ECOLOGY AND DIVERSITY OF ENTOMOFAUNA IN THE LITTER STANDS OF MONOCULTURE AND NATURAL FORESTS IN KANNUR DISTRICT

Thesis submitted to the

UNIVERSITY OF CALICUT

In partial fulfillment of the requirements for the award of the degree of

DOCTOR OF PHILOSOPHY IN ZOOLOGY

By

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Under the guidance of

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Certificate

Certified that the thesis entitled **'Ecology and diversity of Entomofauna in the litter stands of monoculture and natural forests in Kannur district'** submitted by Mr.Vineesh P.J. to the University of Calicut for the award of the degree of Doctor of Philosophy in Zoology is a bonafide record of research work done by him in this department under my guidance and supervision. This has not previously been formed the basis for award of any degree or diploma.

Mr.Vineesh P.J. has successfully completed the preliminary qualifying examination prescribed by the University of Calicut.

Sabu K.Thomas

Declaration

I do hereby declare that the thesis entitled **'Ecology and diversity of Entomofauna in the litter stands of monoculture and natural forests in Kannur district'** submitted to the University of Calicut for the award of the degree of Doctor of Philosophy in Zoology has not been submitted for the award of any other degree or diploma and represents the original work done by me

Devagiri
Date : 27-07-2007

Vineesh P.J

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VINEESH P.J

Dedicated to
my Teachers....

Contents

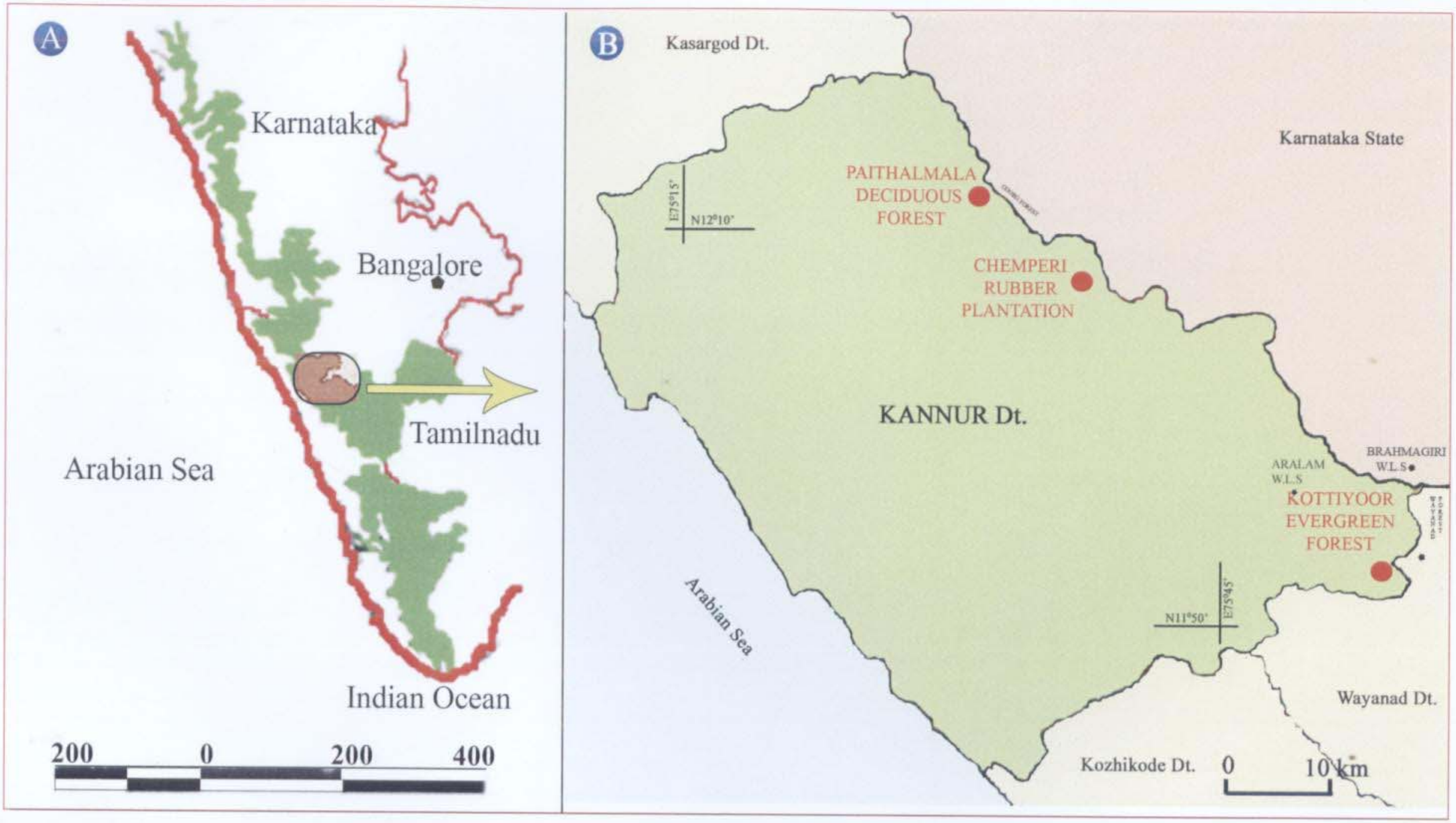
GENERAL INTRODUCTION

Vineesh P.J “Ecology and diversity of Entomofauna in the litter stands of monoculture and natural forests in Kannur district” Thesis. Department of Zoology, St. Jopseph'S College Devagiri University of Calicut, 2007

