IMPACT OF TEAK PLANTATIONS ON FOREST BUTTERFLY COMMUNITIES IN PARAMBIKULAM, SOUTHERN WESTERN GHATS, KERALA

DISSERTATION SUBMITTED TO SAURASHTRA UNIVERSITY, RAJKOT,
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CERTIFICATE

This is to certify that Manoj.V.Nair of the Wildlife Institute of India has carried out a piece of original research work entitled "Impact of teak plantations on forest butterfly communities in Parambikulam, Southern Western Ghats, Kerala" in partial fulfilment of M.Sc.(Wildlife Science) degree of Saurashtra University, Rajkot. These investigations were carried out under my supervision at the Wildlife Institute of India from November 1996 to July 1997. I also certify that this work has not been submitted for any other degree of any other university.

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To Satheesettan who taught me a lot knowingly
And from whom I learnt a lot more unknowingly....

From Nature's chain whatever link you strike,

Tenth or ten thousandth, breaks the chain alike......

Alexander Pope

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ACKNOWLEDGEMENTS

Brevity they say, is always desirable. In pleasant tasks like thanking others, may be the axiom can be done away with. Moreover, being the only place in this little piece of work where I can say something without attaching p-values and F-ratios, I might as well make it long! With these excuses, I embark on a long thanks giving session.

Several people have contributed during the formative stages of this study. Drs. Renee Borges, RJR Daniels, Abraham Verghese, George Mathew and Ajith Kumar commented on my proposal. The latter especially gave very valuable and incisive comments, the full import of which I grasped only in field.

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Finally, there remains a set of people whom I can't think of any appropriate way of thanking : it is like thanking oneself. My parents who allowed me to blaze my own trails, sister who understood me, and a few relatives who did not frown too much at my chosen field, belong to this category. Hence, in that meaningless exercise, I shall not indulge.

SUMMARY

Butterfly communities in natural and man-modified habitats were studied at Parambikulam Wildlife Sanctuary, Kerala, from December 1996 to April 1997 to understand the impact of a long history of habitat conversion on forest butterfly communities. Community attributes were investigated in evergreen and moist-deciduous forests (EGF and MDF respectively,together comprising natural habitats) and a gradient of teak plantations (TKPs) of different ages (14,30,54 and 74 year old TKPs, together comprising altered habitats). Regular line transect and time-effort methods showed that butterfly species richness, abundance and diversity were significantly higher in evergreen forests. Interestingly, moist-deciduous forest was found to be poorer in all these attributes, when compared to the two younger TKPs. In an overall teak age gradient,the trend showed a clear negative correlation of all community attributes with increasing age of teak (14 > 30 > 54 > 74). The two younger plantations, particularly the 14 year old one, were untended ones with good secondary growth, and were ecologically and structurally more akin to natural forests than to classical monocultures, and was probably the reason for the high levels of richness and diversity.

A drastic seasonal shift in buttefly abudance and consequent changes in community composition was observed across cool and dry seasons in both natural and modified habitats. In all strata *except EGF*,abundance and species richness were significantly higher in the cool season than dry season, while EGF showed exactly an opposite pattern. It seems that flower abundance might be playing an important role in determining butterfly abundances and showed high correlation with butterfly abundance and richness in all strata. Among the TKPs, mean and cumulative plant species richness was also negatively correlated with the age of the plantation.

Small scale adult movement was observed within and between spatially proximate habitats across seasons. Data from transects, supplemented by *ad libitum* observations seem to indicate that there is a movement of generalist open-country species from MDF and TKPs to EGF during the dry season, while there may be a reverse movement of specialist evergreen species towards other habitats during cool season and brief spells of cool weather following rains. An analysis of guilds showed that EGF fares much better *vis a vis* other strata. Unique species, habitat specialists, uncommon and rare species and endemic species are all higher in, and in some cases restricted, to EGF.

To sum up, habitat conversion from natural forests to TKPs has definitely had a negative influence on forest butterfly communities. It is likely that generalist species of natural forests, particularly MDF might not have been impacted much; perhaps in some cases, even benefitted. Evergreen species, on the other hand seem to have taken the brunt of habitat alteration. EGFs assume highest conservation priority, when viewed with regard to communities, guilds or individual species. Old growth TKPs with a long history of successive silvicultural practices,though structurally similar to natural forests, support very poor levels of butterfly diversity. Younger untended ones, in contrast is significantly richer, albeit composed largely of generalist species. This implies that phasing out of some old plantations along with active intervention in others, might help in supporting higher levels of butterfly diversity. However, it is highly unlikely that levels of diversity similar to natural forests (EGF in particular), can ever be supported by managed forests.It thus follows that, if we are to conserve the available range of butterfly diversity in the Western Ghats, conserving natural vegetation, in particular, wet evergreen forests is a critical pre-requisite.

1.0 INTRODUCTION

1.1 Butterflies of Western Ghats and significance of the study

"Little things that run the world" is how E.O.Wilson, the renowned ecologist and sociobiologist described invertebrates (Wilson,1987), those seemingly insignificant group of creatures, whose crucial role in effective ecosystem functioning is being currently much appreciated and gradually brought to light. Butterflies are perhaps among the most thoroughly studied and well understood of all invertebrates. Unfortunately, within our limits, butterfly studies are still confined to either faunistic surveys or taxonomic work. Ecological investigations too exist, but only an insignificant number. Of late, with the advent of the age of biodiversity conservation, has dawned the realisation that enumerating insect species and understanding their ecological interactions are critical if they have to be conserved. Butterflies, particularly due to ease of studying them, have been used as a surrogate for insect diversity in many biodiversity assessment exercises (Daily and Ehrlich,1995;Beccaloni and Gaston,1995). Due to their intimate ties with the habitat, they are increasingly being used as indicator species of habitat modification or degradation (Hill *et al.*,1995; Erhardt,1985; Shahabuddin,1993). This study looks at butterfly communities in natural and man-modified habitats in Parambikulam, Western Ghats and tries to find out how forest butterfly communities have been impacted by the clearance of natural vegetation and the establishment of teak monocultures.

Western Ghats, which runs parallel to the west coast of India for over 1500 km, is now regarded as one of the 18 "biodiversity hotspots" of the world. It justifies this distinction conferred on it with regard to butterflies also, as it does with most other taxa. 330 species and 166 genera belonging to 5 families have been recorded from this and the adjoining areas, thus supporting practically all the butterfly fauna of peninsular India south of the Himalaya, and virtually all the species found south of the Satpuras (Gaonkar, 1995). Nearly two-thirds of its butterfly fauna is not found in the rest of peninsular India and it is notable that 37 of these are narrow endemics. These 330 species are dependent on at least 1000 species of host-plants, adult attractants and nectar resources, many of which are also endemic to this range of mountains (ibid). Interestingly, butterflies also show clear-cut zoogeographical affinities (Holloway,1974), studies of which may perhaps help to clear away many of the grey areas in this particular regard. Information existing on even basic butterfly biology in India remains sketchy and as we enter into the realm of ecology, practically nothing is known. Despite being conspicuous and common and considered crucial for effective ecosystem functioning, butterflies in India are little studied and they still languish in sad obscurity while large chunks of their habitats keep getting disturbed and destroyed. In this context an ecological investigation of butterflies with special emphasis on their fast disappearing habitats will help gather information on these aspects.

1.2 Community Ecology and butterflies

The idea of community in ecology, has been one of the most ambiguous of concepts and ever since its inception it has been closely followed by debates and arguments about what it really meant (Weins,1989; Peters,1991). The most inclusive of all definitions is that it consists of all organisms in a given area. But this definition is restricted by at least four ways - spatial, trophic, taxonomic and life-form - to yield less inclusive communities (Roughgarden & Diamond, 1986). Several theoretical and practical difficulties plague community ecology. Properties of multi-species systems which exist in a constant state of flux, both in time and space, are difficult to investigate and decipher. Even if it can be done, easily measurable attributes such as relative abundances estimated from samples, are of questionable significance (Weins,1989). Further, trying to make sense of things by correlation analysis of various community, resource and habitat parameters provide no sure guide to underlying causes for observed community patterns (Gilbert,1984). Despite these obvious problems, community ecology has grown and flourished with tremendous applications, particularly with respect to conservation. Butterflies as a taxon for community investigations has been largely neglected *vis a vis* birds, and butterfly studies have played little role in the development of general theories of community organisation. This is surprising, for they are uniquely suited for such work, being easily observable and identifiable, and much more suited for manipulative laboratory studies which can supplement/verify conclusions drawn from field investigations. Here in this study, a butterfly community is considered as the assemblage of butterfly species within a particular habitat type.

1.3 Habitat conversion and butterflies

What afterall, is the habitat of a butterfly? This seemingly trivial question assumes importance when we consider this fact : a butterfly is a holometabolous insect with a life-history consisting of two ecologically different phases, viz. a larval stage specialized for feeding and an adult stage geared mainly for reproduction and dispersal (Shapiro,1975). The habitat of one need not be necessarily that of the other (Gilbert,1984). Also, the requirements of butterflies exist in a multi-dimensional space which include factors like larval resources, adult resources, micro-climatic conditions, habitat, time and predator escape (Gilbert,1984). Though this interplay of factors brings immense amount of complexity into the picture, this is a blessing in disguise. Precisely because of these complex linkages with the environment and their pivotal position between plants, parasitoids and predators, butterflies offer the opportunity to explore many ecological questions within a single system. And because they are typically host specific and require complex adult resources, butterfly communities provide the best rapid indication of habitat quality (Singer & Gilbert, 1978). No other animal is more typical of a healthy environment, nor more susceptible to change, than a butterfly (Owen, 1971). A debatable point, but more likely to be true than not. Thus, they become ideal organisms to investigate the impacts of habitat change and may serve as bio-indicators (Viejo et. al.,1989), or easy surrogates to assess diversities, or bring out patterns (Daily and Ehrlich, 1995) which might not be readily discernable, with regard to other less sensitive taxa.

1.4 Review of literature

Literature on butterflies in general is voluminous, and deals with a range of aspects which include systematics (Ackrey,1984); populations (Ehrlich,1984); communities (Gilbert and Singer,1975; Gilbert,1984); butterfly resources (Sharp *et al.*,1974); habitat selection (*ibid*) predation, parasitism and defence; genetic variation and speciation; sex and communication; migration and seasonal variation (all reviewed in detail in Gilbert and Singer,1975 and Vane-Wright and Ackrey,1984); and of late, conservation (Hill *et al.*, 1995; Cheverton and Thomas,1982; Raguso and Liorente-Bousquets,1990; Bowman *et al.*,1990; Hanski *et al.*,1995; Jones *et al*,1987; Mohanraj and Veenakumari,1996; and many others. Gilbert and Singer (1975) sums up the research in butterfly ecology till 1975 in their exhaustive review, while Vane-Wright and Ackrey (1984) is a veritable goldmine of information for butterfly ecologists and crisply summarises trends in butterfly biology research scenario till the early 1980s. After the mid 1980s, several papers have appeared, some particularly emphasizing aspects related to conservation. Though this facet of butterfly ecology merit and contains considerable amount of literature, studies dealing explicitly with habitat conversion and its impact on butterflies are scanty.

Coming to butterfly literature from India, except for early taxonomic and faunistic work which gives regional lists, very few systematic scientific work exists. Although detailed information on the butterflies of several districts are available, (e.g., T.R. Bell, 1909-1948 from N.Kanara; T.B.Larsen,1987-1988, from the Nilgiris), no systematic survey of all species occurring in and around Western Ghats mountains had been done till Gaonkar's work from 1987-1995 (unpubl.), which covers all the regions of the Western Ghats from Gujarat to Kerala. This work updates information on the distributional pattern, range and status of almost all the species. Based upon the distribution and status of the butterflies and their host-plants, Gaonkar has broadly recognised three biogeographical sections for the W.Ghats. The first and the most important region is the Southern W.Ghats, then the Central W.Ghats and finally the Northern W.Ghats. A state-wise break-up of species and endemics is also included with an exhaustive bibliography.

Although this is an excellent work and would undoubtedly serve as much-needed base-line information, several lacunae remain in our ecological understanding of butterflies. The only major work I came to know was that by Larsen (1987) in which he discusses swallowtail communities in S.India giving ecological analysis of all the 19 Papilionidae of the W.Ghats. Recently, an extensive treatment of swallowtails of Andaman Islands have also been published (Mohanraj and Veenakumari,1996). Other studies have looked at species diversity of butterflies and moths in evergreen forests (Mathew and Rahmathulla,1993 and 1995; Mathew,1996). Three short studies in Pondicherry, lower Palnis and Mudumalai, all Master's dissertations have come to my notice, but I could collect only one (Shahabuddin,1993). Apart from these, few ecological studies exist, though several short notes on life-histories (*Davidson & Aitken,1890; *Yates 1929, 1930, 1931, 1932, 1933, 1935), regional check-lists (*Fergusson 1891; *Davidson 1893;* Davidson *et al.* 1896; Evans 1910; Home 1934; Ugarte & Rodricks 1960; Donahue 1967); biogeography (Holloway,1974); behaviour (Ganesh & Soubadra,1993); range extensions (Nalini,1996) and other aspects of ecology (Larsen 1986; Larsen 1987) have been published. All * marked references are quoted from Gaonkar,1996) The major works and the main sources of information are Bell 1909-1927; Evans 1927 & 1932; Talbot 1939-1949; Wynter-Blyth 1957 and Gaonkar, 1996 (unpub).

1.5 The Questions

The questions I put forward are basically of two types:

a. those addressing community characteristics of butterflies, and
b. those enquiring about their implications for conservation. They are

1. How do patterns of butterfly abundance, richness, diversity, evenness and endemism (endemic species to W.Ghats) change across natural and modified habitats ?

2. Do more structurally heterogeneous habitats have more diverse butterfly communities ?

3. Do all these strata have uniform guild signatures; if not, which is absent where and (why) ?

4. Is there a strong correlation between plant species richness and butterfly species richness ?

5. Is it larval food plant richness or adult food resource availability which is more strongly correlated with butterfly community attributes?

7. Are there "forest specialists" affected by habitat conversion ?

8. Can plantations support rich butterfly assemblages ?

2.0 THE STUDY AREA : AN OVERVIEW

2.1 A historical overview of habitat conversion at Parambikulam

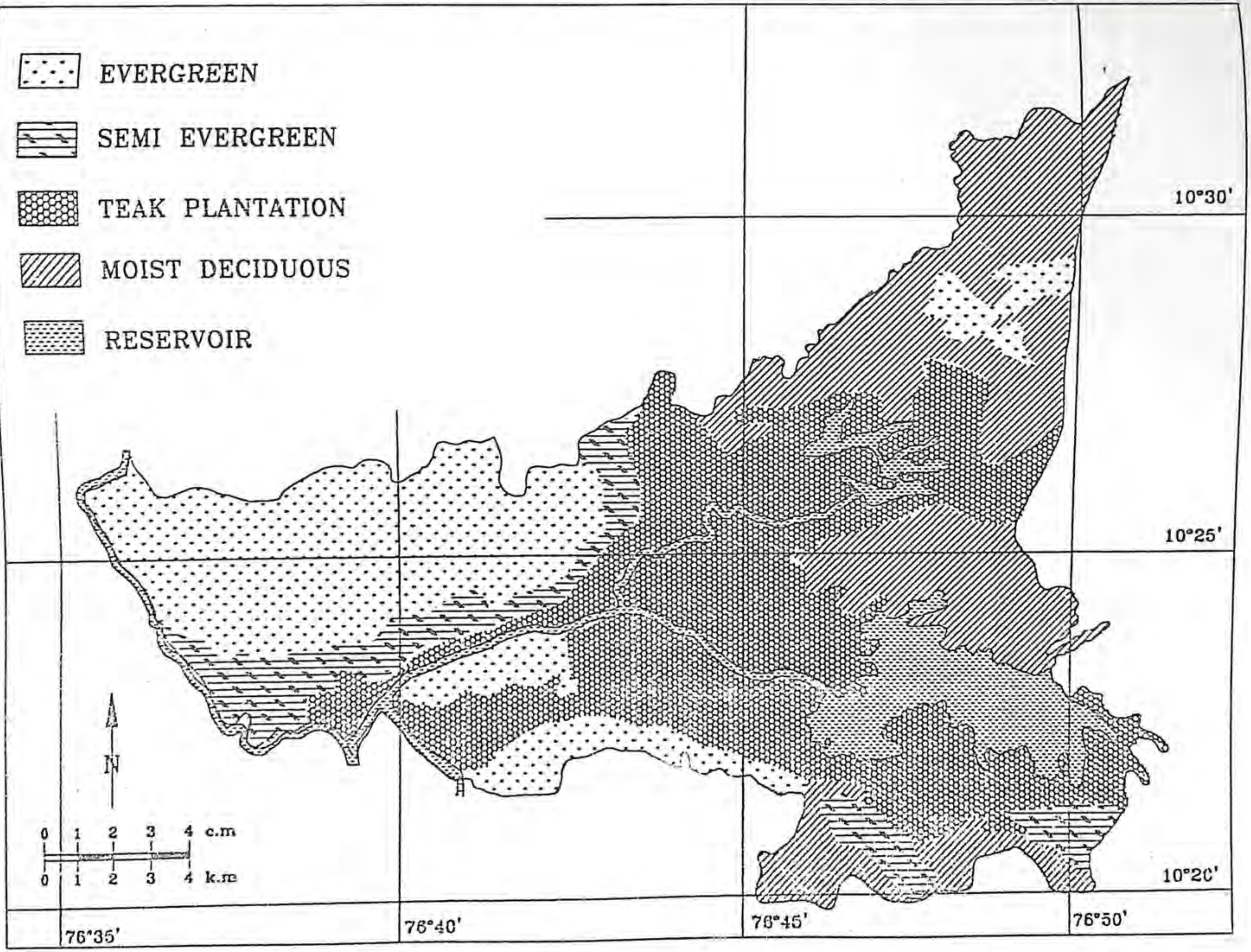
Historically, this area was known for its magnificent natural teak forests and valley evergreen forests. The colonial era ushered in unprecedented levels of exploitation. The first scheme to work these forests was written by Porter, a British forester, in 1885 and a selection system was introduced here in 1886 fixing a rotation of 120 years. In 1889, he recommended clear-felling and planting in this area. Soon enough, dense forests were left only on slopes and other inaccessible hinterlands. The introduction of the famous Orukomban-Chalakudi forest tramway in 1907 accelerated this process of systematic decimation. This continued till 1915 and after yields started progressively decreasing, artificial regeneration was contemplated. Regular planting of teak began from 1921 onwards and has continued ever after. Since then, the plantations have undergone regular standard silvicultural operations and between 1916 and 1972, the forests of Parambikulam valley were clear-felled and planted with teak. Thus, even after the declaration of this area as a sanctuary in 1984, these activities continued unhindered (Uniyal,1987) and still is continuing (*pers.obs.*). The last planting operation was undertaken during 1983, when the 1923 regeneration area was clear-felled. After that no such clear-felling and planting has taken place. The Forest Department embarked on a programme to gradually phase out all teak plantations and ultimately replace them with natural forests following recommendations in the first management plan (Uniyal,1987) and the idea is still being pursued (Sehgal,R. *pers.comm.*). Apart from habitat conversion to teak, fantastic valley forests were submerged in the near past by the three reservoirs in the sanctuary, together covering an area of 23 sq.km. The threat from thre other dam projects, included in the proposed Kuriarkutty-Karappara project, looms ahead and if implemented will spell doom and submerge to a watery death 2500 ha of forests, about 1600 of which is evergreen. Apart from all these, small areas were also sacrificed for *Eucalyptus* and mixed plantations.

