showed specialisation comprising mostly of shrubby vegetation formed by *Stobilanthes kunthianus* and *Rubus* sp., in addition to trees like Syzygium. There were also several species of ground orchids like *Calanthe*. From 1950 m onwards the vegetation was of temperate nature being dominated by *Rhododendron* and ferns besides various species of orchids which are characteristic of temperate forests. Plant diversity decreased from 2.21 at 1750 m ASL to 1.47 at 1950 m ASL (Swarupanandan, *et al*, 1998). Similary insect species diversity and altitude were found to be negatively correlated (r=-0.985) (Fig. 3). It indicates that species diversity decreases with increasing altitude (Fig. 5). It is the climatic, edaphic and vegetation attributes of forests that decide the type of faunal elements surviving in these ecosystems as shown up in the analysis of plant and insect diversity which indicated a high positive correlation (r=0.936) between the plant and insect diversity (Table 7).

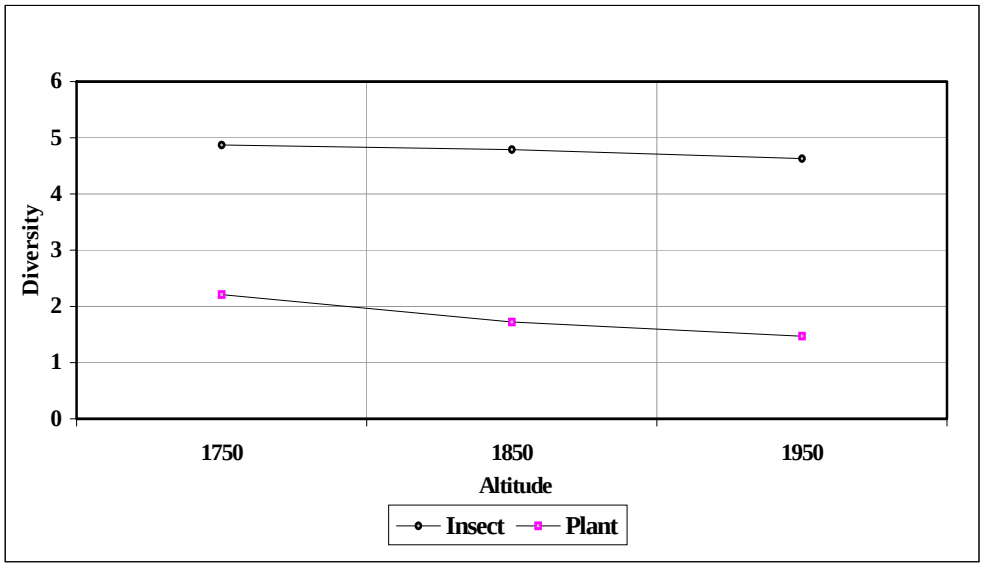

Fig. 5. Relation between plant and insect diversity at different altitudes at Mannavan shola

Table 7. Plant and insect diversity patterns at Mannavan Shola

Location	Insect diversity	Plant diversity
1750 m ASL	4.87082	2.21
1850 m ASL	4.78539	1.72
1950 m ASL	4.62545	1.47

Faunal elements

The faunal elements of Mannavan shola were specialised consisting mostly of arboreal feeding forms indicating a fairly undisturbed forest. Several species of butterflies like *Mycalesis oculus*, *Rohana parisatis*, *Artogeia canidia*, *Colias erata*, *Belanois aurata*, *Vanessa indica*, *V. cardui* etc., found abundantly in Mannavan shola are specialised to this habitat being not frequently found in other forest types. The faunal elements showed specialisation with varying altitudes. While certain species like *Pingasa, Chionaema peregrina, Euclasta* sp., *Euproctis* sp.,

Gnamptoloma aventiaraia, Heliothis sp.*, Mabra eryxalis, Nephopteryx sp,.* and *Semiothisa emersaria* were collected only from the plot at 1950m elevation, others like *Condria* sp.*, Diasemia* sp.*, Eupterote* sp.*, Glyphodes laticostalis, Hypomecis* sp.*, Macotasa* sp. prob*. nubecula, Ourapteryx marginata, Pyrausta* sp.*, Racotis inconclusa,* and *Udea ferrugalis* were present at all altitudes. The host range of most of the insects collected could not be established.