1

GENERAL INTRODUCTION

Plate-1



Map showing (A) Western Ghats and (B) Study sites

Importance of litter arthropod faunal assessment

Belowground invertebrates are the dominant animal group in many terrestrial ecosystems and may have higher biomass on area basis than the above ground herbivorous insects or vertebrates (Odum 1971). They are recognized to play a vital role in the decomposition of plant material (Petersen and Luxton 1982; Paoletti and Hassall 1999; Lee and Pankhurst 1992; Irmler 2000), with particularly strong effects at fine spatial and temporal scales (Lavelle *et al.* 1993) by the processes of fragmentation and comminution. Total ecosystem productivity increases with an increase in belowground biodiversity and the interactions among soil fauna maintain nutrient cycling (Moore *et al.* 1999). Small changes in belowground arthropod communities may have major effects on local nutrient dynamics (Heneghan and Bolger 1998). Complex and diverse food web of below ground arthropods (Pfeiffer 1996; Barberena-Arias and Aide 2002, 2003) play an important role in forest dynamics and their recovery is a crucial part of forest restoration (Heneghan and Bolger 1998). Litter arthropod diversity is proportional to increasing the variety of food resources (litter quality and composition), the range of environmental conditions (rainfall, temperature and humidity) or the structural complexity of the habitat (Anderson 1994; Hooper *et al.* 2000).

Forest litter organisms are greatly diverse both taxonomically and ecologically and they occupy a wide range of microhabitats, consume many kinds of food resources and are active in different seasons and different times of day (Toda and Kitching 1999). A lesser interest in belowground invertebrate communities is obviously due to the fact that litter fauna are locally very numerous, with a wide range of mobility, requiring enormous sampling efforts and are often difficult to identify. Understanding geographical variation in community structure is of growing importance in concern with biodiversity management efforts, conservation of individual species to include efforts to preserve distinct communities (Ehrlich 1996). Many of the studies are from temperate or tropical zones leaving a lacuna in observations from the resource rich subtropical forest habitats (McNeely 1995; Prance 1995).

Role of physical factors and seasonality of litter arthropod fauna

Variations in the litter habitat structure, litter fall, litter thickness, litter moisture and decomposition rates, along with climatic factors, *viz.* rainfall, temperature lead to seasonal variations in the abundance and community structure of litter arthropod fauna (Holt 1985; Levings and Windsor 1982, 1984, 1985; Hassall *et al.,* 1986; Wolda, 1988; Frith and Frith, 1990; Burgess *et al.* 1999; Wakelin 2000; Barberena-Arias and Aide 2003). Population densities of leaf-litter arthropods increase at the beginning of rainy season (Levings and Windsor 1982, 1984, 1985; Tanaka and Tanaka 1982; Ananthakrishnan 1996), particularly if the dry season was intense (Levings and Windsor 1982, 1985; Dangerfield 1997). Seasonal fluctuations in rainfall modify the other physical factors including temperature and humidity of litter habitat directly (Holdridge 1967; Janzen 1983).

Peak in leaf fall during dry season and in the beginning of wet season result in litter layers of different decomposition stages and it lead to structural complexity of the litter and fluctuations in food and water availability to litter insects resulting in different patterns of litter insects in successive litter layers in evergreen and deciduous forests. Seasonal differences in abundance and diversity of litter fauna could be related to the differential leaf shedding nature of litter contributing plants and to the direct influences of rain on weathering activities in litter habitats (Zak *et al.* 1999).

Litter mass is correlated with insect species richness because litter accumulation provides increased resources and structural complexity (Ananthakrishnan 1996; Barberena-Arias and Aide 2003). A deeper leaf-litter layer could provide more refuges and maintain moisture during the dry season (Frith and Frith 1990). While it is clear that seasonal fluctuations in rainfall modify the physical environment (Holdridge 1967) and change resource availability (Fodgen 1972), data on seasonal patterns on insect abundance are generally scarce (Wolda 1988). Western Ghats is well known for spatial and temporal variations in environmental factors such as rainfall, temperature, humidity as well the vegetation type and leaf contributing vegetation (Nair 1991). Except for a few recent studies (Basu 1997; Anu and Sabu 2006), information on seasonality of litter insects is lacking from the Western Ghats region, one of the two internationally recognized biodiversity hotspots of Indian region.

Inter faunal interactions of litter arthropods

An extraordinarily diverse community of below ground arthropods connected by highly complex interactions exists in forests (Hättenschwiler *et al.* 2005). Ecosystem consequences of the diversity of litter organisms are little understood, except for some keystone species or ecosystem engineers such as earthworms, termites and ants (Jones *et al.* 1994; Anderson 1995). Litter arthropods are broadly classified into four feeding guilds *viz.* microbial-detritivores, detritivores, fungivores and predators (Seasted 1984; Moore *et al.* 1988). An overview of the interactions between some major fauna is added. Predaceous mites commonly feed on springtails (Berg *et al.* 1998, Ferguson 2001) and both springtails and mites are common prey of macro-arthropods, including spiders, beetles and centipedes (Eisenbeis and Wichard 1987; Ferguson 2001). Mesostigmatid mites (Acari) are known to be predators of both Collembola and oribatids (Eisenbies and Wichard, 1987), Pseudoscorpions (Arachnida, psuedoscorpions) also prey on the microarthropods in general. Their diet consists of Collembola, mites and nematodes (Eisenbies and Wichard 1987). Dermaptera (earwigs) are also predators of both of these microarthropods (Günther and Herter 1974). As generalist predators, spiders (Arachinida, Araneae) also feed on microarthropod populations (Wise 1993). Rowing wolf spider (Lycosidae) are predators of the soil community and Collembola are one of the main prey groups (Nentwig 1987). Centipeds (Myriapoda, Chilopoda) prey mostly on small insects. It likely that these include mites and collembolans (Eisenbies and Wichard 1987). Many beetles (Insecta, Coleoptera) have specific adaptations for capturing microfauna. Some carabids have evolved a successful visual hunting strategy for fast moving prey like Collembola (Bauer 1981, 1982, 1985). Larvae of Scydmaenidae (ant beetles) resemble woodlice and are oribatid specialists. According to Edward O.Wilson, Ants (Isecta, Hymenoptera) “eat oribatids like popcorn” (in Coleman and Crossely 1996). In most habitat worker ants are the chief predators of insects and spiders (Hölldobler and Wilson 1990).