2.2 Location, Area and Topography

Parambikulam Wildlife Sanctuary is located in Chittur Taluk of Palakkad District in Kerala and lies between longitudes 76° 35' and 76° 50' East and latitudes 10° 20' and 10° 26' North. Encompassing an area of 274 sq.km., it is a part of Western Ghat mountains of Malabar-Western Ghat Biotic Province (5b), immediately south of the Palghat gap. It opens out as a wide valley between the Nelliyampathy hills in the North and Anamalais in the South. The south-eastern parts of the sanctuary merge with the chain of Anamalai hills which extend to the adjoining state of TamilNadu. To the south and south-west, the sanctuary is contiguous with evergreen forests of Vazhachal and Chalakudi Forest Divisions. The ecological continuity of the sanctuary to the outlying natural forests is severely broken in the north and north-west, where the forests are fragmented because of large scale plantations and estates of tea, cardamom and coffee. In the west, the continuity of forests is maintained through natural forests of Vazhachal and Chalakudy which extends upto Peechi.

The sanctuary has an undulating terrain with ridges and broad valleys. About 60% of the sanctuary lies in the hills. The altitude ranges between 300m to 1430m but a major portion has an average elevation of around 600m. The Nelliyampathy hills which rise precipitously immediately south of the Palghat gap

Fig 1. VEGETATION MAP OF PARAMBIKULAM WILDLIFE SANCTUARY



border the sanctuary in the north and west, while Kuchimalai peak (1169 m) forms the north-eastern boundary. The ghats drop abruptly down to the Thekkady-Keerappady valley in the south-west and again rise precipitously upto Pandaravarai ridge. From here, it slopes gently towards south to the relatively broad Thunakkadavu valley of Sungam range and ascends again to Vengoli ridge (1224m) to the south. There are rolling grass hills adjoining this, merging ultimately to the chain of Anamalais, deep to the south. From the north-west, the Nelliyampathy hills descend gradually and opens up into Thuthampara, Thellikal and Parambikulam valley and rises to the hills in Pooppara and Karimala areas. The highest peak Karimala Gopuram (1430 m), and adjoining hills lies here and constitutes the southern boundary of the sanctuary. The low-lying valleys are all covered with artificially regenerated teak plantations. The catchment of Chalakudi and Sholayar rivers, either wholly or in parts, lies in the sanctuary. Several small rivers like Thekkady, Parambikulam, Kuriarkutty, Thunakkadavu, Thellikkal, Karappara, Vetti and Pulickal drain the sanctuary, flowing towards the west, where they converge at Orukombankutty before finally joining the Chalakudy river. Finally, the three reservoirs namely Parambikulam, Thunakkadavu and Peruvarippallam occupy 28.44 km of the sanctuary.

2.3 Climate

Differences in altitude, aspect and precipitation gradient result in an extremely variable climate in the sanctuary. Nevertheless, it is largely monsoonal. The western parts receive more rains than the eastern parts and has a moist-tropical climate. The area gets both the S.W monsoon and N.E monsoon, but the former is the most active. Most of the sanctuary, more than 80% of the total area, lies in the windward side and therefore receives heavy rainfall during the S.W. monsoon. Average annual precipitation is 1723 mm varying between 1178-2268 mm. The maximum temperature fluctuates between 24° C to 33° C and the minimum between 20° to 25° C.

2.4 Vegetation in the park

2.4.1 Natural Forests

The sanctuary exhibits a range of vegetation types from tropical evergreen forests through moist deciduous forests to artificially regenerated teak plantations, while the semi evergreen forests exist as a transitory zone. The natural forests are classified broadly on the basis of Champion & Seth (1969) into

1. West Coast Tropical Evergreen (1A/C4)
2. West Coast Semi-Evergreen forests (2A/C2)
3. South Indian Moist Deciduous forests (3B/C)
4. South Indian Dry Deciduous forests (5A/C3)
5. Moist Bamboo Brakes (2/E3)
6. Reed Brakes (8A/E1)

The evergreen forests are distributed in the higher slopes, as a rule above 800 above MSL, but small patches are also found in the depressions within moist deciduous localities and are considered to be post-climax formations within a moist-deciduous climax. Karian Shola, the patch where the evergreen forest transects were located was one such area. The total extent of such forests in the sanctuary is about 50 sq.km. The forest is well stratified. The top canopy consists of *Palaquium ellipticum, Mesua ferrea, Artocarpus hirsutus, Mangifera indica, Vateria indica, Hopea parviflora, Myristica malabarica, Polyalthia malabarica, Syzigium cumini and Cullenia excelsa,* while the lower canopy has trees like *Canarium strictum, Hydnocarpus wightiana, Mallotus philippinensis, Holigarna arnottiana and Elaeocarpus serratus,* while the undergrowth usually has *Antidesma spp, Calamus rotang, C.travancorius, Glycosmis pentaphylla, Strobilanthes spp, Ixora spp, Murraya paniculata, Pavatta spp, Ochlandra wightii* etc. Lianas and climbers like *Entada scandens, Dioscorea spp, Derris spp* etc also abound and so are *Curcuma spp, Elettaria spp* and other herbs. *Cullenia-Palaquim, Palaquim-Calophyllum, Palaquium- Mesua and Mesua-Cullenia* are the most common associations seen in the sanctuary.

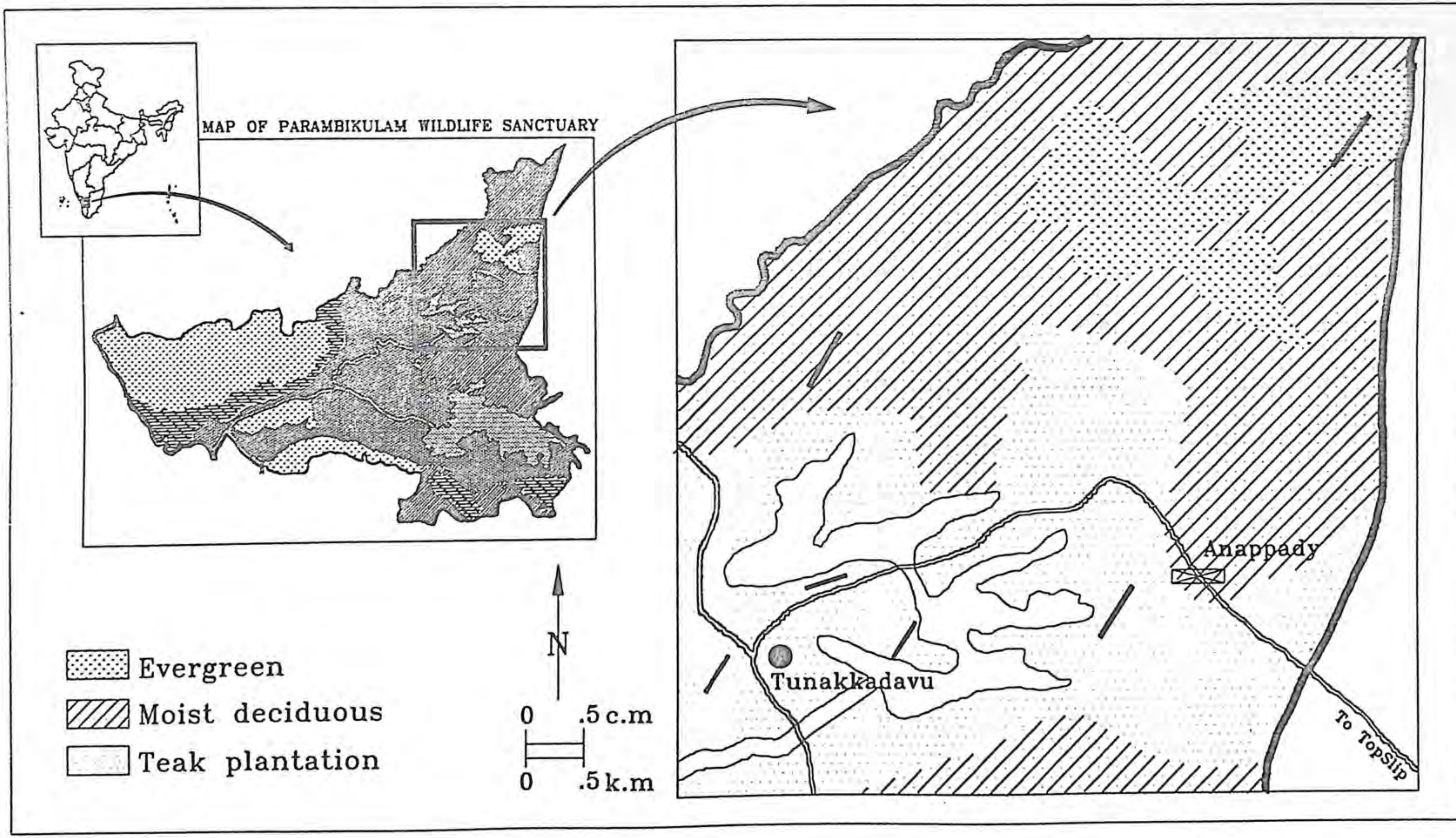
Semi-evergreen forests cover approximately 20 sq.km. The ground receives more light than the evergreen forest floor due to comparatively lighter canopy and thus represents a transitional zone between evergreen and moist-deciduous types. The top canopy has *Adina cordifolia, Bombax ceiba, Holoptelia integrifolia, Cedrela toona, Hopea parviflora, Lagaerstroemia lanceolata, L.speciosa, Vitex altissima, Tetrameles nudiflora* etc., the lower canopy has *Cinnamomum zeylanicum, Evodia roxburghiana, Xanthoxylum flavescens* etc., while the undergrowth consists of species like *Clerodendron infortunatum* and *Croton malabaricum.*

Moist-deciduous forests occur both in ridges and lower slopes between 400-1000 m above MSL and covers almost 60 sq.km area in the sanctuary. This forest type exist in several subtypes depending on local edaphic, micro-climatic and topographical factors. The top canopy consists of *Adina cordifolia, Albizzia procera, Alstonia scholaris, Bombax ceiba, Cedrella toona, Dalbergia latifolia, Grewia tiliaefolia, Holoptelia integrifolia, Lannea spp, Pterocarpus marsupium, Schlechera oleosa, Stereospermum xylocarpum, Tectona grandis, Terminalia tomentosa, T.paniculata, T.bellerica, Xylia xylocarpa* etc. The lower canopy has *Bauhinia malabarica, Bridelia retusa, Carreya arborea, Cassia fistula, Dillenia pentagyna, Erythrina indica, Evodia roxburghiana, Sterculia villosa, Strychnos nux-vomica* while the undergrowth consists of *Callicarpa spp, Clerodendron infortunatum, Glycosmis pentaphylla, Helicteres isora, Holarrhena antidysenterica, Lantana camara and Randia dumetorum.* Climbers like *Acacia indica, A.pennata, Bauhinia vahlii, Caesalpinia bonducella, Calycopteris floribunda, Spathobolus roxburghii* and Bamboo, *Bambusa arundinaceae* are also profuse.

Dry deciduous forests cover about 15 sq.km in the N.E segment of the sanctuary adjoining the Tamil Nadu plains at altitudes between 300-450 m above MSL. Floristically, this forest type has many elements of moist deciduous forests. The top canopy has *Pterocarpus marsupium, Anogeissus latifolia, Terminalia tomentosa, T.chebula, Lannea grandis, Albizzia odoratissima, Bridelia retusa, Tamarindus indica, Dalbergia latifolia* etc; the middle canopy has *Azadirachta indica, Morinda tinctoria, Wrightia tinctoria and Santalum album* while the undergrowth has *Lantana camera and Helicteres isora* with climbers like *Pterolobium indicum, Acacia spp* etc.

Bamboo and Reed brakes are the other two minor vegetation types which occur within the sanctuary. Reed brakes occur within evergreen and semi-evergreen forests, mostly alongside rivulets and streams. The species recorded are *Ochlandra travancorica, O.rheedi and O.brandisii.* Bamboo, *Bambusa arundinacea*

Fig 2. Intensive study area showing locations of transects



brakes on the other hand, comes up in highly fertile and well drained soil in sheltered depressions and reservoir banks. In comparatively drier areas, *Dendrocalamus strictus* grows, and because it is heavily browsed, and hence appear as thickets.

2.4.2 Plantations

The sanctuary contains 8959.215 ha of plantations, 8847.618 ha of which is teak, *Tectona grandis* with the rest 30.09 ha mixed and 81.507 ha *Eucalyptus spp.* Artificially regenerated teak plantations cover a considerable amount of the sanctuary, about 89.592 sq.km. There is good undergrowth in many of these, but most are choked by an overwhelming profusion of weeds, particularly *Eupatorium spp* and *Lantana spp.* Regeneration of forest trees appear to be very poor in all these, but for young untended plantations, where the secondary growth is good (Balakrishnan and Easa,1986; *pers.obs.*).

2.5 The intensive study area

The intensive study area was the low-lying gently undulating Thunakkadavu valley of Sungam range in the sanctuary. The altitude ranged from c.470-600m. Out of the total area of 8175.10 ha., teak plantations comprise 1865.91 ha., mixed plantations consist of 30.9 and Eucalyptus 81.507. Thus the total area under plantations is 1977.507 ha. in the intensive study area while the natural forests cover 6197.593 ha. In addition, two of the three dams also lie here and together cover 7.22 sq.km of the area.

After a thorough preliminary reconnaissance survey, I found out that the mixed and Eucalyptus plantations were at the south-west border of the study area which comprise of very dry rain-shadow regions. Hence, controlling for climatic and vegetational differences becomes problematic and probably no meaningful comparisons with other habitat types can be made. Hence, contrary to my original plan of comparing these also, I decided to limit the study to butterfly communities of natural forests (both evergreen and moist-deciduous) and those of a gradient of different aged teak plantations, all lying within an ecologically similar area. This valley was an ideal place for a study of this kind for it had all the habitat types within an area of roughly 10 sq.km. Thus, I chose part of Karian Shola within Kerala limits as the Evergreen forest site (EGF), the adjoining Anappady forests as the moist-deciduous site (MDF), and the teak plantations (TKPs) all around according to their ages. After detailed discussions with experienced Forest Department officials and with their help, I chose

1. A 74 year old 1923 Regeneration area having an area of 60.72 ha as the oldest plantation (OTT) to be studied

2. A 54 year old 1944 Regeneration area having an area of 52.96 ha as the older teak plantation (ORT)

3. A 30 year old 1967 Regeneration area having an area of 43.2 ha as the young teak plantation (YRT), and

4. A 14 year old 1983 Regeneration area having an area of 35.58 ha as the youngest teak plantation (YTT).

Thus the plantations chosen, adequately represent the available gradient of different aged teak plantations and differ among themselves by an average of 23 years. The intensive study area had two older plantations than the oldest one chosen(1923), namely 1916 and 1921, but these, respectively 2.63 ha. and 1.78 ha., were too small for proper sampling and hence were not considered. Ideally, still younger plantations would have been better, but the youngest available was that of 1983, and hence was chosen as the youngest plantation. After 1983, the authorities have stopped all kinds of planting operations in the sanctuary and hence no younger one could be chosen.