With regard to Chembra hills, the fauna was rich in butterflies containing several endemic and protected species. The fauna showed dominance of herbaceous feeding insects belonging to the families, Pyraustidae, Lymantridae (Lepidoptera) and Chrysomelidae (Coleoptera).

CONCLUSIONS

The insect fauna of shola forests at both locations is rich and diversified consequent to the vegetation as well as eco-climatic conditions. The richness and diversity of fauna is equal to or even superior to that of some of the well-known biodiversity 'hotspots' in the Kerala part of Western Ghats. Both the areas also contained several endemic and protected species. Several species of insects could not be identified which are likely to contain many new species.

The economic and ecological significance of many insects recorded in this study are not yet worked out. The present study was with special reference to certain selected insect groups. A more detailed study might be required to fully work out the faunal wealth of these areas. As has been already stated, the small and large sholas have their own characteristic fauna and protection of all the existing shola patches is necessary to ensure conservation of the entire diversity of this unique ecosystem.

ACKNOWLEDGEMENTS

We are grateful to Dr. K. M. Ganeshaiah, Professor, Department of Genetics and Plant Breeding at the University of Agricultural Sciences, Banglore for many useful discussions on research methodology. Dr. T. C. Narendran, Professor, Department of Zoology, University of Calicut and Dr.C.A.Viraktamath, Professor, Department of Entomology, University of Agricultural Sciences, Bangalore kindly identified several groups of insects referred to them. We are grateful to our colleagues, Drs. R. V. Varma, N. Sasidharan, and K. K. Ramachandran for editorial scrutiny and Dr. K. S. S. Nair (Former Director) and Dr. J. K. Sharma (Director) for their interest and encouragement throughout this study. Thanks are also due to Shri. C.M. Brijesh, Research Fellow for assistance in field work and Shri. V. Asokan, for Typesetting the report. This study was supported by the Kerala Forest Department.

REFERENCES

Champion, H.G. and Seth, S.K. 1968. A Revised Survey of the Forest Types of India. Govt. of India Press, Nasik, 342 pp.

Chandrashekara, U.M., Menon, A.R.R., Nair, K.K.N., Sasidharan, N., and Swarupanandan, K. 1998. Evaluating Plant diversity in different forest types of Kerala by laying out permanent sample plots. KFRI Research Report No. 156, Kerala Forest Research Institute, Peechi, 86 pp.

Cherian, P.T. 1983. Long-term environmental and ecological impacts of multi-purpose river valley projects with special reference to Idukki, Kerala. (Report submitted to the Ministry of Environment and Forests, New Delhi), Zoological Survey of India, 212 pp.

Ganeshaiah, K.N., Uma Shanker and Bawa, K.S. 1997. Diversity of species assemblages of islands: predictions and their test using tree species composition of shola fragments. Current Science, 73(2): 188-194.

GOI (Government of India), 1982. The Gazette of India (Extra ordinary) Part II, Section (3), Sub-section (1). Amendment of the Act, 1972.

Jose, Shibu, Sreepathy, A., Mohan Kumar, B. and Venugopal, V.K. 1994. Structural, floristic and edaphic attributes of the grassland-shola forests of Eravikulam in peninsular India. Forest Ecology and Management, 65(2-3): 279-291.

Larsen, T.B. 1987. The butterflies of the Nilgiri mountains of South India (Lepidoptera: Rhopalocera). J. Bombay nat. Hist. Soc., 84(1): 26-54, 84(2): 291-316; 84(3): 560-584.

Larsen, T.B. 1988. The butterflies of the Nilgiri mountains of South India (Lepidoptera: Rhopalocera). J. Bombay nat. Hist. Soc., 85(1): 2-43.

Magurran, A.E. 1988. Ecological Diversity and its Measurement. Croom Helm. Ltd., London, 179 pp.

Margalef, R. 1968. Perspectives in Ecological Theory. University of Chicago Press, Chicago.

Mathew, G. 1990. Studies on the Lepidopteran fauna, pp.13-53. *In*: Ecological studies and long term monitoring of biological processes in Silent Valley National Park. (Report submitted to Ministry of Environment, Govt. of India), Kerala Forest Research Institute, (March 1990), 239 pp. (mimeo).