Litter faunal studies in different vegetation types of Western Ghats

Form and structure of terrestrial communities are determined by the nature of the vegetation (Smith 1980). The population of litter inhabiting fauna is likely to vary depending on plant species, age, environment and climatic conditions. Moist evergreen, deciduous and monoculture forest and rubber plantations are the major vegetation types in the windward western slopes of southern reach of Western Ghats. Though the floral and vertebrate faunal diversity found in the region are well documented, little is known of the litter insect distributional pattern in the different vegetation types of the region and a strong need exists for the documentation of litter insects of different forest vegetation types of Western Ghats, recognised as a global hotspot of biodiversity.

Litter fall in wet evergreen forests remains consistent as fresh litter is available throughout the year for the invertebrate fauna in comparison to deciduous and plantation forests with a more seasonal trend in litterfall and faunal abundance (Ananthakrishnan 1996). Evergreen forests dominated by dipterocarps constitute the most threatened habitat and its continuum along the Western Ghats has been fragmented (Nair 1991; Pascal 1991). Most of the ecologically sensitive lowland evergreen forests along the foothills of the Western Ghats and on the hillocks in the mid lands were cleared in the early phases of deforestation (Nair 1991). Deciduous forests are characterized by the broad-leaved trees, usually shed their all leaves at a particular period of the year (Santiago and Mulkey 2005; Sundarapandian *et al.* 2005). Seasonality in litter shedding leads to seasonal variations in the litter habitat structure and litter thickness in deciduous forests.

Many attempts have been made to identify Arthropods dynamics in monoculture plantations in Western Ghats *viz. Shorea robusta*, *Eucalyptus* and *Tectona* (Ananthakrishnan 1988, Ananthakrishnan and Sabu 1993; Annadurai *et al.* 1988; Hazra 1991; Reddy and Venkataiah 1990; Sabu *et al.* 1993). But to date, very limited litter arthropod diversity inventories were conducted in the rubber plantations in the region (Bickel and Watanasit 2005; Jobi 2006). The population density of various groups of soil organisms were found to be higher under rubber plantation, which indicated an increased microbial activity and have a beneficial effect on availability of nutrients (Chaudhuri and Bhattacharjee. 2002).

Documentation of insect fauna of the state was initiated with the establishment of the British rule. The results of these surveys were made in areas, which were easily accessible or in areas close to human settlements, many locations, particularly in formidable areas, have been either poorly covered or not covered at all. Also, the intensity of the sampling was low as indicated by data generated by subsequent workers especially of Zoological Survey of India (ZSI), various universities and research institutions (Mathew 2004). A scientifically sound strategy for the conservation of the entire biological diversity of the country requires detailed and accurate ground information on the distribution of all plants and animals. Such exhaustive information on the distribution of all plants and animals is not available for our country. For preparing blueprint for conservation of biota, one of the essential steps is to catalogue all identifiable ecosystems occurring within the particular region. Taxonomic surveys are inadequate in this part of the country for all groups of plants and animals, excepting perhaps birds. Large tracts of the Western Ghats in particular the inaccessible forested areas, remain unsurveyed by Botanists and Zoologists. In the case of much of the taxonomic work, collections were made during the last century or during the early years of this century. Since then the habitat has been so drastically modified that the original type localities may not have the species at all. The status of a significant portion of the biota is unknown. Updating distributional field data, which need to be constantly carried out, particularly rapid destruction and modification of habitat, is grossly inadequate (Nair 1991).

In using species distribution data for preservation efforts, it is also necessary to have scientific data on the minimum population necessary for the species to survive genetically. Except bird and fresh water fish, other groups remain practically untouched. It is possible that many 'hot spots' for species diversity are left out. That this is particularly true with regard to the southern Western Ghats (Nair 1991).

Although the entire southern Western Ghats falls within humid climatic zone, there is considerable variation in the total annual rainfall and more importantly, in its spread. While the southernmost part of the Western Ghats –Agasthyamalai receives in its southern extremity less than 1800mm of rain, the Brahmagiri Ghats in the Kannur district of Kerala receives well over 5000mm. But while Agasthyamalai Range has only two rainless months, Brahmagiri has five to six rainless months. Regional variation in rainfall is related to variation in topography and this has resulted in variation in vegetation (Nair 1991). No records are available on litter entomofauna from Brahmagiri slope of southern Western Ghats in Kannur district, especially regarding to their diversity variation related to vegetation, seasonality in terms of diversity and influence of physical factors on litter fauna of the region (Nair 1991), which prompted me to conduct the present study.

The thesis is presented in five chapters.

The first chapter **"The general introduction"** provides a broad review about the ecological importance of litter arthropod fauna in forests and monoculture plantations, seasonality and inter faunal interactions of litter arthropods, relationship of litter fauna with physical factors and forest vegetation types.