3.0 METHODS

3.1 Selection of general and intensive study sites

Before going on to explain the field methods employed, I shall first make clear the rationale behind the choice of study sites, both general and intensive. Parambikulam with its long recorded history of teak plantation was among the best areas to choose for a study of this kind, in terms of availability of all possible gradients of teak forests in addition to adjoining natural vegetation. At Parambikulam, an initial reconnaissance revealed that Anappady area was the best in terms of logistics, for there was an array of different aged TKPs, MDF and EGF forests, all within an area of roughly 10-12 km². At Anappady, due to carefully maintained plantation journals and the help of experienced officials, I could select almost the exact age of plantation that I wanted. Details of the exact area and other details of each of the selected TKPs were dealt with in detail in 2.5. Thus the four teak plantations chosen (see section 2.5) were approximately of the same area, at the same altitude and climatic regime and were spread evenly within the intensive study area. As butterflies move between habitat patches, care was taken to see that the TKPs selected were as evenly distributed as possible and not within any contiguous and large patch of natural forest. At this point, one fact to be stressed is that the two younger plantations, particularly the youngest were left untended after they were planted. Considerable damage by elephants has resulted in a situation where patches are quite open with good secondary growth. Hence ecologically it is more similar to a upcoming secondary forest than a classical young teak plantation. YRT was situated near an open area, an abandoned elephant camp, also with good secondary vegetation. ORT abutted the reservoir and a patch of disturbed semi-evergreen forest while OTT had MDF adjoining it. All were more or less surrounded by other teak plantations (see fig.2 to get an idea of the location and distribution of transects in the vegetation mosaic).

To get a better idea, of the lie of the land and the dispersion of transects across the landscape see fig.1 and 2. The lines shown give just the general location of transects, and please note that in each are two transects and not one as figure. 2 indicates.

3.2 Field identification of butterflies

Any investigation of communities or assemblages assumes consistent and correct identification of the study taxon as an essential pre-requisite. It often becomes vexatious when one has to deal with very species rich communities, particularly if the species are cryptic or difficult to observe. Most butterflies are colourful and easy to detect, though positive identification of species belonging to certain families, especially Lycaenidae and Hesperiidae can be tricky; many field studies tend to omit these from analysis (eg. Hill *et al.*, 1995). To overcome such difficulties, an exhaustive list of all species likely to occur in the study area was made before leaving for field and keys prepared for the more difficult groups. Standard field guides were referred for this (Wynter-Blyth, 1957; Sathyamurthi,1966; Haribal,1992). A few individuals of species belonging to both the afore-mentioned families were collected from the campus to get acquainted with diagnostic morphological marks and identification features. The first ten days in field was spent in identifying butterflies, collecting specimens and closely observing behaviour, general ecology and macro and micro-habitat preferences. This process of getting acquainted continued for the whole of the first month.Index cards were maintained for certain rare/habitat-specialist species. In addition, *ad libitum* observations were regularly maintained and later compiled. All this later proved invaluable for developing appropriate search images for butterflies (particularly canopy species), quick and correct identifications during transect walks and honing field skills, but certain closely related species could not be differentiated positively, despite all this effort. Also, an essential caveat has to be born in mind, at least while considering abundance estimates for the evergreen forest : they are most likely to be under-estimates, a problem which other studies have also encountered (Raguso and Llorente-Bosquets, 1990).

3.3 Sampling butterfly communities

Investigators have used a variety of methods like a. Capture-recapture (Morton,1984; De Vries,1988); b. Time unit-effort (Raguso & Llorente-Bousquets,1990); and c. Strip transects (Pollard,1977; Hill *et al.*,1995; Cheverton & Thomas,1982; Bowman *et al.*,1990; Jones *et al.*,1987; Warren, 1985; and many others), to study butterflies. The first one, though more robust and consistent was ruled out in this study because of constraints in time and effort. Line transects on the other hand is a much easier and efficient method for arriving at robust estimates of butterfly abundances, and is most useful particularly for short studies, where the focus is more on reliable comparative estimates than absolute values. Thus, I used 1.the strip transect method and 2. a modification of time-unit effort method to sample butterflies for this study. Southwood(1978) was referred for general design and methodology.

3.3.1 Strip transects

The strip transect method used was a modification of the classical line transect (Pollard,1977). Butterflies were recorded upto 5 m in front and 5 m on either sides. Stops were made to resolve identification problems, recording being resumed from the point where the walk was interrupted. If occasionally, a butterfly could not be identified, it was recorded as the commoner of the likely alternatives present in the area. The axiom of "No record is better than an erroneous one" was strictly adhered to and needless to say, a butterfly, not identified at least to the genus level, was not considered for any analysis . Butterflies in high flight or perching above 8m were identified using a pair of 8 x 30 Carl Ziess binoculars.

I had two 250 m x 10 m strip transects for each stratum (habitat type). Thus, each stratum had just one replicate, but the two transects were walked four times per month, making the total number of pseudo-replicates per stratum for the entire study period to 40. The total number of walks, for all strata was, thus 240. I walked each transect at a slow and uniform pace and on an average took 20 to 35 minutes to complete one, depending on the stratum, season and butterfly detections. My field assistant walked alongside flushing out butterflies with a c.1 m long bamboo pole. When a butterfly was detected, the following variables were recorded apart from basic information like date, starting and ending time and weather during the sampling session.

1. species and number of individuals.

2. height at which the individual was first seen.

3. activity (feeding/basking/chasing/foraging/ovipositing/flying) and 4. height and substrate if seen perching

3.3.2 Time-Effort sampling

After a month of walking transects, it became clear that some butterflies were difficult to spot and identify to the species level, during walks. This included fast-flying species like certain Swifts of genus *Boaris* ; certain Nymphalids of *Pantoporia-Neptis* complex; closely related and virtually identical species complex like Line Blues, *Nacaduba* genus and Blue Pierrots, *Tarucus* genus and few Browns of *Mycalesis* and *Lethe* genus. Most Satyrids, particularly, *Lethe*, *Mycalesis* and *Melanitis* genera presented a problem during the later half of the study, when most individuals were in dry season morphs, where the diagnostic field characters were almost entirely obliterated. So, in order to capture the species richness information lost while walking transects, each stratum was searched, keeping the effort in terms of the time spent, a constant. Thus I walked along trails and paths within each stratum, recording the butterfly species (but not the abundance of each) that I encountered for an hour. The aim was to record all species occurring in that stratum. This was done two to four times a month from February to March in all the strata, but due to unequal and inadequate sample sizes, the data was taken into account only for rarity rankings and not used for the calculation of richness, diversity or other community attributes.

3.3.3 Weather, time of the day and butterfly detections

The temporal component of butterfly species diversity has been widely appreciated (Shapiro,1975). Initially, transects were walked during different times of the day to determine the peak activity time for butterflies. These observations indicated that generally, they were most active from c.0930 hrs -1300 hrs, though it varied from species to species and between strata, to a minor degree. Apart from this, local weather conditions were seen to have serious effects on butterfly activity patterns : cloudy and overcast days had little or no butterflies fluttering by, while bright sunny days had the maximum number up and about. Naturally, data from a transect was only considered valid if it fulfilled both these conditions. Initially, the light meter of a Pentax P-30 camera was used to objectively assess light suitability conditions.

3.3.4 *Ad libitum* observations

Detailed casual and ad libitum observations were made and separate index cards for rare/uncommon species were maintained. Incidental records of phenology, butterfly micro habitat preferences, larval food plants and life-history stages were made. All instances of oviposition and development were also recorded.

3.2 Habitat structure,vegetation and phenology

In the six strata, mentioned earlier, sampling points were laid alternately on either side of the transects, 10 m alternatingly left and right from it, at 50 m intervals, giving a total of 5 sampling points per 250 m transect. Thus, each stratum had a total of 10 vegetation plots. Within these plots, the following structural and vegetational parameters were assayed. The extent of canopy cover was scored as 0 when there was none overhead, 1 when the canopies of adjacent trees barely met, 2 when adjacent canopies overlapped with the canopy still showing through, and 3 when the sky was no longer visible through the overhead leaves (Daniels *et al.* 1992). A total of 50 points were scored per transect, the readings having been taken 2 metres away, alternatingly to the left and right of the transect)

3.2.1 Vegetation.

Vegetational parameters measured were

1. Tree density (those >20 cm GBH), height and GBH in 10 m X 10 m square plots.

2. Tree species diversity within the above plots.

3. Shrub density and height in a 5 m X 5 m square plot nested within.

4. Ground cover, with litter, soil, rock and grass in percentages, within a 1 m X 1 m square plot.

5. Plant species richness within the 10 m X 10 m plot.

6. Canopy cover in 5 points within the same plot and hence a total of 100 canopy cover scores per stratum.

In addition, for arriving at more ecologically meaningful comparisons across teak plantations as butterfly habitats, each of them was searched thoroughly and the cumulative plant species richness and flowering plant richness were determined. This procedure, though very desirable for the natural forest strata also, but was dropped after exploratory efforts. EGF particularly was too formidable a strata to get total plant species richness.

3.2.2 Structure - Vertical

An index of vertical heterogeneity was obtained by scoring the presence or absence of foliage within a 1 m radius circle in the following heights : 0-0.25 m; 0.25-0.50 m; 0.50-1 m; 1-2 m; 2-4 m; 4-8 m; 8-16 m, 16-24 m, 24-32 m, and >32 m. The arithmetic mean of the number of strata with foliage present was used to calculate Vertical Heterogeneity index (VH).

3.2.3 Structure - horizontal

Spatial heterogeneity index (SHI): As the vertical stratification were taken at 100 points along both the transects in a habitat type, its coefficient of variation was used to calculate Horizontal Heterogeneity Index, an index of horizontal heterogeneity of the vegetation. The sum of vertical and horizontal diversity values of a habitat type was considered as an index of its Complexity (C).

3.2.4 Phenology

Twice during the study period, once in cool and once in dry season, the phenophases of herbs, shrubs and trees within the plots were recorded. Special emphasis was given for the assessment of adult nectar resources. It was subjectively ranked as 4:abundant (>150 flowers/flower-heads per 100 sq.m plot), 3:present (50-150), 2:rare(25-05), 1:very rare (0-25) and absent(0).

In addition, detailed incidental and *ad libitum* observations on the phenology of flora in the intensive study area with special attention to oviposition plants and adult nectar resources were made (see Appendix I and II).

3.5 Guild and abundance rankings

To elucidate trends in abundance and rarity, butterfly species were placed in five abundance classes. I followed Lynch (1989,1990) and ShankarRaman (1995) in doing this with slight modifications.

1. Unique/Characteristic species : species detected a minimum of three times solely in a given stratum or detected at least thrice as many times as in other strata.
2. Abundant species : those detected >30 times but not belonging to (1).
3. Frequent species: species detected >20 times but not belonging to (1)
4. Infrequent species: species detected >10 times but not belonging to (1)
5. Rare species: species detected <10 times in a stratum, and
6. Vagrants/Strays: those seen <3 times in a stratum

As the mosaic of habitat types, particularly teak plantations were juxtaposed closely in the intensive study area, and butterflies are known to move a lot, those species belonging to (6) were avoided as a conservative measure from all further analyses.

To discern patterns in resource utilisation of butterfly communities in each stratum, I classified them into guilds, for which the criterion I used was the height at which adults fly and the zone they normally occupy in a vertical axis. Accordingly butterflies were grouped into

a.herb zone(HZ) : species found only near the ground layer of vegetation, below 0.5 metres.
b.shrub zone (SZ) : those found between 0.5-2.5 metres.
c.middle zone(MZ) : those found between 2.5 to 10 metres, and
d.canopy zone(CZ) : those found above 10 metres to 35 metres or more.
e.zoneless (NZ) : those species using all height zones relatively equitably.

An essential caveat to bear in mind is that, unlike normal guilds, these do not pre-empt each other. They actually exist in a hierarchical arrangement : those belonging to (d) can ,if needed use resources in the herb zone, those in (c) can go to the SZ, and so on. But not the other way round. Nevertheless, most species restrict themselves to a particular zone, though there may be temporal shifts.I did not come across any guild classification system for butterflies,from literature, which I could follow and hence,despite the limitations,I will use it to bring out differences between the communities of the different strata.

3.6 Analysis of data

The mean buttefly species richness and total abundance of all species per transect plus the cumulative species richness within a particular habitat type were the primary variables of interest.
Abundance (A) was the total number of butterflies recorded from a transect or data pooled from all transect

walks (40) from that stratum. Species richness (R) was the total number of species (Krebs,1989). Species diversity was calculated by Shannon-Weiner index (Magurran,1988), which is $H' = -\Sigma \text{ pi log pi}$

Changes in butterfly community attributes across strata were obtained by pooling data from all 40 pseudo replicates (20 from each one) of two transects. A one-way Analysis of variance (ANOVA) for each variable, followed by a Duncan's Multiple range Test for multiple comparison of means was used for seeing differences in community attributes. A probability of 0.05 level was considered significant.

To determine the similarity between strata, in terms of butterfly communities, I used the technique of cluster analysis. Species-abundance matrix of data pooled from all transects was used as input to generate a dendrogram using hierarchical cluster analysis (Ward's method) to graphically bring out differences across strata in terms of butterfly community composition.

Seasonal differences in butterfly community variables were tested for significant differences across cool and dry seasons within a stratum using a two-tailed t-test.

The vegetation variables were tested for normality using a Kolmogorov-Smirnov test, and most were not normally distributed. Hence, assumptions for a parametric procedure could not be satisfied. Hence, overall differences in vegetational and structural attributes across strata were tested for significant variation using a non-parametric Kruskal-Wallis ANOVA, followed by pair wise Mann-Whitney U-test to detect differences between each of the six strata. The same test was used to test for differences in flower abundance and structural attribute differences across strata, and between seasons.

A Spearman Rank Correlation test was used to test for correlations between age of teak plantations, flower abundances, cumulative and plot-wise plant species richness with butterfly community attributes.

All tests were done using the soft ware package, SPSS for Windows 95, and the results interpreted with the help of standard biostatistics books (Zar,1984) and the SPSS manual (Norusis,1990).

An explanatory note:

Throughout this thesis, I have used followed Wynter-Blyth (1957) in butterfly nomenclature, for ease of classification, though there has been taxonomical revisions as explained in Varshney (1977-1990). Also, for clarity and easy comprehension, I have stuck to trivial (common) than the scientific names throughout the text. In case of any confusion, the readers are requested to refer Appendix I, where a total list with both are included.

4.0 RESULTS

4.1 Butterflies in the study area : An overview

During the course of the study, from 26 November 1996 to 28 April 1997, I recorded 140 species of butterflies from the study area. Only 88 species were detected from transect counts, the rest were from *ad libitum* observations. Of the 10 families of butterflies known to occur in South India, all except one, viz. Amathusidae were represented. Family Nymphalidae had the largest number of species (35) while Acraeidae and Erycinidae, both having one species each, had the lowest number. A detailed treatment of the total list and break-up into families is given below in Table 1. Of the 30 endemic species in the W.Ghats, 10 were recorded (see Table 10).