Mathew, G. 1993. A status survey of insect fauna of Malayattoor, pp.135-158. In: Baseline studies for the proposed Nature Study Centre at Kalady in Malayattoor Forest Division. (Report submitted to the Ministry of Environment and Forests, New Delhi). KFRI Research Report, 248 pp.

Mathew, G. and Nair, K.S.S. 1986. Bagworms (Lepidoptera: Psychidae) of Kerala and their potential as pests of forest tree crops. Proc. III Orient. Ent. Symp. (Association for Advancement of Entomology, Trivandrum), pp. 163-167.

Mathew, G. and Menon, M. G. R. 1984. The Pyralid fauna of Kerala. J. ent. Res. 8(1): 5-13.

Mathew, G. and Rahamathulla, V.K. 1993. Studies on the butterflies of Silent Valley National Park. Entomon, 18(3&4): 185-192.

Mathew, G. and Rahamathulla, V.K. 1995. Biodiversity in the Western Ghats- a study with reference to moths in the Silent Valley National Park, India. Entomon, 20(2): 25-33.

Mathew, G., Rugmini P. and Sudheendrakumar, V.V. 1998. Insect biodiversity in disturbed and undisturbed forests in the Kerala part of Western Ghats. KFRI Research Report No. 135, Kerala Forest Research Institute, Peechi. 113 pp.

McArthur, R. H. and Wilson, E. O. 1967. The Theory of Island Biogeography: Monographs in population biology. Princeton University press, Princeton, NJ.

Meher-Homji, V. M. 1965. Ecological status of the montane grasslands of the south Indian hills: a phytogeographic assesment. Indian For. 91(4): 210-215.

Menhinick, E. F. 1964. A comparison of some species diversity indices applied to samples of field insects. Ecology, 45:859-861.

Narendran, T. C. 1986. New species of *Rhynchochalcis* (Chalcidae). Current Science 55(11): 544-546.

Narendran, T. C. 1992. A new species of *Rickisura* from India. J. Adv. Zool 13(1&2): 57-58.

Narendran, T. C. 1998. Two new species of *Xenastatus* with a key to species of Indo-Australia region. Senckenbergiana biologica, 77(2): 205-209.

Prabhoo, N. R. 1971. Distribution of soil and litter Collembola of south India. Oriental Insects, 5(2):243-262.

Pielou, E. C. 1975. Ecological Diversity. John Wiley & sons, New York, 165 pp.

Pielou, E. C. 1977. Mathematical Ecology, John Wiley & sons, New York, 305 pp.

Ranganathan, C. R. 1938. Studies on the ecology of the shola grassland vegetation of the Nilgiri Plateau. Indian For. 64(9): 523-541.

Shanker, Kartik 1996. Sholas. Science Reporter (June, 1996), pp. 10-13.

Sudheendrakumar, V. V. and Mathew, G. 1999. Studies on the diversity of selected groups of insects in the Parambikulam Wildlife Sanctuary. KFRI Research Report No. 165, Kerala Forest Research Institute, Peechi, 77 pp.

Swarupanandan, K., Sasidharan, N., Chacko K.C. and Chand Basha, S. 1998. Studies on shola forests of Kerala. KFRI Research Report No. 158, Kerala Forest Research Institute, Peechi, 143 pp.

Thomas, Sabu, K., Jayakumar, A., Ananthakrishnan, T. N. 1995. Dynamics of insect communities at varying altitudes in shola forests of Kodaikanal hills, in relation to the chemical diversity of litter. International Journal of Ecology and Environmental Sciences, 21: 109-129.