Second chapter, titled "**Composition and seasonality of litter arthropods an evergreen forest in the south Western Ghats"** aims to analysis the composition, seasonality and the influence of controlling physical factors on entomofauna in an evergreen forest in the Brahmagiri slope of the Western Ghats.

Third chapter, titled **"Composition and seasonality of litter arthropods in a moist deciduous forest in south Western Ghats"** aims to conglomerate information on the composition, seasonality, moulding physical parameters and the inter taxa interactions among faunal groups belonging to different feeding guilds in a deciduous forest in the Brahmagiri slopes of Western Ghats.

Fourth Chapter, titled **"composition and seasonality of litter arthropods in a rubber plantation of south Western Ghats"** assess the composition, seasonality and the influence of controlling physical factors on entomofauna in a rubber plantations, in the slopes of Brahmagiri region in Kannur district is provided.

In chapter five **"Conclusions"** an overall comparison of the seasonality, abundance, diversity, feeding guild composition and the influence of physical factors on litter arthropods in forests and monoculture rubber plantation in Kannur district.

COMPOSITION AND SEASONALITY OF LITTER ARTHROPODS IN AN EVERGREEN FOREST IN THE SOUTH WESTERN GHATS

Vineesh P.J "Ecology and diversity of Entomofauna in the litter stands of monoculture and natural forests in Kannur district " Thesis. Department of Zoology, St. Jopseph'S College Devagiri University of Calicut, 2007

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COMPOSITION AND SEASONALITY OF LITTER ARTHROPODS IN AN EVERGREEN FOREST IN THE SOUTH WESTERN GHATS

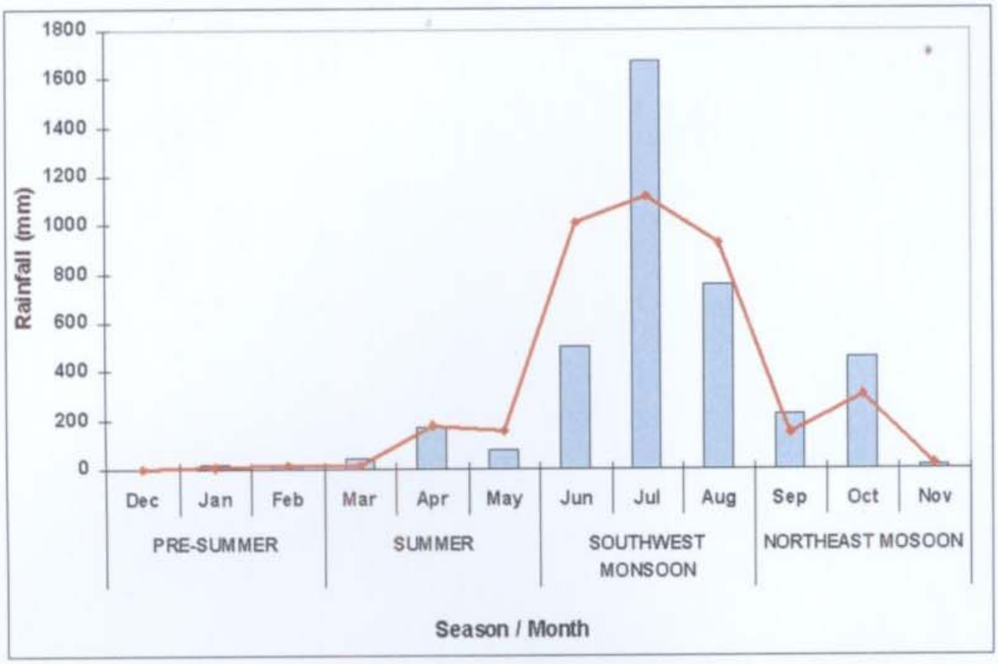

Figure 2.1a. Rainfall received during different seasons and months in the evergreen forest study region. Vertical bars represent monthly rainfall during Dec. 2002 to Nov. 2003. Line represents the monthly means during 2000 to 2003

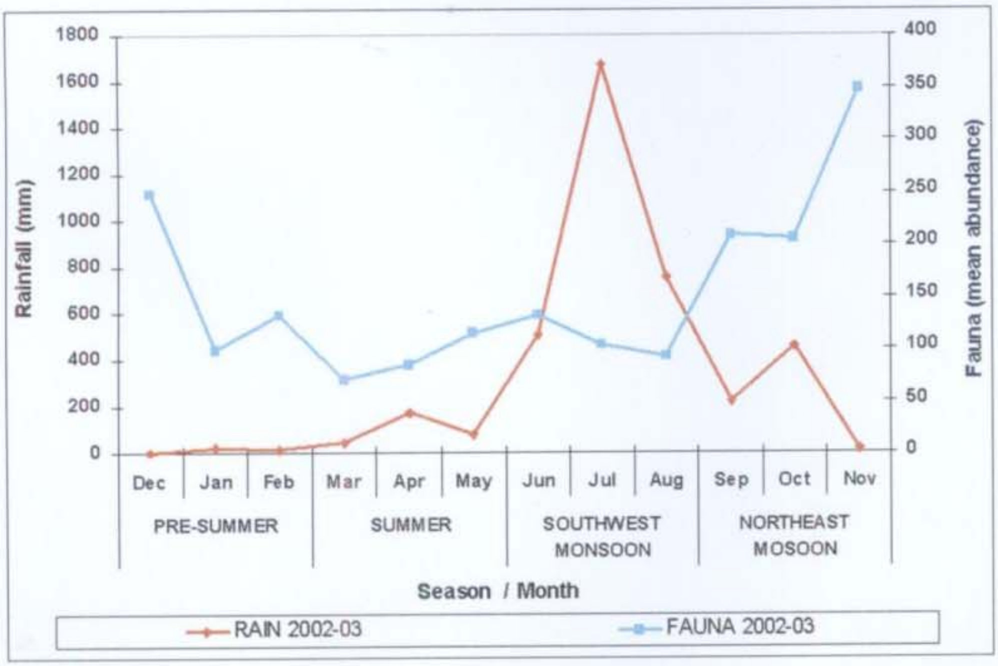

Figure 2.1b. Pattern of rainfall and faunal abundance in the evergreen study habitat during Dec 2002 to Nov 2003.