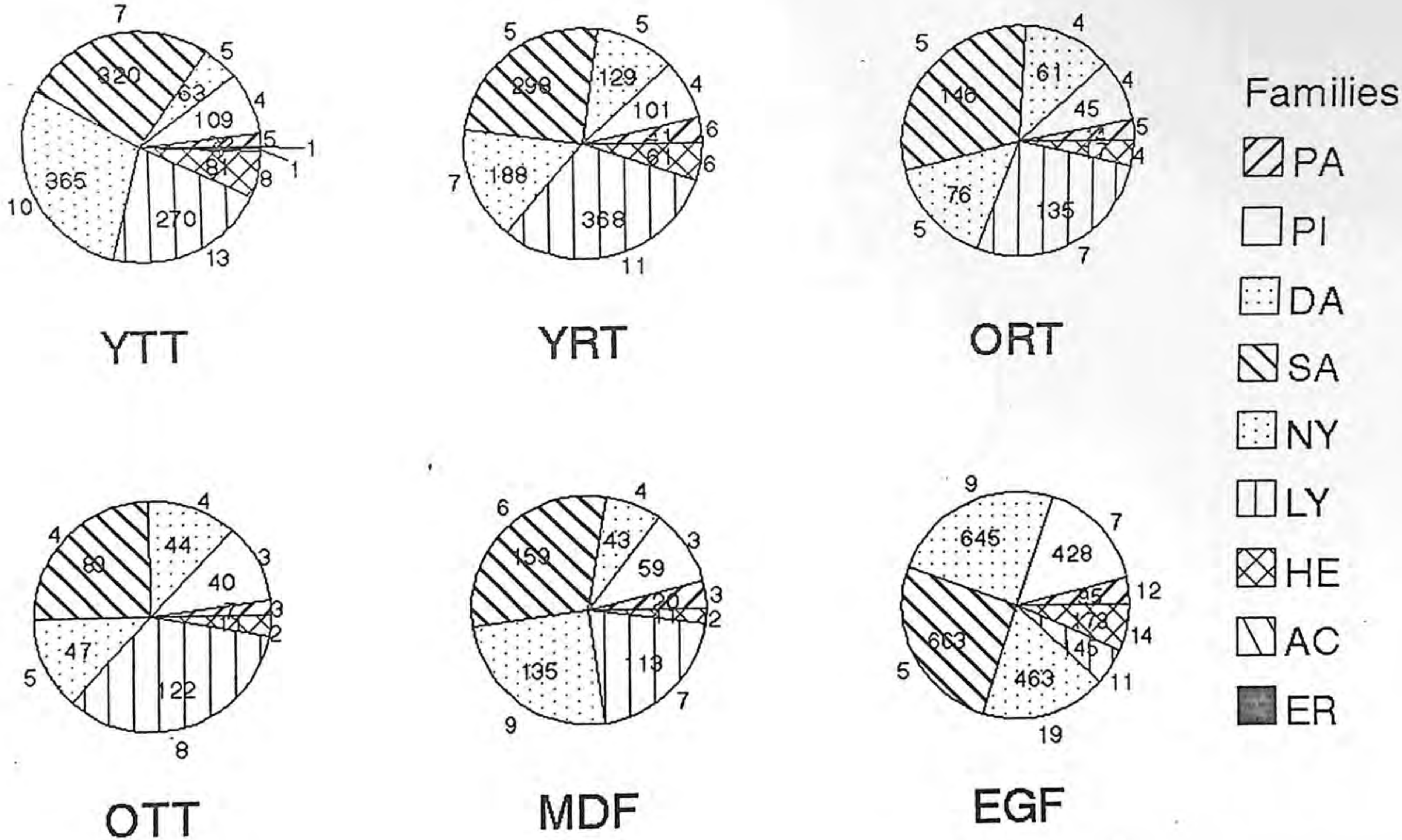
TABLE.1 : THE BUTTERFLY FAMILIES AND SPECIES AT PARAMBIKULAM

FAMILY	DAN	SAT	NYM	ACR	ERY	PIE	LYC	PAP	HES
NO.SP	9	12	35	1	1	18	32	16	15

FAMILY CODES:

DAN Danaidae
SAT Satyridae
NYM Nymphalidae
ACR Acraeidae
ERY Erycinidae
PIE Pieridae
LYC Lycaenidae
PAP Papilionidae
HES Hesperiidae

Family-wise abundance and richness of butterflies



numbers inside indicate abundance, while those outside indicate number of species

4.2 Richness, diversity, evenness and similarity : A comparison

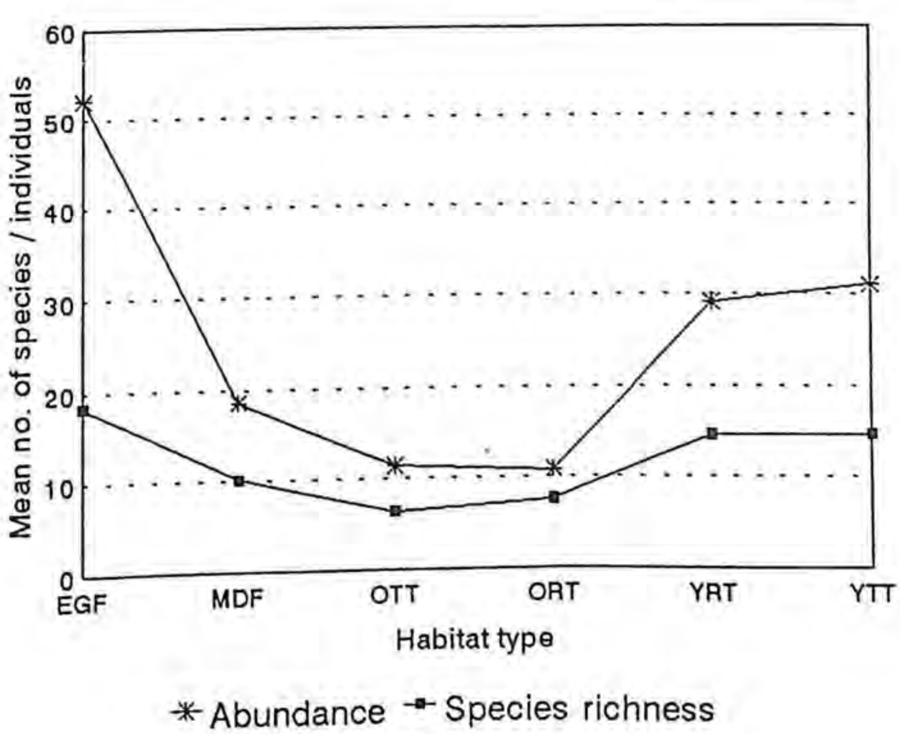
Comparing butterfly abundance (A), species richness (S), species diversity (H) and evenness (J) gave interesting results. Abundance (ANOVA,F=42.2959,p<.001,df=39) and richness (ANOVA,F=34.2914,p<.001,df=39) values were significantly different across the habitat types while H and J did not exhibit much variation. EGF had as many as 2082 individuals and 74 species recorded from 40 transect walks, while OTT on the other hand had only 445 individuals and 32 species respectively. In between these extremes are YTT, YRT, MDF and ORT in a decreasing order of both the variables. The mean number of individuals and species per transect also shows similar trends across the strata (see FIG.5).

Table 2 : A summary of butterfly community attributes across strata

STRATA	ABUND.	SP.RICH	SP.DIV.	EVENNESS
EGF	2082*	74*	3.27	0.7597
MDF	608*	37*	3.22	0.8917
OTT	445*	32*	2.90	0.8156
ORT	4938*	35*	3.05	0.8578
YRT	1172*	44*	3.174	0.8386
YTT	1238*	54*	3.288	0.8072

(* indicates significant difference, ANOVA, F=42.2959 for Abundance and 34.294 for Species richness, p<.001)

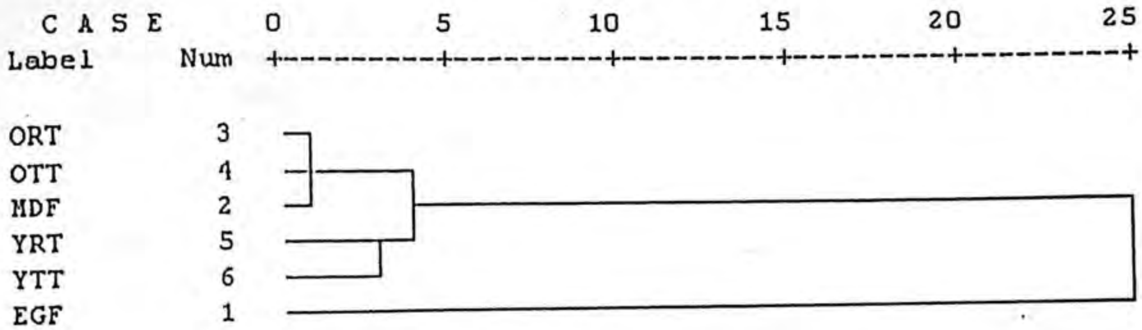
Mean butterfly abundance and species richness per transect



* * * * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * *

Dendrogram using Average Linkage (Between Groups)

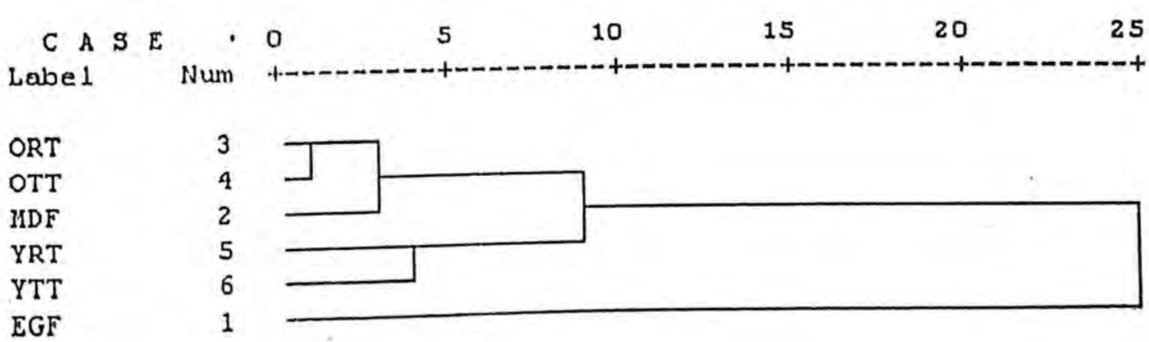
Rescaled Distance Cluster Combine



* * * * * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * * *

Dendrogram using Ward Method

Rescaled Distance Cluster Combine



4.3 Seasonal variation : trends in different habitat types

Butterflies were found to respond very markedly to the change in seasons. Cool season (1 December to 15 February) had significantly more abundance (t-test, 2-tailed p <.001) and richness (t-test, 2-tailed p <.001) of butterflies when compared to dry season (15 February to 28 April). This was the rule in all strata except EGF, which in stark contrast, showed exactly the reverse trend. A look at Table.3 will help elucidating these patterns more clearly.

TABLE 3 : SEASONAL DIFFERENCES IN BUTTERFLY COMMUNITY ATTRIBUTES

		EGF	MDF	OTT	ORT	YRT	YTT
	A	798*	608*	261*	328*	888	922*
COOL	R	61*	37*	29*	33*	43*	48*
	H	3.07	3.22	2.94	3.07	3.1364	3.2247
	J	0.7468	0.8917	0.8731	0.8780	0.8338	0.8329
	A	1284*	137*	107*	165*	284*	316*
DRY	R	64*	24*	23*	23*	35*	37*
	H	3.19	2.94	3.02	2.874	3.345	3.2162
	J	0.7670	0.9250	0.9631	0.9162	0.9408	0.8906

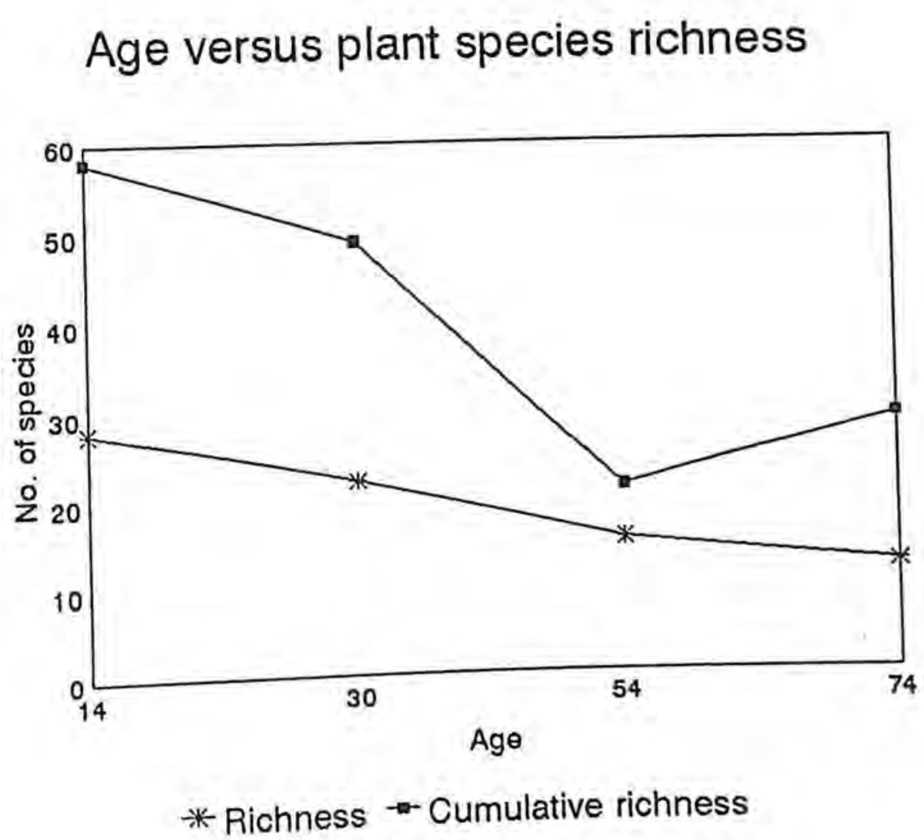
(* indicates significant difference, ANOVA, F=66.2982 for R, F=23.3626 for A, df=5, p<.001)

COMMUNITY ATTRIBUTE CODES

A Abundance
R Species richness
H Species diversity
J Jaccard's evenness

4.4 Teak age gradient : changes in butterfly community attributes

Changes in butterfly community attributes in different aged TKPs are clear-cut. Contrary to the expected pattern, the two younger teak plantations (YTT:1983:14 years old) and YRT:1967:30 years old) harbour more individuals and species of butterflies than the two older plantations (OTT:1923 and ORT:1940). In short, all three attributes viz. A (r=-0.9453), R (r=-0.9691) and H (r=-0.9890) showed very high negative correlation with increasing teak plantation age. This seemingly counter-intuitive result is later explained sequentially in the forthcoming sections, where I shall attempt to explain it biologically. Evenness (J) on the other hand, showed a slight positive correlation with plantation age (r=0.2258). This also calls for an explanation, and is dealt with later. Coming to differences between individual strata, YTT and YRT does not significantly differ among each other in either butterfly richness or abundance nor does OTT and ORT (t-test,2-tail p >.05). In contrast, YTT and OTT, YRT and OTT, YRT and ORT, YTT and ORT differ in both significantly as results of pair-wise t-tests indicate (t-test, 2-tailed p <.05). Thus, the two younger plantations are similar to each other and so are the two older plantations, while between them they are very different. The dendrogram from the hierarchical cluster analysis graphically represents these similarities and differences very well. Apart from the differences in butterfly communities, they are also different in floristic and physiognomic attributes.



4.5 Vegetation, habitat structure and butterflies

4.5.1 Vegetation

Table 4 sums up the vegetation variables in all the strata. But for soil cover (K-W one way ANOVA,chi-square 4.3475,df=5,p=.5005), all others were significantly different between strata (K-W one way ANOVA,df=5,p<.05).

4.5.2 Structural variables

TABLE 5 : STRUCTURAL ATTRIBUTES ACROSS STRATA

HABTAT	VHI	HHI	COMPLEXITY
EGF	0.55	0.92	1.47
MDF	0.36	0.77	1.14
OTT	0.29	0.65	0.94
ORT	0.38	0.79	1.17
YRT	0.3	0.66	0.96
YTT	0.38	0.8	1.17

INDEX CODE

VHI: Vertical heterogeneity index
HHI: Horizontal heterogeneity index
COM: Complexity (VHI + HHI)

All the three structural variables also showed significant difference between the strata. Vertical Heterogeneity (VH) and Complexity (C) were very highly significant (K-W one way ANOVA,df=5,p<.001), while Horizontal Heterogeneity(HH) was significant at p=.05 level.

4.5.3 Floristics, Physiognomy and their influence on butterflies

The above results show that structural and floristic variables, when taken independently showed considerable positive correlation with butterfly community attributes.

4.6 Larval foodplants and adult resources: their distribution

Quantification of larval foodplants was confined only to all the four TKPs due to reasons mentioned in section 3.4.5. Assuming that larval foodplant richness is a function of total plant richness (PTR) in any strata, figs.7 & 8 indicates that the richness of larval foodplants are higher in young than old TKPs. Yet again, butterfly richness (Pearsons r=0.7574), abundance (r=0.7551) and diversity (r=.6972) show high positive correlations to PTR (see figs. 7 & 8).

4.6.1 Adult resources across strata

Adult resources, largely flower abundance, shows the following trend. Flower abundance was seen to be high during the cool season and low in dry season in all the strata except EGF. Tables 6 & 7 compiles the flower abundance index for cool and dry seasons. Both butterfly abundance and richness showed a positive correlation with flower abundance during dry season (Spearmann rank correlation, r=0.52 and .9402 respectively for A and R). In winter, A was positively correlated weakly (r=0.52) and R was negatively correlated(r=-0.3573). Interestingly, when EGF was removed from the analysis, both the variables showed very high correlation (r=0.9087 and 0.764 respectively. This brings to light an interesting pattern, the ecological explanation of which will be dealt with later. Species diversity was positively correlated with flower abundance in both seasons. Given below is Table.6, a summary of the flower abndance indices for all the strata.