Appendix –I

List of insects recorded from Mannavan shola and Chembra hills

Sl. No.	Order/family/ species	Study areas		Remarks
		Mannavan Shola	Chembra hills	
LEPIDOPTERA **RHOPALOCERA** **PAPILIONIDAE**				
1.	*Graphium sarpedon teredon* Felder	*	*	Larva feeds on *Cinnamomum* sp., *Litsea glutinosa*, *Alseodaphne semecrapifolia* and *Milusa odoratissima*. Adults generally aggregate on damp places.
2.	*Papilio demoleus demoleus* Lin.	*	*	Not very common in Mannavan shola. In Chembra hills, it is common in forests at lower elevations adjoining the tea estates. Larva feeds on cultivated citrus, orange, jasmine, lime berry, Wingle leaf, Prickly ash, *Glycosmis* sp. and Z*anthoxylum* sp.
3.	*Papilio helenus* Lin.	*	*	At Mannavan Shola it is very abundant from 1850m to 1950m. It has also been spotted at 2300m. At Chembra hills, it is common throughout the forest patches and in the adjoining tea estates. Larva feeds on orange, lime, Pomelo, *Glycosmis pentaphylla* and *Zanthoxylum rhesta*.
4.	*Papilio paris tamilana* Moore	-	*	Larva feeds on *Zanthoxylum ovalifoliu* and *Citrus* spp.
5.	*Papilio polymnestor parinda* Moore	*	*	Endemic to South India and Sri Lanka.

				At Mannavan shola, it is found up to 2200m. In Chembra hills, it is common throughout the forest patches and in tea estates adjoining it but not common in the drier parts at lower elevations. Larva feeds on wild orange, *Garcinia* sp., *Paramigyna monophylla* etc.
6.	*Papilio polytes* Lin.	*	*	Found at lower elevations. Larva feeds on orange, lemon etc.
7.	*Troides minos* Cramer	-	*	Endemic to Western Ghats Fairly common below 1600m. Larva feeds on Indian Birth wort, *Aristolochia tagala*, *A.* griffithi, *Thotea wallichi* and *T.siliquosa*.
	NYMPHALIDAE			
8.	*Argynnis hyperbius* Johannsen	*	*	Common in Mannavan shola up to 2200m and in Chembra hills up to 1750m.
9.	*Ariadne merione* Cramer	*	-	Found at lower elevations.
10.	*Athyma nefte* Doubleday	*	-	Found above 1800m. Rare.
11.	*Cirrochroa thais thais* Fb.	*	-	Endemic to south Indian hills. Found above 1850m mostly in the wetter parts. Aggregation observed during the months, February to April . Larva feeds on *Hydnocarpus wightiana.*
12.	*Cupha erymanthis maja* Fruhstorfer	*	*	Fairly common in the wetter parts. In the former, common up to 2300m, usually in interior forest.
13.	*Cyrestis thyodamas ganescha*	*	*	Confined to the moist forests. Larva feeds on *Ficus* spp.

	Kollar			
14.	*Euthalia lubentina* Cramer	*	-	Protected, Schedule IV. Rare.
15.	*Hypolimnas bolina* Lin.	*	*	Fairly common at low elevations in both locations.
16.	*Hypolimnas missipus* Lin.	*	*	Protected, Schedule II. Fairly common at low elevations in both locations. Larva feeds on Barleria, *Asystasia gangetica*, *Justicia betonica*, *Portulaca tuberosa*, etc.
17.	*Junonia almana* Lin.	*	*	Not common in Mannavan shola but fairly common in lower parts of Chembra hills. Larva feeds on white Barleria, Blue-bell Barleria, Common Gloxinia, *Osbeckia chinensis*, *O. crinata, O. cupularis,* and *Mimulus gracili.*
18.	*Junonia heirta* Fb.	*	*	Commonly found in forest areas adjoining wattle plantations at the lower parts of Mannavan shola. In Chembra hills, it is common in the open (disturbed patches) forests.
19.	*Junonia lemonias vaisya* Fruhstorfer	*	*	Not very common in Mannavan shola but fairly common in Chembra hills up to 1750m. Larva feeds on *Ruellia prostrata*, *Nelosonia canescens*, *N. campestris*, *Barleria prionitis* etc.
20.	*Junonia stygia*	*	*	Commonly found both in Mannavan shola and Chembra hills.
21.	*Kaniska canace haronica* Moore	*	*	Common in the wetter parts of Mannavan shola up to 1800m. Larva feeds on wild yams and *Smilax* spp.
22.	*Neptis hylas varmona* Moore	*	*	Common in the wetter parts of Mannavan shola up to 1950m. Larva feeds on *Helicteres isora*, *Nothanpodytes nimmoniana*, *Paracalyx scariosa*, *Mappia foetida*