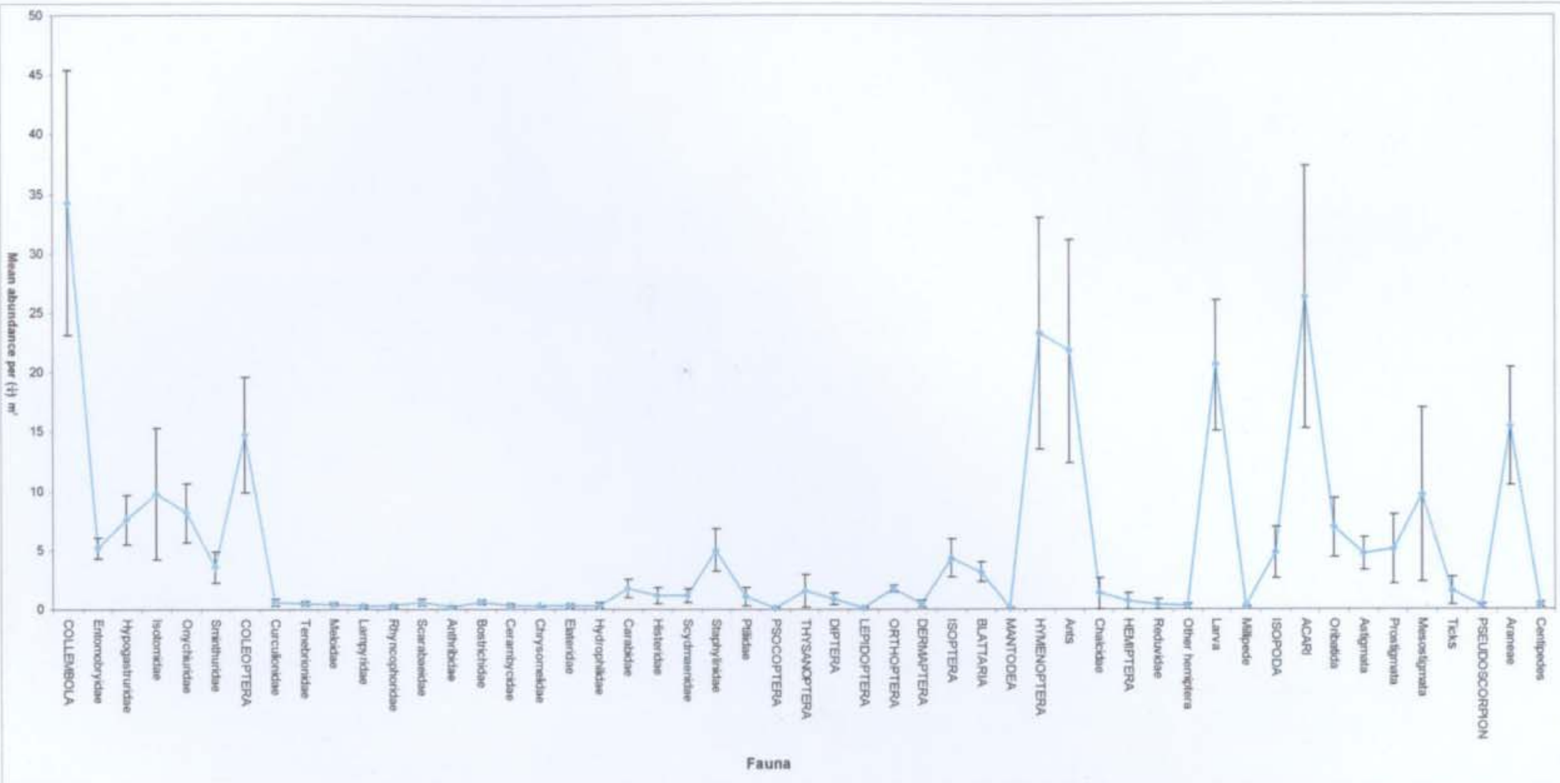

Figure 2.2. Abundance of litter arthropod fauna in the evergreen forest at Kottiyoor during the study period of Dec 2002 to Nov 2003.