TABLE 6 : INDEX OF FLOWER ABUNDANCE

STRATA	FL.INDEX	SE
EGF	1.150	0.32
MDF	1.18	0.33
OTT	1.17	0.32
ORT	0.55	0.2
YRT	1.63*	0.28
YTT	1.90*	0.28

(overall difference significant across all strata K-W ANOVA, chi-square 27.7007, df=5, p<.001)
(* indicates a significant difference) Mann-Whitney U-test, p<.05)
SE Standard error.

Table.7 given below shows the fluctuation in flower abundance across the cool and the dry seasons. Note how EGF is different from the rest of the strata in this regard.

TABLE 7 : FLOWER ABUNDANCE INDEX ACROSS SEASONS

	EGF	MDF	OTT	ORT	YRT	YTT
COOL	0.35	2.1	1.63	1.05	1.95	2.55
SE	0.18	0.47	0.45	0.32	0.4	0.33
DRY	1.95	0.16	0.19	0.11	1.3	1.17
SE	0.5	0.12	0.12	0.1	0.39	0.34

(All are significantly different between seasons for all strata; Mann-Whitney U-test, $p<.05$)
SE : Standard error

4.7 Guild signatures across strata : the patterns

Analysis of guilds revealed no special patterns, except that all strata shared SZ,MZ, and GZ guilds equitably. Only EGF had species belonging to the CZ guild, while YTT clearly showed a larger number of HZ guild when compared to strata.

4.8 Butterfly movements : the trends

As mentioned in section 4.3, there was considerable fluctuation in abundance of butterflies. Together with was seen movement also in a small scale. These will be elaborated in section 5.4.2. As the figure below indicates, there seems to be a significantly higher number of open-country generalist species within the EGF during the dry season.

Abundance of some generalist species encountered in EGF in cool and dry seasons.

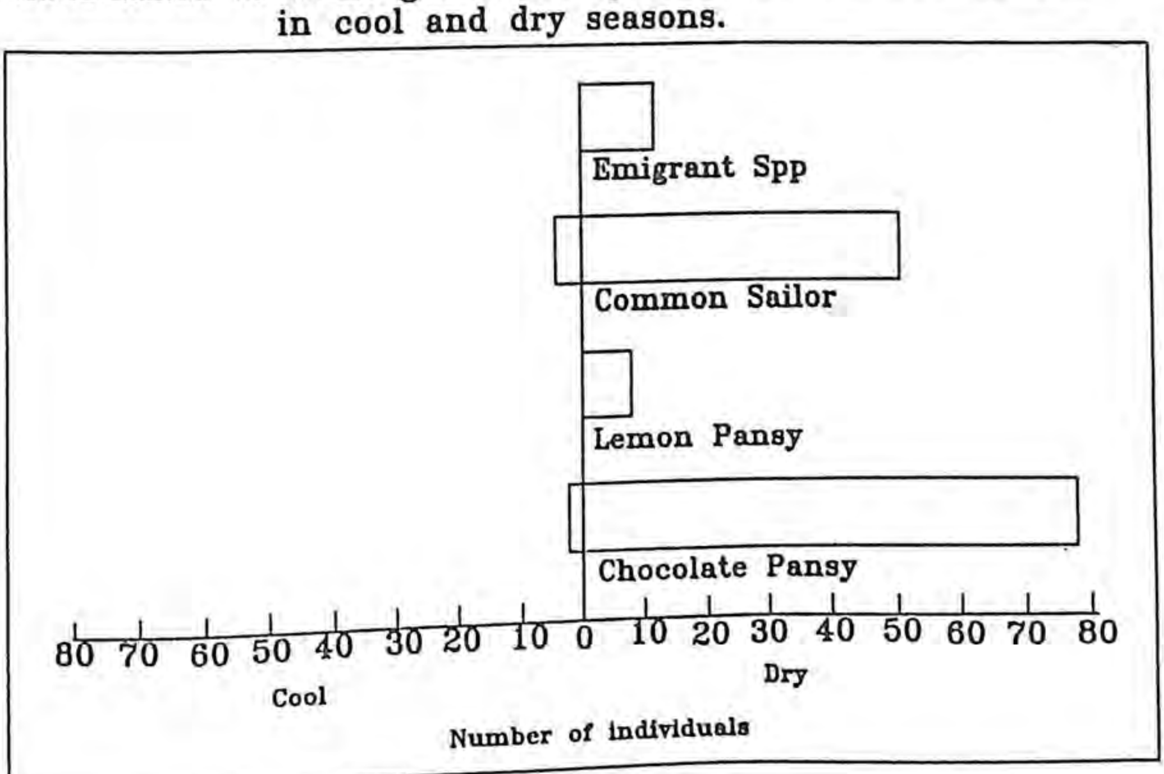


Fig. 10
Butterfly abundance versus flower abundance in cool season

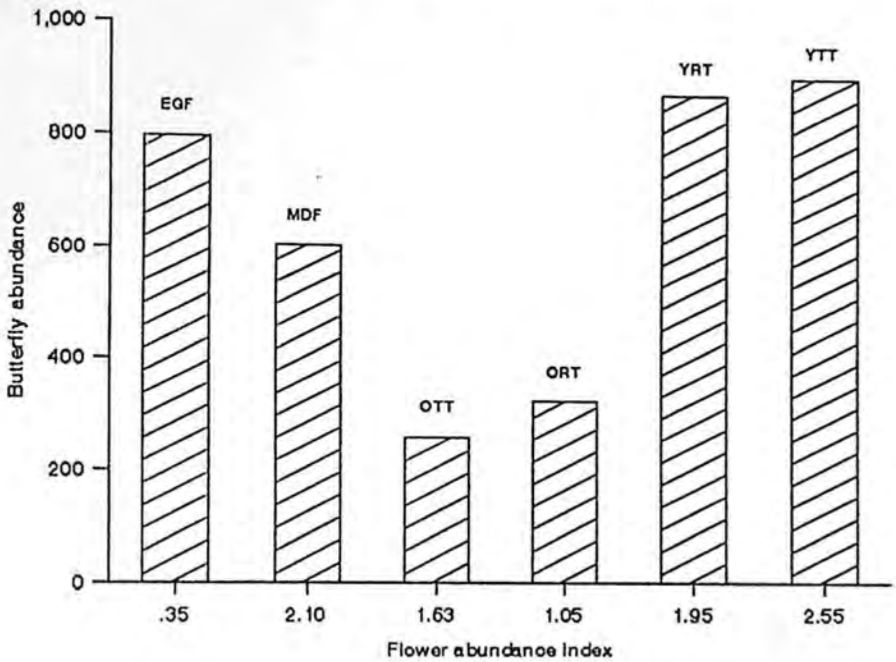
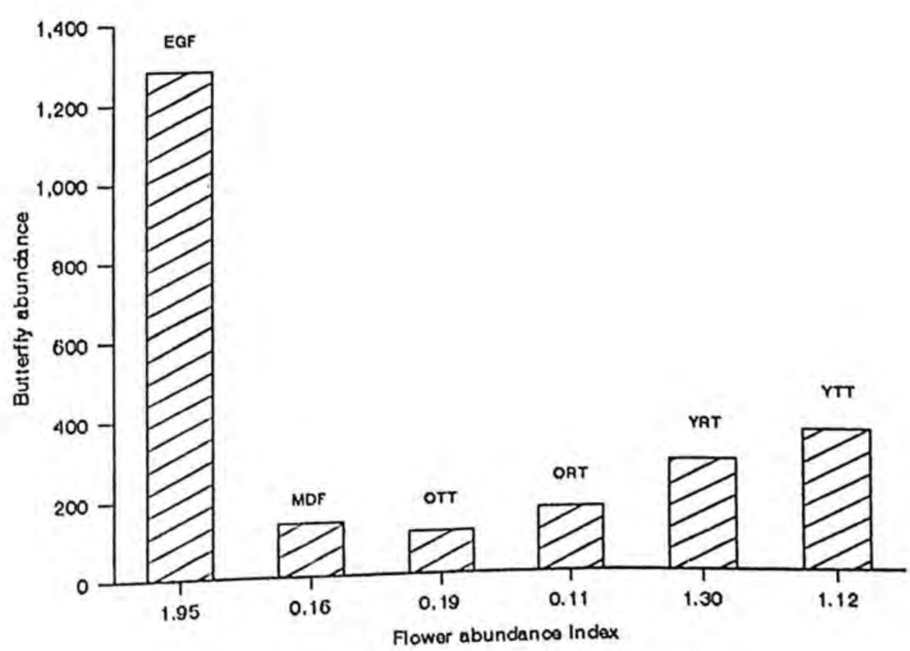
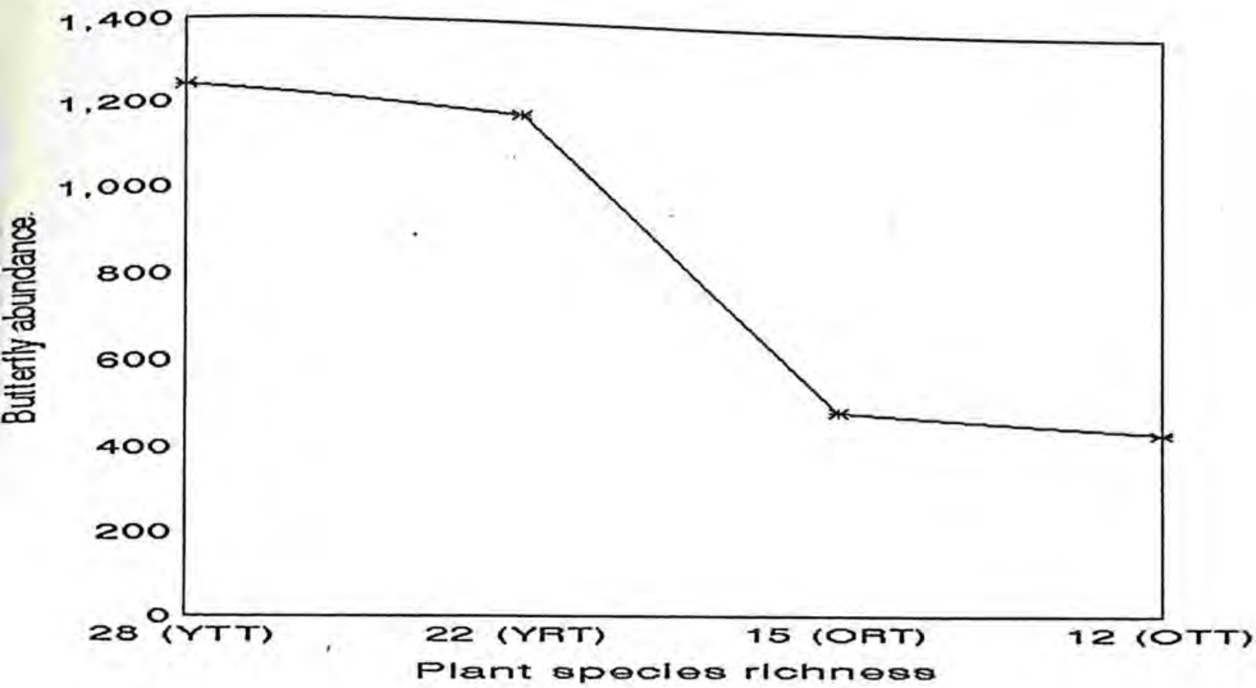