				etc.
23.	*Neptis perius perius* Linn.	*	-	Fairly common in Mannavan shola above 1850m. Larva feeds on *Glochidion lanceolarium* and *G. velutinum*.
24.	*Pantoporia ranga* Moore	*	-	Found throughout Mannavan shola, but not very common.
25.	*Phalanta phalanta* Drury	*	-	Common in Mannavan shola up to 2300 m. Larva feeds mostly on plants of Bixaceae.
26.	*Rohana parisatis* Cramer	*	*	Adults usually found feeding on wet decaying materials along with *Vanessa indica* and *Cirrochroa thais*.
27.	*Vanessa indica* Fruhstorfer	*	*	Commonly found in Mannavan shola (up to 1950m) and Chembra hills. Larva feeds mostly on nettles.
28.	*V. cardui* Lin.	*	-	Commonly found up to 1950 m.
	DANAIDAE			
29.	*Danaus chrysippus* Lin.	*	*	Found at lower elevations.
30.	*Danaus genuita genuita* Cramer	*	*	Rare in Mannavan shola but fairly common in Chembra hills.
31.	*Euploea core core* Cramer	*	*	Common. Larva feeds on *Ficus* spp.
32.	*Parantica nilgiriensis* Moore	*	-	Endemic to Western Ghats. Found up to 2200m.
33.	*Tirumala limniace* Butler	*	*	Common. Larva feeds on *Dregea volubilis*.
34.	*Tirumala septentrionis* Fruhstorfer	*	*	Common. Larva feeds on *Dregea volubilis*, *Vallaris glabra*, *Vallaris solanacea* etc.
	PIERIDAE			
35.	*Appias indra*	*	*	Protected, Schedule II.

	shiva Moore			Found at lower elevations.
36.	*Appias libythea* Fb.	*	*	Protected, Schedule IV. Found at lower elevations.
37.	*Catopsilia florella* Fb.	*	*	Common in lower parts of Mannavan shola mostly in areas adjoining Wattle plantations. Found throughout Chembra hills.
38.	*Catopsilia pomona* Fb.	*	*	Found up to 2300m in Mannavan shola but only up to 1750m in Chembra hills.
39.	*Catopsilia pyranthe* Lin.	*	*	Found at lower elevations.
40.	*Colotis fausta* Olivier	*	-	Found in the wetter parts up to 1800m.
41.	*Colias erate* (Esper)	*	-	Found on the hills
42.	*Delias eucharis* Drury	-	*	Endemic to south India and Sri Lanka. Not found in Mannavan shola but fairly common in Chembra hills.
43.	*Eurema blanda* Boisduval	*	*	Common at lower elevations.
44.	*Eurema brigitta* Stoll	*	*	Found along forest edges at low elevations.
45.	*Eurema hecabe* Lin.	*	*	Commonly found at low altitudes (1700m) in Mannavan shola and Chembra hills
46.	*Eurema laeta* Boisduval	*	*	Common at low elevations.
47.	*Leptosia nina* Fb.	-	*	Found along the forest edges bordering tea estates in Chembra hills.
48.	*Artogeia canidia*	*	-	Very common through out Mannavan shola, mostly at low elevations.

	Sparrman			
	SATYRIDAE			
49.	*Elymnias caudata* Butler	*	-	Rare.
50.	*Lethe drypetis todara* Moore	*	-	Found above 1900 m. in Mannavan shola.
51.	*Lethe neelgheriensis* Guerin	*	-	Rare. Found in interior forest.
52.	*Lethe rohria* Frushstorfer	*	*	Found in gaps within the forests.
53.	*Melanitis leda* Lin.	*	*	Found in interior forest in Mannavan shola. Not very common in Chembra hills.
54.	*Mycalesis oculus* Marshall	*	-	Endemic to Western Ghats. Common in Mannavan shola above 1800m.
55.	*Ypthima avanta Moore*	*	*	Common at 1750m both at Mannavan shola and Chembra hills.
56.	*Ypthima ceylonica* Hewitson	*	-	Commonly found below 1700m.
57.	*Ypthima chenui* Guerin	*	-	Endemic to Western Ghats. Commonly found below 1700m.
58.	*Ypthima ypthimoides* Moore	*	-	Endemic to Western Ghats. Commonly found below 1700m.
59.	*Zipoetis saitis* Hewitson	*	-	Protected, Schedule II. Endemic to Western Ghats.
	HESPERIDAE			
60.	*Celaenorrhinus leucocera* Kollar	*	*	Common.