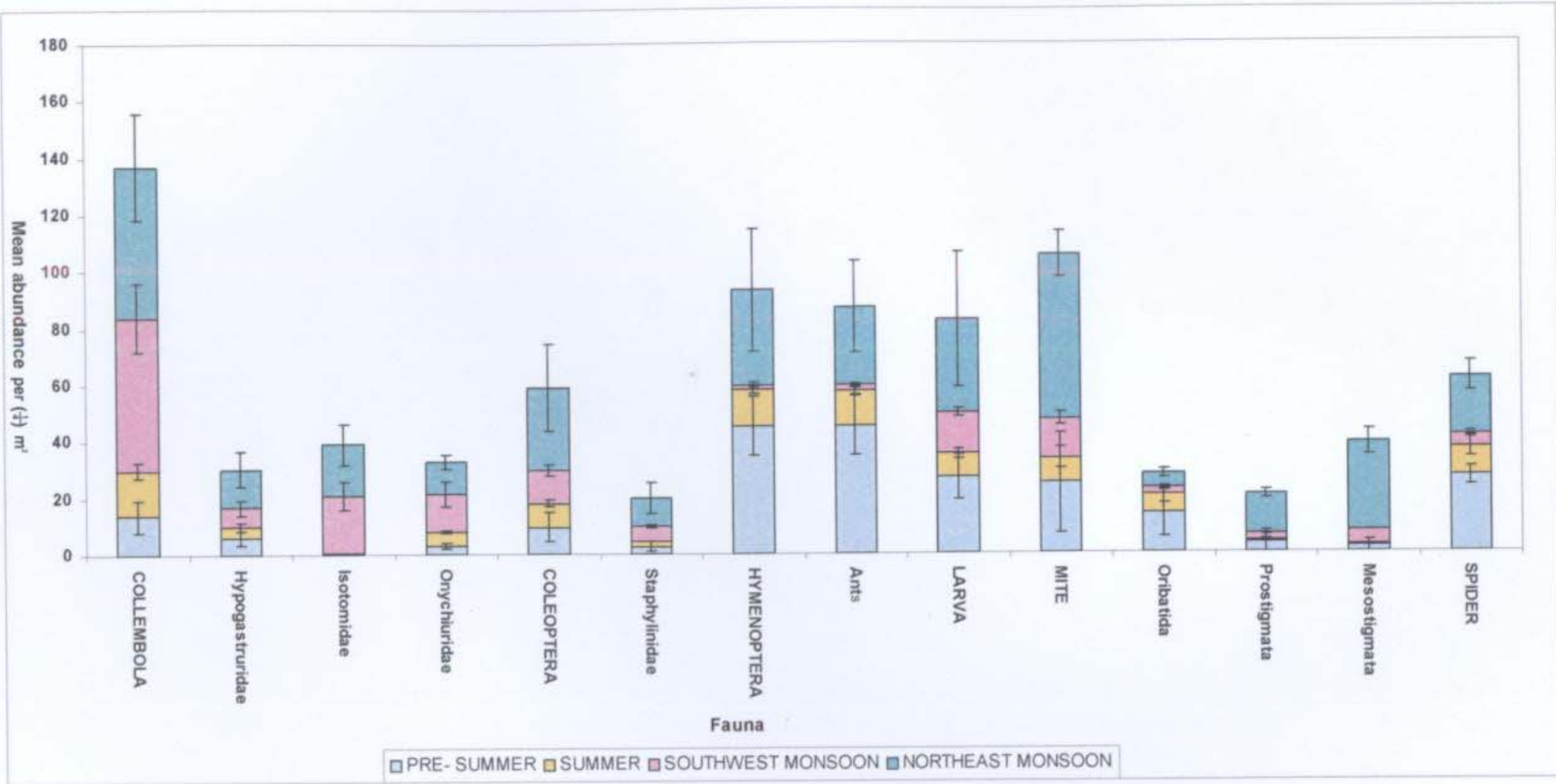

Figure 2.3. Seasonal distribution of major litter arthropod fauna in the evergreen forest at Kottiyoor during the study period of Dec 2002 to Nov 2003.

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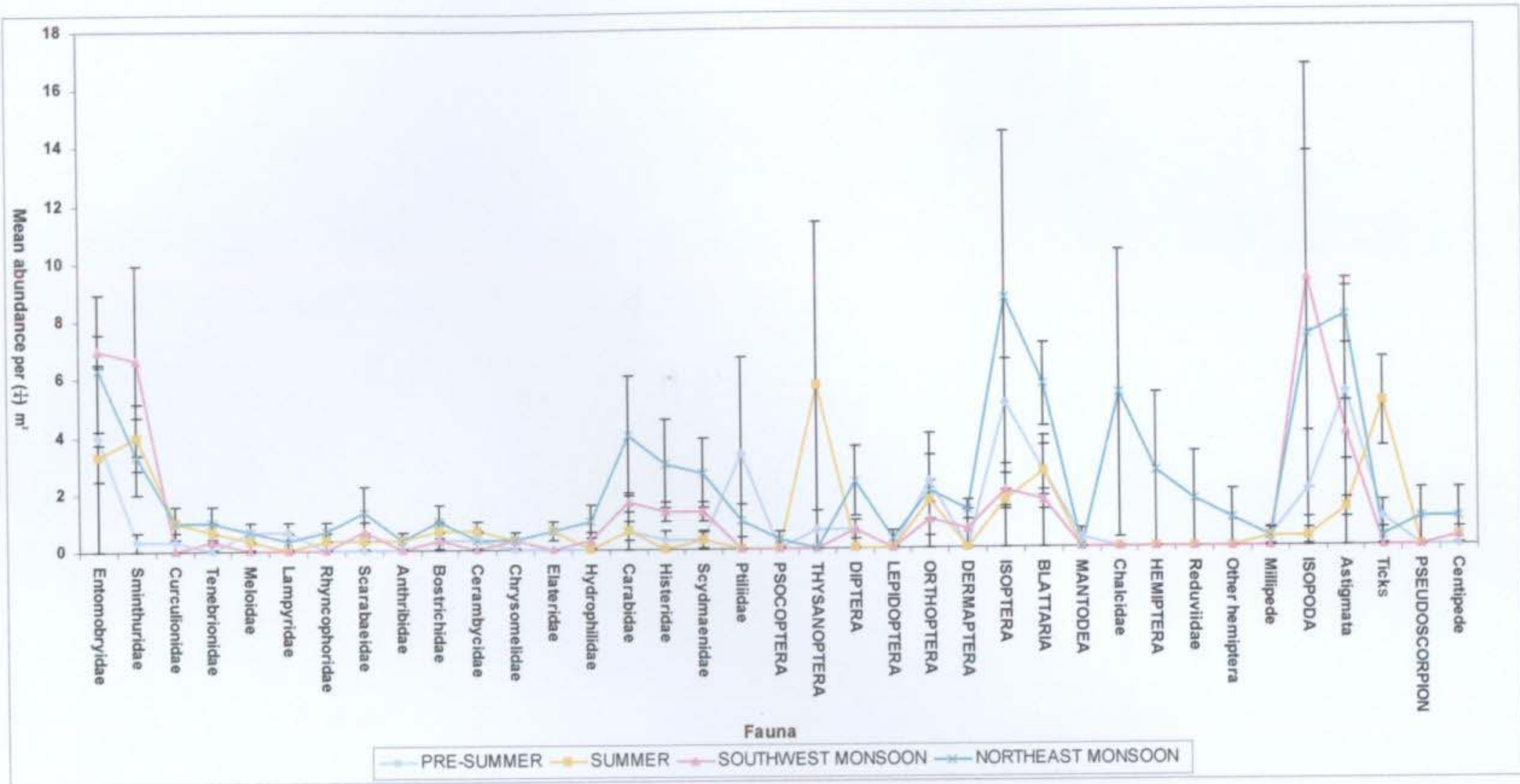