Fig. 11
Butterfly abundance versus flower abundance in dry season



Butterfly abundance versus plant species richness



utterfly diversity and richness versus plant species richness

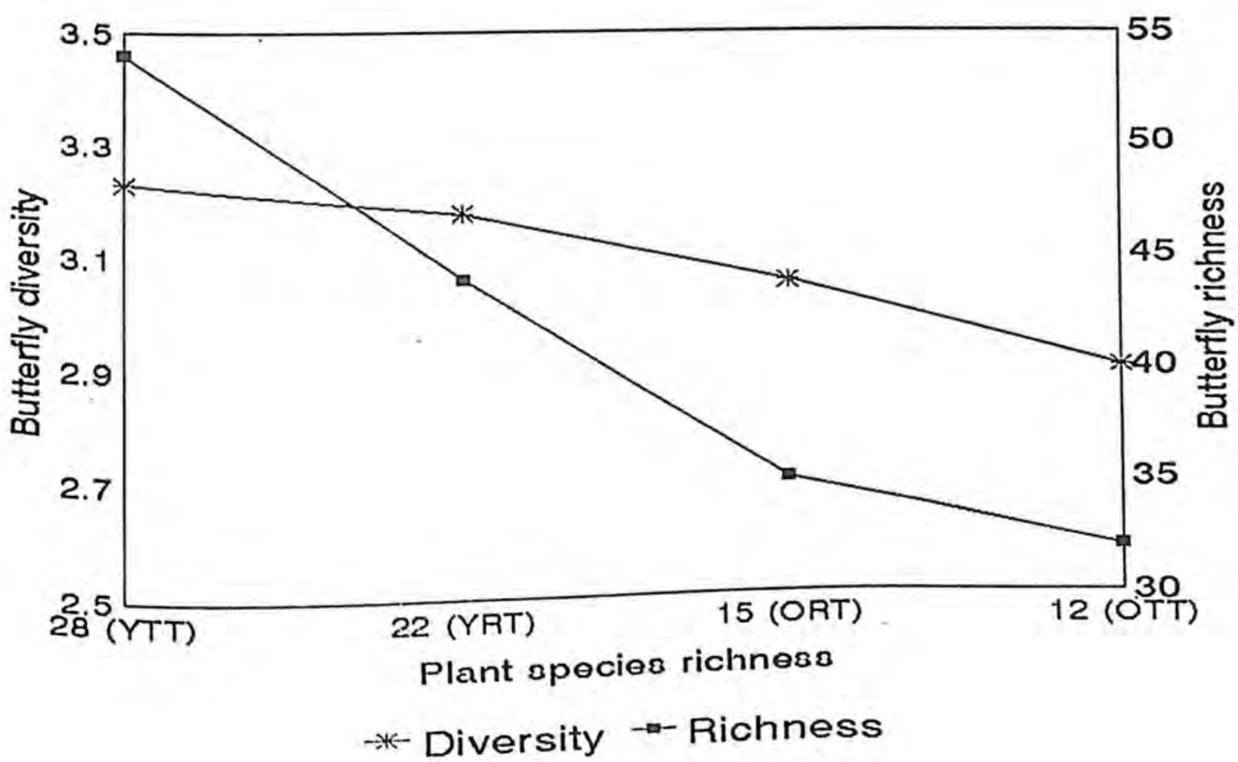


Fig. 6 Foliage profile across strata

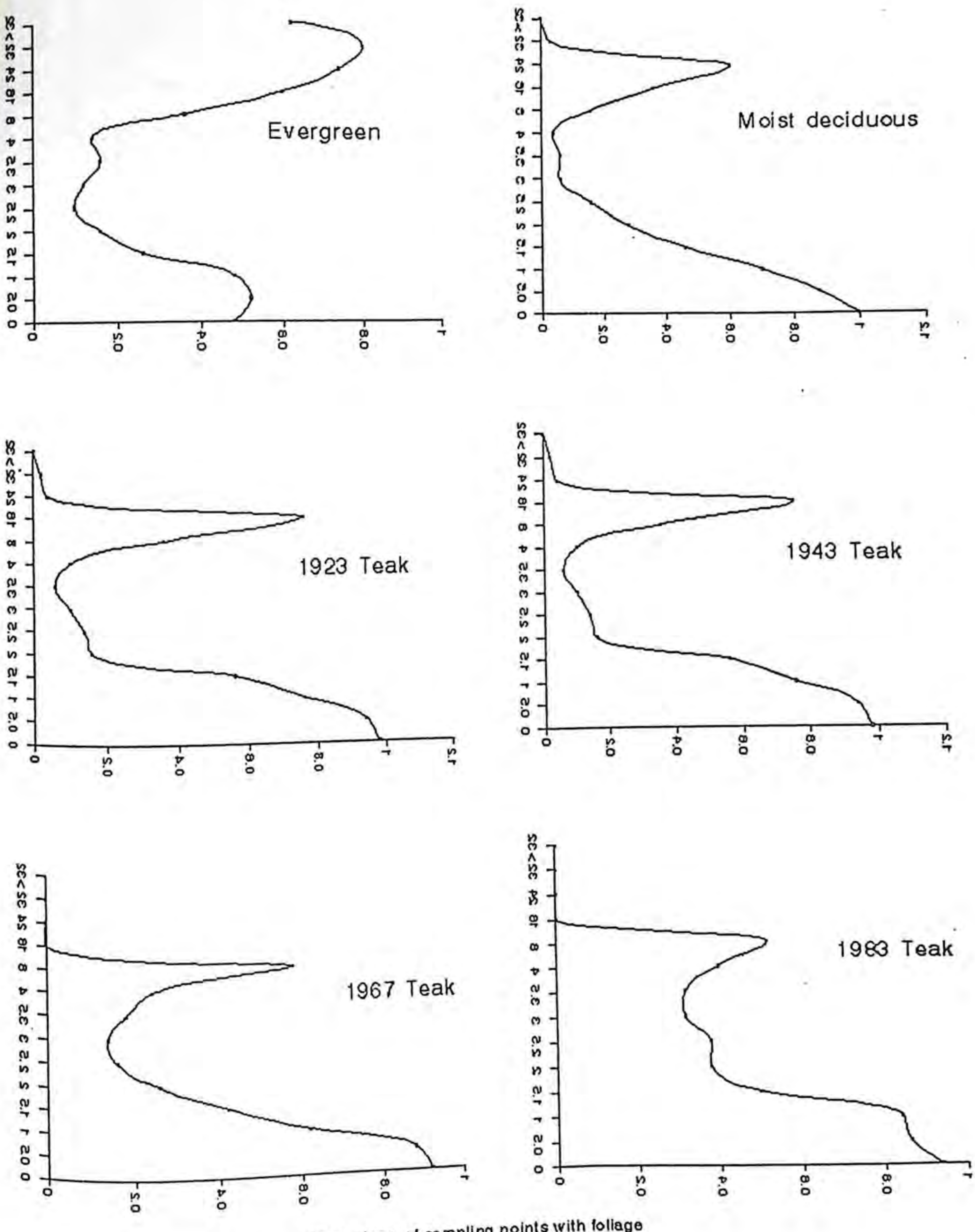


TABLE 4 : SUMMARY OF VEGETATION VARIABLES ACROSS STRATA

STRATA	TRDEN	SHDEN	CANHT	SHHT	CANCOV	LICOV	ROCOV	SOCOV	PLRICH	GBH
EGF	12.1	36.1	35.7	1.98	2.16	72.5	0	26.5	23	39.4
(SE)	0.8300	2.0854	0.9803	0.0784	0.1011	4.5414	0	4.9015	1.5556	2.9024
MDF	3.4	51.7	28.1	1.48	0.88	38	12	37	14.6	104.6
(SE)	0.5513	2.9565	1.3449	0.1129	0.1678	6.6030	7.4565	5.8395	0.6511	8.3704
OTT	1.2222	35.222	31.111	1.4777	1.0666	61.111	0	26.666	15.111	155.33
(SE)	0.2897	2.1436	0.5665	0.0711	0.1032	4.8176	0	3.3333	0.5258	35.072
ORT	2.9090	47.545	31.454	1.4	0.8727	53.636	4	27.272	12.454	134.90
(SE)	0.3149	2.3869	0.4929	0.0924	0.0727	6.6432	0	4.8786	0.8018	8.6017
YRT	3.9	38.6	21.8	1.09	0.80	50	5	37	22.9	118.9
(SE)	0.3591	4.1813	0.7042	0.0767	0.0748	6.6332	0	6.0083	1.0044	1.9618
YTT	12	56.3	9.2	1.39	0.82	23	6	32	28.1	33.3
(SE)	1.0862	5.4204	0.7042	0.1178	0.0660	6.2928	0	9.3327	1.0435	0.9700

(All except soil cover show highly significant differences across strata: K-W ANOVA $p<.001$)

4.9 Rare, uncommon and endemic species : their preferences

An analysis of the occurrence of rare (R) and uncommon (UC) species in the various habitat types shows that there is an overwhelming preference towards EGF. Of the sixteen R and UC species in the study area 12 (75%) are EGF specialists, two (12.5%) can also be seen in MDF, while one (8%) visits open areas also. But all can be seen within EGF.

TABLE 8 : RARE AND UNCOMMON SPECIES WITH HABITAT PREFERENCES

SPECIES	STATUS	FAMILY	HABITAT
GAUDBARON	UC	NYMPHALIDAE	EGF
REDSPOT DUKE	UC	"	EGF,MDF
BLACKVEIN SEARGEANT	UC	"	EGF
SHORTBANDED SAILOR	UC	"	EGF,MDF
AUTUMN LEAF	R	"	EGF
BANDED ROYAL	R	"	EGF
FLUFFY TIT	UC	LYCAENIDAE	EGF
PARIS PEACOCK	R	PAILIONIDAE	EGF
COMMON BANDED PEACOCK	R	"	EGF
MALABAR BANDED PEACOCK	R	"	EGF
FIVEBAR SWORDTAIL	R	"	EGF
MALABAR BANDED SWALLOWTAIL	R	"	EGF
MALABAR RAVEN	R	"	EGF
PLAIN PUFFIN	UC	PIERIDAE	EGF,MDF
CHOCOLATE ALBATROSS	UC	"	EGF
LESSER ALBATROSS	R	"	EGF

HABITAT CODES
EG Evergreen
MD Moist deciduous

ABUNDANCE CODES
R Rare
UC Uncommon

TABLE 9 : UNIQUE SPECIES AND ABUNDANCE CATEGORIES ACROSS STRATA

	UNIQUE	ABUNDANT	FREQUENT	INFREQUENT	RARE	VAGRANT
EGF	15	16	7	12	17	16
MDF	0	8	5	9	3	12
OTT	0	5	5	5	0	11
ORT	0	6	6	4	6	9
YRT	0	16	3	7	5	6
YTT	3	16	5	4	9	16

(please see section 3.5 for criteria employed for abundance ranking)

Endemic species too show the same trend. Of the 10 species recorded during the study, 8 (77%) were EGF specialists, and one (11%) each can also be seen in open country and MDF,TK. Again, all occur within EGF also.

TABLE 10 : ENDEMIC WESTERN GHAT BUTTERFLIES RECORDED FROM THE STUDY AREA

SPECIES	FAMILY	HABITAT	STATUS
NILGIRI TIGER	DANAIDAE	SH,OP	C
REDDISC BUSHBROWN	SATYRIDAE	SH,EG	C
GLADEYE BUSHBROWN	LYCAENIDAE	EG,MD,TK	VC
WHITEDISC HEDGEBLUE	LYCAENIDAE	EG	C
MALABAR BANDED PEACOCK	PAPILIONIDAE	EG	R
MALABAR BANDED SWALLOWTAIL	"	EG	R
MALABAR RAVEN	"	EG	R
LESSER ALBATROSS	PIERIDAE	EG	R
TAMIL DARTLET	HESPERIIDAE	EG	NC
COON	HESPERIIDAE	EG	C

(Abundance rankings from Wynter-Blyth (1957) and Gaonkar (1995)

HABITAT CODES

SH Sholas
EG Evergreen
MD Moist deciduous
OP Open areas
TK Teak plantations
OP Open areas
TK Teak

ABUNDANCE CODES

VC Very common
NC Not common
C Common
R Rare

5.0 DISCUSSION

5.1 Natural forests or teak plantations : which is better ?

A straightforward question, easy to answer. But evidence from literature suggest that it might not be so, for studies have indicated other trends (Raguso and Llorente-Bosquets,1990; Gadagkar *et al.*,1990; Shahabuddin,1993). Also, unlike detailed studies in temperate habitats in the West, which have now graduated from pure ecology to studies of practical conservation interest (Prendergast and Eversham,1995), in India we lack enough basic ecological data, which makes empirical interpretations difficult. In this study, of the two natural forest categories, *viz.* EGF and MDF, the former is superior in all butterfly community attributes, while the latter is not very clearly so. Butterfly species richness and abundance in the MDF is poorer than both the younger plantations (YRT and YTT), though richer than ORT and OTT, the older plantations. This result, obtained largely from transect data needs to be supplemented by *ad libitum* natural history observations and biologically explained in terms of location and characteristics of the MDF patch in which they were laid, in order to bring to light the true picture.

The Anappady MDF where I had my transects was drier than most other MDFs in the sanctuary, and had dry deciduous floral elements like *Anogeissus latifolia* in the vegetation, a fact also emphasized in official sanctuary records (Uniyal,1987). Also, the sampling was probably inadequate to capture the entire heterogeneity of micro sites within the MDF. Casual observations, on the other hand tended to suggest that butterflies preferred other MDFs and other sites within the same MDF to adjoining TKPs. Time-effort sampling, in which I could cover different areas of the same patch yielded corroborative data to the same effect. I also recorded several EGF specialists in MDF occasionally (see section 5.4), which I never saw in any of the TKPs. Yet another fact to be borne in mind is that the young TKPs, both YRT and YTT, are **untended** with good secondary vegetation and lesser weed cover than older TKPs. Hence, in an ecological perspective, they are nothing but fast regenerating secondary successional stages, more akin to natural forests than to true plantations. TKPs of different ages and their role as butterfly habitats will be dealt with in detail in one of the following sections (see sections 5.3 and 5.7).

In the case of EGF, the very high and significantly different values of species richness and abundance as summarised (see table 2), plus the prominent place of endemics/habitat specialists in its butterfly community (see tables 7 and 8), unequivocally indicates that it is superior to TKPs in all these respects and hence ranks very much higher as a butterfly habitat. To sum up, natural forests are definitely better for butterflies than are plantations. It will now be interesting to look at the factors which might be responsible for this.

5.2 Vegetation, habitat structure and butterflies : Are they related ?

While trends emerging from the study suggest that butterflies definitely respond to both floristics and physiognomy as made clear by numerous earlier studies (Warren,1985; Cheverton and Thomas,1982; Shapiro, 1975; Clench, 1967) these have to be interpreted on a cautious note. Floristics as in this study, is a function of both flower abundance and plant species richness, while structure is a function of vertical (VH) and horizontal heterogeneity (HH). It is interesting that, taken in isolation, most of these components are highly correlated with both butterfly A and R (see section 4.5 and figures 8 and 9) and it becomes difficult to quantify the independent effect of each variable. Earlier studies have also encountered exactly the same difficulty (Warren,1985). EGF among all the strata is different from the rest in terms of both vegetation and structure, and as explained by the high values of all the three structural heterogeneity indices (see table 5), is the most stucturally complex stratum of all. But can the high levels of butterfly diversity there be explained by this factor alone ?

A more conclusive answer can be obtained by separating the effects of floristics with that of physiognomy. But this requires much more data, than what was collected during this study. Statistically significant results are often lack ecological meaning due to inherent biases in sampling furthered by purely mathematical artefacts that creep in during the play of numbers. In this study for instance, plant species richness in both EGF and MDF (as obtained by sampling) are lower than that in YTT, a result which has very little biological meaning and which is obviously a result of undersampling. But short field studies cannot always obtain large samples, being constrained by time and effort. Moreover, as the emphasis was more on comparing butterfly communities, much time could not be devoted to habitat and vegetation quantification. Hence, hereafter, I treat in detail, only the structure and vegetation in teak plantations, which were roughly of the same area and look at them from the perspective of a butterfly habitat. This is biologically more meaningful because, apart from data from plots, cumulative plant species richness and other variables of interest in each plantation were obtained by further sampling (see methods and table for details). Further, in spatially limited areas like plantations, one can attempt to look at processes behind the observed patterns.

5.3 TKPs as butterfly habitats : where do they stand?

Any good butterfly habitat, ideally should contain adequate adult and larval resources and a suitable range of microhabitats. To see how each of the TKPs rank, in these criteria will be interesting ; I look at flower abundance, plant species richness and habitat heterogeneity in each of the TKPs studied to see how good they rank as butterfly habitats.

5.4.1 Flower abundance and butterflies

That butterflies are influenced by flowers seems obvious, and have been corroborated by studies (Clench,1967; Douwes,1978 and Jennersten,1980 as cited in Ehrlich,1984), though some studies have found no significant relation (Sharp et al.,1974). However, it seems safe to assume that it is a major component. Hence, more the number and density of flowering plants in a plantation, the more suitable it is for butterflies. Table 6 shows that the younger and older TKPs differ among themselves significantly in both the seasons in flower abundance. Also, YTT and YRT had a greater array (15 species of which 8 were used by butterflies) of flowering plant species than ORT and OTT (5 species of which 3 were used). Also, some flowers like those of *Alternanthera sessilis*, used consistently, were present only in YTT. Hence, in terms of both flower richness and abundance, younger TKPs are better, which seems to be reflected in the butterfly community attributes. Apart from the mere abundance of flowers, there also exist other factors. There also, there seem to be preferences for certain flowers by butterflies. *Lantana, Eupatorium, Alternanthera, Tridax,* and three *Sida* species were noticed to be much frequented. Certain others like *Tephrosia spp*, though present in great abundances were completely avoided. There also seems to be feeding specialisations. Hesperiids and many Nymphalids seem to be generalists using all available range of flowers except the very big ones. Flowers of Labiatae family were used only by *Baoris* genus of Hesperiidae, while that of *Ipomoea* spp was seen to be used only by Birdwing (see Appendix , for a complete list of all flowers visited by butterflies). Hence, the younger TKPs are clearly higher in this respect.

5.3.3 Larval food resource and butterflies

If we are to assume that, larval food plant richness is a function of plant family richness and plant species richness, which is quite a logical surmise to make, as other studies have done (Cheverton and Thomas,1982), and that butterfly richness is a function of plant species richness (Sparks and Parish,1995), younger TKPs fare far better again (see section 4.6). There is a very high correlation between butterfly species richness and abundance with mean and cumulative plant species richness (section 4.6). There are some food plants like *Cryptolepis buchanani, Dendrophthoe phalcata, Cassia fistula and Zizyphus oenoplia*, which are distributed widely in all TKPs, some others like *Tragia involucrata*, and *Grewia tilaefolia* are confined to yonger ones. Older TKPs show very poor regeneration of indigenous vegetation (pers.obs), possibly due to a combination of weed invasion and altered moisture regimes. Chances of succession setting in afresh and bringing along with it more plants, and consequently more butterflies is indeed a remote possibility. Younger TKPs, thus are better butterfly habitats in terms of this perspective also.

5.3.4 Habitat structure and butterflies

There exists, apart from the floristic differences expounded above, structural differences between older and younger TKPs. The former are fairly homogeneous habitat types when compared to the latter (see table 5). This is because of the regular tree dispersion in older TKPs with very few gaps and a dense growth of weeds, mainly Eupatorium. In wetter areas the undergrowth may be replaced by *Glycosmis pentaphylla* or *Helicteres isora (pers obs.)*. As most butterflies like open areas, the lack of them by a uniform canopy closure, may not be very congenial. Then again, there is a drastic change in TKP structure with change in seasons. The canopy opens up totally, undergrowth becomes sparse, and most herbaceous flora wilt away. Thus older TKPs are systems in constant flux, as opposed to EGF or wetter pockets in MDF. Younger TKPs do not show such drastic a change (pers.obs.) and still retains greenery because of good secondary growth, many of them not fully deciduous, and offers some refuge for butterflies. Structure per se, or its immediate derivative like shade can play crucial roles in determining butterfly distributions (Warren, 1985) and maintaining stratification of communities (DeVries,1988). A model by DeVries (1988) predicts that light may be more important than the related factors of temperature and humidity in determining stratification of forest butterflies and that drastic changes in light intensity may act as barriers between habitats. If this is a general rule ,it implies that changes in the structure *per se*, when natural forests are converted to monocultures, apart from differences in adult and larval resources, may inhibit specialist species from inhabiting altered habitats. More insights into basic butterfly biology have to be gathered before arriving at any further conclusion. Having made clear that yonger untended TKPs are better habitats for butterflies, I will now deviate and discuss another aspect, viz. the seasonal changes in butterfly abundance and movement patterns in butterflies, and see how it is related to habitat conversion.

5.4 Seasonal changes and butterfly movement : what are the patterns ?

5.4.1 Butterfly abundance and change in seasons

Changes in butterfly populations with shifting seasons has been reviewed in detail (Gilbert and Singer,1975), factors influencing a butterfly to migrate have been outlined (Baker,1984) and the temporal component of butterfly species diversity (Shapiro,1975) have been established. In W.Ghats, regular migrations (Larsen,1987;1988) take place, and there are distinct peaks in abundances with seasons (Wynter-Blyth, 1957). During the study period, I observed drastic shifts in butterfly numbers as summarised in Table 3. The contrasting patterns in seasonal movement, between EGF and other strata seems largely to be determined by the abundance of nectar resources. Butterfly community attributes showed very high positive correlations with flower abundance, a result consonant with many earlier studies (as reviewed in Gilbert and Singer, 1975 and Gilbert,1984). EGF was the only strata maintaining high numbers of butterflies in both the seasons, though in summer it was higher. Small-scale movements also were observed, the details of which, are dealt with in section 5.4.2

5.4.2 Butterfly movement across and within strata

Butterflies move from one habitat to another, mainly when the larval and adult resources are separated (Ehrlich,1984;Wiklund,1977). This might be large scale migrations spanning months through local movements for days or short excursions lasting for minutes. Movement of butterflies within the study area can be looked at two different scales. First, clear movements from habitat to habitat with shifting seasons and second, finer scale movements of species within a season. I discuss here, two kinds of trends seem to emerge from my observations. During the cool season, generalist species in MDF and TK seemed fairly parochial with very little movement, probably due to abundant nectar resources in their respective habitats. But with dry season setting in, the abundances started going down gradually and in peak summer, it had gone down drastically. This might be a function of two factors : 1. of butterflies dying out and 2. of them moving out or both. I did not observe any conspicuous movements during December to early February in the study area, though most individuals seen during summer were old and tattered. Interestingly, EGF in which I had recorded mostly specialist species in the cool season started having generalist species during summer. I speculate that generalist species from adjoining MDF and TK move into EGF during summer, which is the crunch period in terms of nectar availability in those habitats. In contrast, EGF trees start flowering during summer and may provide resources to migrating generalists. This influx is clearly seen in the summer transect detections of generalist species in EGF (see fig 10). Similar trends of butterflies moving to denser habitats from more open ones have been recorded earlier (Rajasekhar,1995).