61.	*Telicota acigias* Lin.	*	*	Found in wet grassy areas along trek paths in forests.
	LYCAENIDAE			
62.	*Catachrysops strabo* Fabricius	*	_	Found above 1750m.
63.	*Celastrina lavendularis* Moore	*	*	Common at 1600m.
64.	*Jamides bochus* Cramer	*	_	Found above 1750m.
65.	*Udara akasa* Horsfield	*	*	Endemic to south India and Sri Lanka. Common in the wetter parts of the forest.
	LIBYTHEIDAE			
66.	*Libythea celtis leptoides* Moore	*	*	Found at low elevations. Adults commonly seen around decaying matter.
67.	*L. myrrha* Godart.	*	-	Common above 1750m.
	HETEROCERA **HEPIALIDAE**			
68.	*Sahyadrasus malabaricus* Moore	*	-	
	AMATIDAE			
69.	*Amata extensa*	-	*	
70.	*Syntomis* sp.	-	*	
71.	*Syntomis thoracica*	-	*	
	ARCTIDAE			
72.	*Asura confirta*	*	*	

73.	*Cyne gratiosa* Guerin-Meneville	*	-	
74.	*Eilema tetragona* Walker	*	-	
75.	*Lemyra* sp.	*	-	
76.	*Macotasa* sp.? *nubecula* Moore	*	-	
77.	*Paraplastis hampsoni* Swinhoe	*	-	
78.	*Paraplastis* sp.	*	-	
79.	*Spilosoma* sp.	*	-	
	COSSIDAE			
80.	*Cossus* sp.	*	-	
	GEOMETRIDAE			
81.	*Abraxas* sp.? *latizonata* Hampson	*	-	
82.	*Abraxas* sp. of *poliaria* Swinhoe	*	-	
83.	*Abraxas* sp 1.	*	-	
84.	*Abraxas* sp 2.	*	-	
85.	*Aplochlora vivilaca* Wlk.	*	-	
86.	*Chionaema peregrina* Wlk.	*	-	
87.	*Cleora* sp.	*	-	
88.	*Cleora* sp.*? alienaria* Walker	*	-	

89.	*Cusiala raptaria* Wlk.	*	-	
90.	*Dirades* sp.	*	-	
91.	*Eclitoptera subapicalis* Hampson	*	-	
92.	*Gnamptoloma aventiaraia*	*	-	
93.	*Hypomecis pallida* Hampson	*	-	
94.	*Hypomecis* sp 1.	*	-	
95.	*Hypomecis* sp 2.	*	-	
96.	*Hypomecis* sp 3.	*	-	
97.	*Ourapteryx marginata* Hampson	*	-	
98.	*Pingasa* sp.	*	-	
99.	*Pyrrhorachis pyrrhogona*	*	-	
100.	*Racotis inconclusa* Walker	*	-	
101.	*Racotis* sp 1.	*	-	
102.	*Racotis* sp 2.	-	*	
103.	*Scopula* sp 1.	*	-	
104.	*Scopula* sp 2.	*	-	
105.	*Scopula* sp 3.	*	-	
106.	*Scopula* sp 4.	*	-	
107.	*Scopula* sp 4.	*	-	
108.	*Scopula* sp 5.	*	-	

109.	*Semiothisa emersaria* Walker	*	-	
110.	*Semiothisa* sp.	*	-	
111.	*Semiothisa* sp. prob *nora* Walker		*	
112.	*Xanthorrhoe* sp.	*	-	
	LYMANTRIDAE			
113.	*Euproctis diagramma* Guer.	-	*	
114.	*Euproctis* sp 1.	-	*	
115.	*Euproctis* sp 2.	-	*	
116.	*Euproctis* sp 3.	-	*	
117.	*Eupterote flavida* Moore	*	-	
118.	*Eupterote* sp. 1	*	-	
119.	*Eupterote* sp. 2	*	-	
120.	*Eupterote* sp. 3	*	-	
121.	*Eupterote* sp. 4	*	-	
122.	*Rahica rosea* Hampson	*	-	
	NOCTUIDAE			
123.	*Condria* sp.	*	-	
124.	*Heliothis* sp.	*	-	
125.	*Hypena subalbida bethune* Baker	*	-	
126.	*Ophiusa dotata*	*	-	