Figure 2. 4. Seasonal distribution of minor litter arthropod fauna in the evergreen forest at Kottiyoor during study period of Dec 2002 to Nov 2003.

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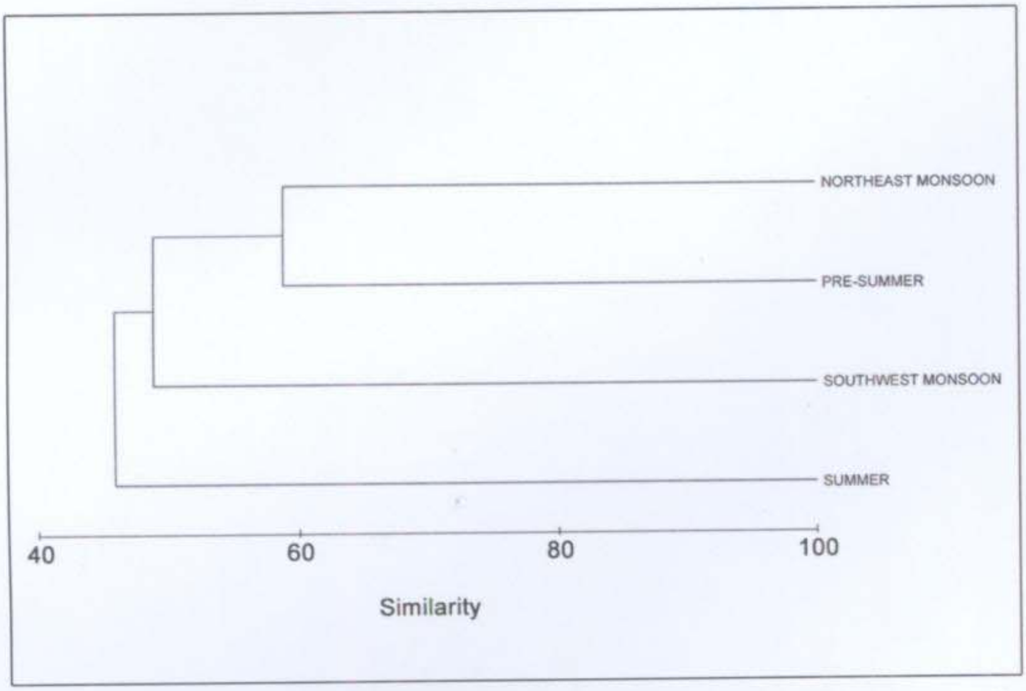

Figure2.5. Dendrogram of litter arthropod faunal assemblage during different seasons of Dec. 2002 to Nov. 2003, study period, based on hierarchical agglomerative clustering (group - linking)

COMPOSITION AND SEASONALITY OF LITTER ARTHROPODS IN AN MOIST DECIDUOUS FOREST IN THE SOUTH WESTERN GHATS

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COMPOSITION AND SEASONALITY OF LITTER ARTHROPODS IN A MOIST DECIDUOUS FOREST IN THE SOUTH WESTERN GHATS

Plate-2

Deciduous forest habitat
Leaf shedding season (A&B); Leaf dense canopy during pre-summer season(C)

INTRODUCTION

Tropical rain forests are stable systems according to many north temperate biologists and the degree of seasonality in tropical rainforests is lesser than that in temperate forests (MacArthur 1969; Whittaker 1969). However, subsequent studies on the tropical regions show a specific seasonality in leaf litterfall (Swamy and Proctor 1994; Clark *et al.* 2003; Wood *et al.* 2005), rise in litter fall which can be linked to the strong winds during high precipitation and the consequent rise in nutrient rich green litter fall (Cueva and Lugo 1998), premature senescence of leaves due to water stress during non-rainy periods (Wieder and Wright 1995), presence of a strong seasonality of litter invertebrate faunal abundance with its peak during low rain transitional period between the wet and dry seasons (Anu 2006; Anu and Sabu 2006), moderate wet season (Ogino *et al.* 1965; Frith and Frith 1990), wet season (Wolda 1980; Novotny and Basset 1998; Burgess *et al.* 1999) and at the beginning of the dry season (Levings and Windsor 1985). These findings establish that strong seasonality exists in tropical wet evergreen rain forests and they are not static communities that function under consistently optimal moist and warm climatic conditions.