In a more finer scale, comes the movement of individuals within seasons. This was prominent particularly in the cool season, when nectar resources were almost non-existent in EGF. EGF specialist species, were seen moving into fringes and open areas in close proximity, to forage on flowers. *Lantana camara, Asclepias currassavica* and *Eranthemum spp* flowers, and were very regularly used by EGF specialist species. None of these nectar sources were inside the EGF proper; rather they were in clearings or EGF edges. Again, I consistently noticed that some of the EGF species like Clipper moved into MDF for a short time, immediately following spells of rain. They were not observed to forage actively, but interestingly, showed the typical "food plant searching" behaviour that female butterflies have. The species observed were not sexually dimorphic and hence, individuals could not be sexed. But it seems possible that they were females dispersing from natal habitats in search of suitable oviposition sites. To sum up, observations indicate that movements across habitats seem to be largely governed by the presence and abundance of adult nectar resource and partially by that of larval feeding resources. The implication here seems to be the dependence of butterflies on nectar and the propensity of several butterfly species to move beween habitats based on the adult resource. Natural forests, EGF especially, might be crucial for open-country generalist species during dry season, both in terms of resource and micro-climatic conditions. Coming down to the level of a few species specialised to natural forest conditions, and seeing their persistence, if any, in TKPs will shed further light on effects of habitat alteration.

5.5 Guild analysis : what conclusions can we derive ?

An analysis of guild signature across strata, immediately brings to light the fact that EGF is the only habitat having all the five guilds (see section 3.5 for details). Canopy zone (CZ) guild, which is absent in all other strata is represented only by species found here. Apart from this notable omission, the guild signature seems fairly uniform - HZ, SZ and MZ guilds are more or less equitably distributed across strata, though in the younger plantations there seems to be a slight preponderance in HZ guild when compared to that in the others. This seems logical when one takes into account the habitat structure. In EGF, with tall trees and well stratified layers, the entire available vertical resource axis seems to be occupied by species, right from the canopy to the ground level. It may be that, it is just the presence of empty niches in a vertical space, which makes species to occupy them. If so, why is CZ zone guild not represented in MDF and old growth TKPs, which also have, in places, structure similar to EGF and similar niches, waiting to be occupied ? It also might be that the answer is not so simple, and cannot be explained by just invoking the heterogeneity of the vertical component of the habitat. There might be a variety of factors involved. If differences in light levels are important for maintaining stratification in rain forest butterflies, as was found out in a study of forest butterflies, we might predict that in habitats without pronounced differences in light levels (i.e.,disturbed forest, deciduous forest during dry season or forest edges), stratification will not be as distinct as in closed canopy forest (DeVries,1988).

The presence of canopy species might be determined and influenced by several subtle factors not easily discernible and quantifiable. Hence, instead of trying to explain the processes behind the observed patterns, a task which calls for meticulous long-term investigations, it might be better to document patterns across habitats and highlight the differences. In this case, the main implication is that species belonging to CZ guild may not take very kindly to habitat conversion.

5.6 Specialists, unique and endemic species : How are they impacted ?

5.6.1 Specialists and generalists

A look at section 4.8 in conjunction with 3.5, will immediately make it clear that natural forests harbour both specialists and generalists, while TKPs do not have many specialists. Again, while analysing the composition of butterfly communities in MDF and EGF, the fact stands out that the latter is much richer in terms of specialist species than is MDF (see table 8). Casual observations in the Karimala Gopuram part of the study area where extensive areas of EGF were converted to teak plantations indicated that even in TKPs adjoining EGFs, the butterfly diversity and abundance was clearly low. Hence, specialist EGF species have come to take the brunt of habitat conversion, while most generalist species can, and are thriving in TKPs.

5.6.2. Unique species

Following the methods given in section 3.4, I analyzed butterfly communities across the habitat types and within each stratum. Table 9 summarises the findings. It is notable that only EGF and YTT, the two habitat types at both ends of the spectrum (in terms of age and habitat structure), are the only ones having unique/characteristic species. The former had 14 and the latter 3. The characteristic evergreen species were Psyche, Puffin spp and Albatross spp among Pierids; Gaudy Baron, Redspot Duke, Common Sergeant, Great Eggfly, Common Leopard and Cruiser among Nymphalids; Angled Pierrot in Lycanids and Suffused Snow Flat, Coon, Water Snow Flat and Tamil Dartlet among Hesperiids. Many others which were eliminated as vagrants while adhering to the uniqueness criterion (see section 3.5) were probably intrinsically rare species, perhaps more qualified than the rest to be called evergreen specialists. They are Malabar Banded Peacock, Malabar Banded Swallowtail, Fivebar Swordtail, and Malabar Raven among Papilionids, Chocolate Albatross and Lesser Albatross among Pierids, Yamfly, Fluffy Tit, Leaf Blue, Blue Oakblue,Banded Royal and Common Imperial among Lycaenids while Nymphalids were represented by Shortbanded Sailor, Blackvein Seargeant, Autumn Leaf and Common Map. Cruiser, another potential "unique", which was detected more than 3 times in evergreen transects, was also detected once in MDF, thus disqualifying its inclusion to the list of unique species.

Unique species in YTT are represented by three species : Indian Skipper, Gram Blue and Nigger. This again, has to be re-examined in the light of observations from time-effort and casual butterfly watching. Except for the first species, the others were seen in other strata also, and hence might not be eligible to be called uniques. Indian Skipper, a weak flier, frequents grassy and herby undergrowth in open areas and YTT, with such microsites provides an ideal habitat for it. With the limited scope of this study, it becomes difficult to conclusively arrive at the conclusion that there are characteristic autochthonous, stenotypic species (species restricted to one type of vegetation throughout their life-cycles) inhabiting any of the strata except perhaps EGF, as Erhardt (1985) found out from his study.

5.6.3 Abundant, frequent and rare species

Table 8 reveals that across the strata, there are only two species qualified to be called **abundant** species. They are Common Evening Brown and Common Bushbrown, both satyrids. Satyrids, particularly both these species feed on overripe fruits and tree sap, never visit flowers as a rule, and have a wide range of species belonging to Poaceae as their foodplants. **Frequent** species are Common Crow, Common Fourring, Grassblue (*Zizeeria spp*) and Peablue. Again, all of them have very general adult and larval requirements and are able to thrive in a variety of habitats.

Now, I will go on to analyze the presence and occurrence of W.Ghat endemics across the habitat continuum. Alongside, I shall also deal with uncommon and rare species. Here, there has to a careful distinction between rarity in this section and the next one. In this section, rarity is largely a function of the presence and abundance of species from transects, operates in a small spatial scale, and functions as a tool to gain better understanding of butterfly communities across strata. In the next, it is more a function of faunistic surveys and inferences of earlier authors, details of which are synthesised in Wynter-Blyth (1957) and Goankar (1995). It also operates in much larger spatial scales than the previous one.

5.5.4 Rare and endemic species

Again, section 4.8 together with Tables 9 & 10, will clarify that EGF is yet again crucial for the survival of rare, uncommon and endemic species. Only one endemic species, viz. Gladeye Bushbrown was observed using all strata and was quite common in TKPs. This is easily explainable for this satyrid hardly needs nectar during its adult stage, while the larva feeds on grasses. The other endemics, Whitedisc Hedgeblue, Malabar Banded Peacock, Malabar Banded Swallowtail, Malabar Raven, Lesser Albatross, Tamil Dartlet and Coon are all EGF species. All this seems to support the contention of earlier studies that habitat modification by man, hence will affect most the endemic species of a landscpe (Jones et al, 1990)

5.7 Teak plantations and butterflies : can both go together ?

The answer is both Yes and No! As discussed earlier, plantations can and do support several generalist butterfly species, most of which can survive just about anywhere. But they fail in holding populations of rare and uncommon habitat specialists. And as the negative trend in community attributes with increasing age of teak plantations shows, older plantaions which have undergone repeated cycles of silvicultural operations might not be the best of habitats for butterflies. On the contrary, untended younger plantations with good secondary growth serves the purpose much better. A mosaic of TKPs also can have differential impact on forest species. Bowman et al (1990) discuss differential response of two species of Birdwing butterflies to habitat conversion by jhuming : both oviposit in a forest Aristolochia spp, but only one frequents open habitats and gardens to feed on flowers, while the other never strays out of its forest habitat. The former, in this case may actually benefit from a jhum-forest habitat mosaic while the latter may be badly affected. Similar trends might be present in the study area also as ad libitum observations indicated. The Southern birdwing, essentially a forest papilionid was detected regularly, drinking nectar from flowers in open areas/plantation edges far from natural forests, while other forest papilionids like Peacocks, Malabar Raven or Fivebar Swordtail were never seen anywhere far from their forest habitat. Thus, while plantations and butterflies are not entirely mutually exclusive entities, it is only a very limited subset of the total butterfly diversity that they can support. Ecological investigations and the insights derived from them should tell us ways to increase that subset, a topic with which we deal with in the next section.

5.8 Managing plantations in future : what can we do ?

Managing any habitat calls for a deep understanding of the system. Here, the general issue in question is the management of teak plantations for wildlife, and in this particular context, butterfies. Previous studies have suggested several potential steps from which it is possible to draw some conclusion. Daily and Ehrlich (1995) found adults of forest interior species in a 16 h.a highly managed botanical garden adjoining moist forests and concluded that even heavily managed systems of largely exotic plants, such as agricultural systems could be designed to serve as corridors for butterflies. Cheverton and Thomas (1982) also emphasizes the role of natural vegetation strips as corridors and repositories of butterfly diversity within unsuitable habitats.

Experiments like planting foodplants amidst cash crops with a long-term view of creating new areas of potential habitat, are being carried out (Parsons, 1985)
for supporting endangered species, which can also be attempted. Selective lumbering has been recommended to increase butterfly diversity in Panama (Cheverton & Thomas, 1982).

Keeping in mind the fact that no amount of management can probably harbour levels of diversity tantamount to natural forests (Owen,1971; Pettersson et.al 1995), it would be useful to speculate at certain possible steps to increase it. The potential steps can be broadly divided into passive and active modes.
The former includes

1. maintaining strips of natural vegetation within plantations
2. leaving stream and rivulet-side vegetation intact, and
3. not weeding plantations where plant species richness is high.

The latter includes

1. opening up mature teak plantations to allow secondary succession
2. redefining silvicultural practices for minimal impact, and
3. replacing extensive uniform aged plantations with a mosaic of different aged ones.

Special care has to be taken during initial phases of opening up, to quell weed growth, and as in other places, plantations here, might serve as favourable areas for natural forest regeneration (Chapman and Chapman,1996). Also, if properly implemented, butterflies in opened-up plantations can also be used as an index of regeneration success and index of habitat quality (Pollard,1982; Shahabuddin,1993).
Keeping aside these general suggestions, with special regard to Parambikulam, there are two interesting problems which require careful examination : one, that of weed management and the other, that of managing plantations for particular taxa, in this case, butterflies. Two very common and supposedly noxious weeds in the study area are *Lantana camara* and *Eupatorium adenophorum*, flowers of which are extensively used by butterflies for nectar; the importance of Lantana flowers as an adult nectar resource have been widely accepted and documented. In fact, Lantana clumps adjoining evergreen patches are sure places to find evergreen specialists feeding and I speculate that it forms quite a crucial resource for them, at least during certain times of the year. Particularly *Eupatorium* flowers form a very important nectar resource during cool season. In fact, butterfly abundance in the study area showed a high correlation with flower abundance during cool season, a significant amount of which was contributed by *Eupatorium*. So, wiping out these two species abruptly, (if at all it is possible) might not be very beneficial for butterflies. On the other hand, if left uncontrolled these species can proliferate at astonishingly fast rates, all at the expense of native plant species,

many of which are butterfly hostplants. Naturally, the question here is whether a balance could be struck between these two options. Also, what impacts will managing TKPs for butterflies, which is quite unlikely an event to happen, have on other taxa ? Conversely what impacts will managing TKPs for ungulates have on butterflies? Questions which require deeper understanding of the system and its denizens, some of which is slowly being gathered (Balakrishnan and Easa, 1986; Easa and Balakrishnan,1995) Saravanakumar,1995).

The idea of managing ecosystems for particular taxa, very much a western concept, calls for much caution when being implemented in tropical areas with complex multi-taxal linkages. A good butterfly habitat might not be a good bird habitat and vice-versa. Hence, active management is best done after detailed investigations. The present official policy at Parambikulam is to phase out teak plantations gradually and allow natural forests to take over (Uniyal,1987 and Rajan Sehgal, *pers.comm*). But how to accomplish this, still remains a matter of debate and discussion. Conservation of butterflies in managed woodlands and differential response of species to varying thinning and felling cycles are dealt with in Thomas(1985), but such predictive and exhaustive treatments are an outcome of years of meticulously collected data. Also, most temperate landscapes have a very long history of extensive anthropogenic habitat modification, which has led to a stage where, those species left are able to tolerate and flourish under the altered conditions (ibid). Tropics present a different picture, and only recently are these issues pursued for investigation. Hence it might be premature to speculate on how tropical systems will behave, based entirely on the tends exhibited by their temperate counterparts.

5.9 This study : What are the implications for conservation ?

With accumulating ecological knowledge and greater understanding of a system comes the power and moral responsibility to formulate and implement strategies needed to conserve it. Three trends which are evident from the study are

1. the clear difference between EGF and the rest of the habitat types in terms of butterfly community attributes
2. the progressively decreasing trend of butterfly community attributes with increasing age of teak plantations, and
3. the drastic differences in abundance and shifts in community structure with seasons in all habitat types except EGF.

These three, together with several related corollaries have very significant implications for conservation. The most obvious conclusion that we can arrive at is the overwhelming importance of EGF in conserving butterfly communities. It harbours several habitat specialists found nowhere else, possibly act as refugia for generalist species during pinch periods and might also serve as repositories of source populations which in future can recolonise suitable and unoccupied adjoining habitats. Thus in any landscape, EGFs demand the highest priority for conservation, should be given all possible protection and are best left untouched. This assumes critical dimensions as evergreen forests, despite their acknowledged intrinsic values, continue to be destroyed (Myers,1986). To take the specific example of Parambikulam, a proposed move to build three dams is threatening to drown 2500 *ha* of natural vegetation, 1600 of which are lowland evergreen forests within the park (Uniyal,1995), home to numerous endangered species of all taxa, probably including all EGF specialist butterflies mentioned here, and maybe more. Butterflies despite their small size, may need surprsisingly large areas of suitable habitats for their effective conservation as Daily and Ehrlich (1995), in their study on Costa rican mid-elevation moist forest butterflies concluded. An analysis of metapopulation persistence of an endangered butterfly in a fragmented landscape revealed that local populations are not safe from extinction even in managed reserves (Hanski,1995). Even within our limits, the importance of natural vegetation, particularly EGF have been established (Larsen,87,88; Mathew and Rahmathulla,93; Mathew,96). Undisturbed natural forests, clearly are needed for effective conservation.

Second in order, comes the interesting pattern across teak plantations of different ages. Older plantations, despite having a structural similarity to natural forests do not hold as rich a butterfly community as do younger plantations. Which essentially imply that they have to be replaced with more heterogeneous habitats akin to natural forests, to support higher levels of butterfly diversities, in the longer run. Similarly, the high levels of richness and abundance in the two younger plantations, show that regenerating secondary growth is favoured by butterflies.

Finally, the trend in seasonal shifts again point to the fact that plantations, for that matter even moist-deciduous forests, are prone to shifts in climatic patterns and thus are highly unstable in the perspective of a butterfly habitat Naturally, species adapted to stable, very specific micro-habitat conditions are unable to survive. And often, many of them are intrinsically rare and endemic with very narrow niche breadths, making them ideal candidates to be affected by any perturbation in their environment.

To recapitulate briefly, by replacing natural forests with monocultures we replace complex, stable systems with infinitely simpler and fluctuating ones. Short field studies do nothing but take hasty snapshots of complex ecological systems and consequently are prone to errors of different types and scales, in all stages right from design through data collection to interpretation. They serve better as documentaries of patterns than explanations of processes behind them. This study is no exception. Thus, the patterns observed during this study suggest that teak plantations have had a negative impact on forest butterfly communities, atleast evergreen ones, and that they support only a few common species. Conserving the entire spectrum of butterfly diversity in the W.Ghats means conserving all natural vegetation, particularly wet evergreen forests.