	Wlk.			
127.	*Othreis fullonica* Clerek	-	*	
128.	*Tiracola plagiata* Walker	*	-	
	PHYCITIDAE			
129.	*Assara* sp. 1	*	*	
130.	*Assara* sp. 2	*	-	
131.	*Nephopteryx* sp.	*	-	
	PYRAUSTIDAE			
132.	*Bocchoris onychinalis* Guen.	*	-	
133.	*Bradina* sp	*	-	
134.	*Chilo* sp 1.	*	-	
135.	*Chilo* sp 2.	*	-	
136.	*Corgatha semiparata* Walker	*	-	
137.	*Diasemia* sp.	*	-	
138.	*Euclasta* sp.	*	-	
139.	*Glyphodes laticostalis* Guen.	*	*	
140.	*Parotis vertumnalis* Guenee	-	*	
141.	*Mabra eryxalis Wlk.*	*	-	
142.	*Maruca testulalis* Geyer	-	*	

143.	*Myelopsis* sp.	*	-	
144.	*Nymphula fluctuosalis* Zell.	*	-	
145.	*Patissa* sp.	*	-	
146.	*Psara* sp 1.	-	*	
147.	*Psara* sp 2.	-	*	
148.	*Pyrausta* sp 1.	*	-	
149.	*Symitha* sp.	*	-	
150.	*Syngamia abruptalis* Wlk.	-	*	
151.	*Syngamia* sp.	-	*	
152.	*Udea ferrugalis* Hubner	*	-	
	TORTRICIDAE			
153.	*Cacoecia micaceana* Wlk.	*	-	
	COLEOPTERA **SCARAEBIDAE**			
154.	*Holotrichia* sp.	*	-	
	CHRYSOMELIDAE			
155.	Unidentified sp.1	-	*	
156.	Unidentified sp.2	-	*	
157.	Unidentified sp.3	-	*	
	PASSALIDAE			
158.	*Pleurarina brachyphyllus* Stal	*	*	

	HYMENOPTERA **ICHNUEMONIDAE**			
159.	*Ericospilus* sp.	*	-	
	MEGACHILIDAE			
160.	*Coelioxys* sp.	*	-	
161.	*Pititis unimaculata* Smith	*	-	
	ANTHOPHORIDAE			
162.	*Amegilla* sp. 1	*	-	
163.	*Amegilla* sp. 2	*	-	
164.	*Xylocopa* sp. 1	*	-	
165.	*Xylocopa* sp. 2	*	-	
	HALICTIDAE			
166.	*Halictus vishnu* Cameron	*	-	
167.	*Halictus* sp.	*	-	
168.	*Lasioglossum* sp.1	*	-	
169.	*Lasioglossum* sp.2	*	-	
	APIDAE			
170.	*Apis cerana* Fb.	*	-	
	FORMICIDAE			
171.	*Camponotus* sp.1	*	-	
172.	*Camponotus* sp.2	*	-	
173.	*Camponotus*	*	-	

	sp.3			
	VESPIDAE			
174.	*Vespa orientalis* Lin.	*	-	
	ORTHOPTERA **ACRIDIDAE**			
175.	*Stauroderus* sp.	-	*	
176.	*Acrida gigantia* Hbst.	-	*	
177.	*Heiroglyphus bettoni* Kir.	*	-	
178.	*Cercina obtusa* Stal	*	-	
179.	*Zygophlaeoba* sp.	-	*	
180.	*Oxya intricata* Stal	-	*	
181.	*Mesambria* sp.	*	-	
182.	*Zygophlaeoba* sp.	*	-	
	HETEROPTERA **CICADELLIDAE**			
183.	*Traigume* sp. nr *verticalis*	*	-	Restricted to South Indian Forests
	* Species present - Not recorded			

Appendix –II

List of unidentified insects

Order	Number of unidentified species
Lepidoptera	150
Coleoptera	48
Diptera	25
Hymenoptera	15
Orthoptera	10
Hemiptera	18
Trichoptera	6
Neuroptera	2