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CHECK-LIST TO THE BUTTERFLIES OF PARAMBIKULAM WILDLIFE SANCTUARY

FAMILY PAPILIONIDAE

COMMON BIRDWING	*Troides minos*
CRIMSON ROSE	*Tros hector*
COMMON ROSE	*Tros aristolochiae*
COMMON MIME	*Chilasa clytia*
BLUE MORMON	*Papilio polymnestor*
PARIS PEACOCK	*Papilio paris*
COMMON BANDED PEACOCK	*Papilio crino*
MALABAR BANDED PEACOCK	*Papilio budha*
MALABAR RAVEN	*Papilio dravidarum*
RED HELEN	*Papilio helenus*
COMMON MORMON	*Papilio polytes*
MALABAR BANDED SWALLOWTAIL	*Papilio liomedon*
LIME BUTTERFLY	*Papilio demoleus*
SPOT SWORDTAIL	*Pathysa nomius*
FIVE-BAR SWORDTAIL	*Pathysa antiphates*
COMMON BLUEBOTTLE	*Zetides sarpedon*
COMMON JAY	*Zetides joson*
TAILED JAY	*Zetides agamemnon*

FAMILY PIERIDAE

PSYCHE	*Leptosia nina*
JEZEBEL	*Delias eucharis*
COMMON GULL	*Huphina nerissa*
LESSER GULL	*Huphina nadina*
PIONEER	*Belenois mesentina*
PLAIN PUFFIN	*Appias indra*
CHOCOLATE ALBATROSS	*Appias lyncida*
COMMON ALBATROSS	*Appias albina*
LESSER ALBATROSS	*Appias wardii*
LITTLE ORANGE TIP	*Colotis etrida*
YELLOW ORANGE TIP	*Ixias pyrene*
WHITE ORANGE TIP	*Ixias marianne*
GREAT ORANGE TIP	*Hebomoia glaucippe*
COMMON WANDERER	*Parenonia valeria*
COMMON EMIGRANT	*Catopsila crocale*
MOTTLED EMIGRANT	*Catopsila pyranthe*
SMALL GRASS YELLOW	*Eurema brigitta*
COMMON GRASS YELLOW	*Eurema hecabe*

FAMILY DANAIDAE

TREE NYMPH	*Hestia lynceus*
GLASSY TIGER	*Danais aglaea*

NILGIRI TIGER	*Danais nilgiriensis*
BLUE TIGER	*Danais limniace*
DARK BLUE TIGER	*Danais melissa*
COMMON TIGER	*Danais plexippus*
PLAIN TIGER	*Danais chrysippus*
COMMON INDIAN CROW	*Euploea core*
DOUBLE BRANDED CROW	*Euploea coreta*

FAMILY SATYRIDAE

WHITE-BAR BUSHBROWN	*Mycalesis anaxias*
COMMON BUSHBROWN	*Mycalesis perseus*
DARK BROWN BUSHBROWN	*Mycalesis mineus*
RED-DISC BUSHBROWN	*Mycalesis oculus*
GLAD-EYE BUSHBROWN	*Mycalesis patnia*
BAMBOO TREE BROWN	*Lethe europa*
COMMON TREE BROWN	*Lethe rohria*
PALNI FOUR-RING	*Ypthima ypthimoides*
WHITE FOUR-RING	*Ypthima ceylonica*
COMMON FOUR-RING	*Ypthima hubneri*
COMMON FIVE-RING	*Ypthima baldus*
TAMIL CATSEYE	*Zipoetis saitis*
NIGGER	*Orsotrioena medus*

FAMILY NYMPHALIDAE

TAWNY RAJAH	*Charaxes polyxena*
COMMON NAWAB	*Eriboea athamas*
GREY COUNT	*Euthalia lepidea*
BARON	*Euthalia garuda*
GAUDY BARON	*Euthalia lubentina*
RED-SPOT DUKE	*Euthalia evalina*
CLIPPER	*Parthenos sylvia*
COMMANDER	*Limenitis procris*
BLACK-VEIN SEARGEANT	*Pantoporia ranga*
COMMON SEARGEANT	*Pantoporia perius*
SHORT-BANDED SAILOR	*Neptis columella*
CHESTNUT STREAKED SAILO	*Neptis jumbah*
COMMON SAILOR	*Neptis hylas*
COMMON LASCAR	*Neptis hordonia*
COMMON MAP	*Cyrestis thyodamas*
GREAT EGGFLY	*Hypolimnas bolina*
DANAID EGGFLY	*Hypolimnas misippus*
AUTUMN LEAF	*Doleschalia bisaltidae*
BLUE OAKLEAF	*Kallima philarchus*
YELLOW PANSY	*Precis hierta*
BLUE PANSY	*Precis orithya*
LEMON PANSY	*Precis limonia*
GREY PANSY	*Precis atlites*
CHOCOLATE PANSY	*Precis iphita*

PAINTED LADY	*Vanessa cardui*
RED ADMIRAL	*Vanessa indica*
BLUE ADMIRAL	*Vanessa canace*
INDIAN FRITILLARY	*Argynnis hyperbius*
COMMON LEOPARD	*Atella phalanthe*
RUSTIC	*Cupha erymanhis*
CRUISER	*Cynthia erota*
TAMIL YEOMAN	*Cirrochroa thais*
TAMIL LACEWING	*Cethosia nietneri*
ANGLED CASTOR	*Ergolis ariadne*
COMMON CASTOR	*Ergolis merione*

FAMILY ACRAEIDAE

TAWNY COSTER	*Telchinia violae*

FAMILY ERYCINIDAE

PLUM JUDY	*Abisara echerius*

FAMILY LYCAENIDAE

RED PIERROT	*Talicada nyseus*
COMMON PIERROT	*Castalius rosimon*
ANGLED PIERROT	*Castalius caleta*
BANDED BLUE PIERROT	*Castalius ethion*
ZEBRA BLUE	*Syntarucus plinius*
MALAYAN	*Megisba malaya*
WHITE-DISC HEDGE BLUE	*Lycaenopsis albidisca*
COMMON HEDGE BLUE	*Lycaenopsis puspa*
PLAIN HEDGE BLUE	*Lycaenopsis lavendular*
GRASS JEWEL	*Zizeeria putli*
TINY GRASS BLUE	*Zizeeria gaika*
LESSER GRASS BLUE	*Zizeeria otis*
GRAM BLUE	*Euchrysops cnejus*
FORGET-ME-NOT	*Catochrysops strabo*
PEA BLUE	*Lampides boeticus*
COMMON CAERULEAN	*Jamides celeno*
METALLIC CAERULEAN	*Jamides alecto*
DARK CAERULEAN	*Jamidus bochus*
LARGE FOUR-LINE BLUE	*Nacaduba pactolus*
LEAF BLUE	*Horsfieldia anita*
TAMIL OAKBLUE	*Amblypodia bazaloides*
YAMFLY	*Loxura atymnus*
COMMON SILVERLINE	*Spindasis vulcanus*
SILVERLINE SPP	*Spindasis spp*
WHITE ROYAL	*Pratapa deva*
BANDED ROYAL	*Charana jalindra*
COMMON IMPERIAL	*Cheritra freja*

MONKEY PUZZLE	*Rathinda amor*
FLUFFY TIT	*Zeltus etolus*
LARGE GUAVA BLUE	*Virachloa perse*
SLATE FLASH	*Rapala schistacea*
INDIGO FLASH	*Rapala varuna*

FAMILY HESPERIIDAE

SUFFUSED SNOW FLAT	*Tagiades obscurus*
WATER SNOW FLAT	*Tagaides litigosa*
COMMON SMALL FLAT	*Saraganesa dasahara*
FULVOUS PIED FLAT	*Coladenia dan*
GOLDEN ANGLE	*Caprona ransonnetti*
INDIAN SKIPPER	*Syrichtus galba*
COMMON BANDED AWL	*Hasora alexis*
INDIAN AWLKING	*Choaspes benjaminii*
BROWN AWL	*Badamia exclamationis*
COMMON RED EYE	*Matapa aria*
GIANT RED EYE	*Gangara thyrsis*
DARK PALM DART	*Astychus pythias*
COMMON DARTLET	*Oriens gola*
CONJOINED SWIFT	*Baoris conjuncta*
COMMON BANDED DEMON	*Notocrypta paralysos*
GRASS DEMON	*Udaspes folus*
COON	*Sancus puligo*
TAMIL DARTLET	*Oriens concinna*

APPENDIX-B

LIST OF PLANTS COLLECTED FROM THE INTENSIVE STUDY AREA

Acanthaceae

Justicia simplex
Rungia plicata
Dipteracanthus prostratus
Crossandra infundibuliformis
Eranthemum spp
Barleria cristata

Amaranthaceae

Achyranthes àspera
Alternanthera sessilis

Amarylladaceae

Curculigo orchioides

Anacardiaceae

Mangifera indica
Lannea coromandelica
Holigarna arnottiana

Anonaceae

Artabotrys zeylanicus

Apocynaceae

Alstonia scholaris
Cryptolepis buchanani
Hemidesmus indicus
Rauwolfia densiflora
R. serpentina
Tylophora indica
Wrightia arborea

Arecaceae

Caryota urens
Calamus spp

Asclepiadaceae

Caralluma umbellata
Asclepias currasavica

Asteraceae

Bidens bipinnata
Eupatorium adenophorum
Eclipta prostrata
Tridax procumbens
Blumea rhomboidea
Agyratum conizoides

Bignoniacea

Stereospermum chelonoides
Radermacheria xylocarpa

Bombacaceae

Bombax ceiba

Boraginaceae

Trichodesma zeylanicum
Cynoglossum furgatum
Cordia myxa

Burseraceae

Canarium strictum
Garuga pinnata

Caesalpineacea

Erythrina stricta
Ailanthus triphysia
Entada scandens
Albizzia odoratissima
Bauhinia variegata
Cassia fistula
C.occidentalis
C. tora
Dalbergia latifolia
D.lanceolaria
Xylia xylocarpa
Caesalpinia bonduc

Chenopodiaceae

Chenopodium ambrosioides

Clusiaceae

Calophyllum elatum
Mesua ferrea

Combretaceae

Terminalia bellerica
T.tomentosa
T.allata
Anogeissus latifolia
T.chebula
Calycopteris floribunda

Commelinaceae

Commelina spp

Convolvulaceae

Evolvulus alsinoides
Merremia tridentata
Ipomoea staphylina
Ipomoea spp
Ipomoea spp

Cycadaceae

Cycas circinalis

Dilliniaceae

Dillenia pentagyna

Dioscoraceae

Dioscorea spp

Dipterocarpaceae

Vateria indica
Hopea parviflora

Ebenaceae

Diospyros spp

Euphorbiacea

Jatropha spp
Bridelia squamosa
Trewia nudiflora
Emblica officinalis
Euphorbia hirta
Givotia rottleriformis
Tragia involucrata
Ricinus communis
Macaranga peltata
Acalypha wilkesiana
Mallotus tetracoccus

Fabaceae

Desmodium spp
Alysicarpus vaginalis
Rhynchosia minima
Pongamia pinnata
Cynometra spp
Spatholobus roxburghii
Pterocarpus marsupium
Tephrosia purpurea
Crotalaria verrucosa

Flacourtiaceae

Hydnocarpus laurifolia

Lamiaceae

Orthosiphon thymiflorus
Leucas biflora

Lauraceae

Cinnamomum malabatrum

Lecythidaceae

Careya arborea

Loranthaceae

Dendropthoe falcata

Lythraceae

Lagerstroemia speciosa
L. lanceolata

Malvaceae

Malvastrum coromandelianum
Sida cordata
S. acuta
S. cordifolia
Hibiscus micranthus

Meliaceae

Dysoxylon malabaricum
Melia dubia

Menispermaceae

Clematis gouriana
Cissampelos pereira
Cyclea peltata

Mimosaceae

Mimosa pudica

Moraceae

Ficus glomerata
F.hispida
F.benghalensis
F. drupacea
Plecospermum alatum
Artocarpus heterophyllus

Myristicaceae

Myristica dactyloides

Myrsinaceae

Maesa indica
M. perottetiana

Myrtaceae

Psidium guajava
Syzygium jambolanum
S. cumini

Nyctaginaceae

Boerhavia diffusa
B. chinensis
Breynia vitis-idea

Oleaceae

Jasminum rottlerianum
J. sambac
J. malabaricum

Onagraceae

Ludwigia suffruticosa

Oxalidaceae

Oxalis corniculata

Passifloraceae

Passiflora spp

Piperaceae

Piper spp

Plumbaginaceae

Plumbago zeylanica

Poaceae

Dendrocalamus strictus
Bambusa arundinacea
Ochlandra travancorica

Ramanaceae

Zizyphus oenoplia
Z.rugosa

Rananculaceae
Naravelia zeylanica

Rubiaceae

Psychotria spp
Mussaenda frondosa
Adina cordifolia

Randia dumetorum
Hymenodictyon excelsum
Ixora pavetta
Mitragyna parvifolia

Rutaceae

Clausena dentata

Sabiaceae

Schleichera oleosa

Sapindaceae

Spondias spp
Cardiospermum halicacabum

Sapotaceae

Palaquim ellipticum

Scrophulariaceae

Stachytarpheta indica
Scoparia dulcis

Solanaceae

Physalis minima
Solanum verbascifolium

Sterculiaceae

Sterculia villosa
Pterospermum spp
Helicteres isora
Urena lobata

Tiliaceae

Grewia bracteata
G. tiliaefolia

Ulmaceae

Holoptelea integrifolia
Trema orientalis

Verbanaceae

Vitex altissima
Gmelina arborea
Tectona grandis
Lantana camera

Vitaceae

Cissus glauca

Zingiberaceae

Curcuma spp

APPENDIX-C

LIST OF LARVAL FOOD PLANTS RECORDED .

Butterfly	Foodplant	Family
Glassy tiger	*Tylophora indica*	(Apocynaceae)
Plain tiger	*Asclepias curassavica*	(Asclepidiaceae)
Common Crow	*Cryptolepis buchanani*	(Asclepideaceae)
	Tylophora indica	(")
Common Bushbrown	*Grass spp*	(Poaceae)
Gladeye Bushbrown	*Grass spp*	(")
Gaudy Baron	*Dendrophthoe phalcata*	(Loranthacaeae)
Clipper spp	*Passiflora spp*	(Passifloraceae)
Commander	*Mussaenda frondosa*	(Rubiaceae)
Common Sailor	*Helicteres isora*	(Sterculiaceae)
Lemon Pansy	*Asteracantha spp*	(Acanthaceae)
Chocolate Pansy	"	(")
Tamil Yeoman	*Hydnocarpus spp*	(Bixaceae)
Angled Castor	*Ricinus communis,*	(Euphorbiaceae)
	Tragia involucrata	(")
Common Pierrot	*Zizyphus oenoplia*	(Rhamnaceae)
Southern Grass Jewel	*Oxalis corniculatum*	(
Peablue	*Crotalaria spp*	(Papilionaceae)
Blue Mormon	*Glycosmis pentaphylla*	(Rutaceae)
Common Mormon	*Murraya paniculata*	(
Lime butterfly	*Glycosmis pentaphylla*	(Rutaceae)
Jezebel	*Dendropthoe phalcata*	(Loranthaceae)
Emigrant spp	*Cassia fistula*	(Papilionaceae)
	Cassia tora,	(")
	Cassia occidentalis	(")
Common Grass Yellow	*Pithacolobium dulce*	(")
		(
Indian Skipper	*Sida rhombifolia*	(Malvaceae)
Common Redeye	*Bambusa arundinaceae*	(Poaceae)

LIST OF OBSERVED ADULT RESOURCES AND SPECIES USING THEM

A.PREFERRED NECTAR RESOURCES

1. Lantana camara
2. Eupatorium adenophorum
3. Alternanthera sessilis
4. Leucas biflora
5. Tridax procumbens
6. Stachytarpheta indica
7. Sida cordat
8. Sida acuta
9. Sida cordifolia
10. Orthosiphon thymiflorus
11. Ipomoea staphylina
12. Blumea rhomboidea
13. Eranthemium spp
14. Leea indica
15. Calycopteris floribunda
16. Asclepias currassavica

B.FRUIT SAP

1. Zizyphus oenoplia

C.ANIMAL EXCRETA

Grass Jewel
Angled Castor
Common Nawab

D.MUDPUDDLING

Five-bar Swordtail
Malabar Raven
Red Helen
Malabar Banded Swallowtail
Tailed Jay
Common Bluebottle
Common Crow
Blue Tiger
Common Puffin
Common Albatross
Emigrant spp

Chocolate Albatross
Leaf Blue
Common Imperial
Common Nawab
Banded Blue Pierrot
Angled Pierrot
Malayan
Common Caerulean