Among the many environmental factors that have been identified as the limiting elements of litter insect seasonality (Frith and Frith 1985, 1990; Kato *et al.* 1995; Waklin 2000), rainfall is the most influential factor (Frith and Frith 1990). Even moderate fluctuations in rainfall can impose a distinct seasonality (Janzen and Pond 1975; Janzen 1983) and change the resource availability of both plants and animals (Davis 1945; Fodgen 1972). Rainfall has a controlling effect (Holdridge 1967; Janzen 1983) on other limiting climatic / environmental factors such as moisture, (Swift *et al.* 1979; Lensing *et al.* 2005) temperature, (Hopkin 1997) and humidity (Frith and Frith 1990). Ample moisture is required for decomposer organisms to operate efficiently, though, excessive moisture or anaerobic conditions resulting from prolonged inundation may hinder the activity of soil flora and fauna (Tate 1980; Paul and Clark 1989; Groffman *et al.* 1996). A deeper leaf-litter layer could provide more refuges and maintain moisture during the dry season (Frith and Frith 1990).

Litter arthropods are classified broadly under three trophic groups *viz.* predators, detritivores and fungivores and recently collembolans were categorised as microbial detritivores (Swift *et al.* 1979; Seastedt 1984; Wise 2004; Lensing *et al.* 2005). Categorization of litter fauna into well-defined trophic groups or feeding guilds and the identification of inter group faunal abundance interactions (Olson 1994; Johnston 2000; Barberena-Arias and Aide 2003) is difficult, mainly because of the limited amount of experimental evidence of the dietary requirements of most litter fauna (Hunt *et al.* 1987; Lee and Pankhurst 1992; Anu 2006).

The recent "Global 200" classification by the WWF ranks the Western Ghats as the twentieth among the 200 ecologically sensitive regions (WWF 2001). Though the litter arthropod biodiversity documentation and seasonal fluctuations of litter arthropod dynamics are obviously recognized as vital for biodiversity conservation, seasonality studies of litter arthropods, their feeding guild and controlling factors are found to be very scarce from the Western Ghats except for the analysis of litter fauna in an upland evergreen forest in Wayanad region (Anu 2006; Anu and Sabu 2006). The current study provides first time data on the following aspects of litter arthropods -1. Seasonal variation in abundance, diversity, and feeding guild composition; 2. Influence of climatic and habitat physical factors on litter arthropod abundance and diversity and 3. Reciprocal relationships among the faunal abundance from a lowland evergreen forests in the Western Ghats.

MATERIALS AND METHODS

Site and Climate: The study site is at Kottiyoor in the western slopes of Brahmagiri Ghats in Kannur district, a tract in the northern region of South Western Ghats and geographically situated at 75° 35' East 12° 5' North. The entire southern Western Ghats falls within humid tropical climatic zone, the climate is controlled by both southwest monsoon and northeast monsoon. There is considerable variation in the total annual rainfall and more importantly in its spread. Since, the monsoon always arrives and retreats from the south of the peninsula, the dry season always lasts longer in the north than in the south and there is a marked increase in total annual rainfall from south to north, along the western slopes of Western Ghats. The southern tip of South Western Ghats, experience comparatively higher rate of south west and north east monsoon while the northern region receive very little rains during north east monsoon. The vegetation has responded by being tropical wet evergreen in the south with a gradual trend tending to drier conditions in the north (WWF 2001). While Agasthyamalai in the southern part of the Western Ghats receives in its southern extremity less than 1800mm of rain, the Brahmagiri Ghats in northern part of South Western Ghats (Kannur district of Kerala) receives well over 5000mm. But Agasthyamalai range has only two rainless months whereas Brahmagiri has five to six rainless months. However, the intensity of rain, during the southwest monsoon, is higher in the north than that in the southern part.

There are local regions in the north has higher rainfall is experienced related to the variation in the topography. Variations in topography have led to differences in the rainfall pattern and vegetation (Nair 1991).

Similarly, from the coast across the Ghats to the eastern foothills there is a distinct gradient in rainfall (Patwardhan and Asnani 2000). Rainfall increases from west to the east and reaches the highest values along the outermost western slopes of the main range, and then gradually recedes eastward to reach the lowest value at the eastern foot hill zone. But in the southernmost parts of the Ghats, the equal influence of the north-east and south-west monsoons modifies this pattern (Nair 1991).

There are seven loci of extreme heavy rainfall on the western slopes of the southern Western Ghats in Kerala, with an average annual rainfall of about 4500mm. They are: (1) Aralam- Kottiyoor areas of the Brahmagiri slopes in Kannur district; (2) Kuttiyadi-Vythiri section of the south-western slopes of Wayanad; (3) western outer slopes of Silent Valley facing Nilambur plains; (4) Sholayar-Karappara valleys in south-west Nelliampathy; (5) a tract along the north-western edge of Idduky district extending from Pooyankutty to Neriyamangalam and Kaliyar in south; (6) lower Pamba Valley-Erumeli area; (7) Chenduruny Valley – The upper reaches of Kulathupuzha (Nair 1991) .

With an area of 35 km^2, Kottiyoor is sandwiched between the Aaralam and Brahmagiri Wildlife Sanctuaries (Plate 1) and Wayanad forest region. It is located at a distance of 46 km from Thalasseri seashore and is on the Iritti –Mananthawadi road via Kottiyoor – Palchuram (new passage). The terrain is northwest sloping and comprises an undulating hilly area with an altitude 450 m a msl – the peak is at Ambalapara (Forest and Wildlife 2001). The average slope of the terrain is above 25°. The original vegetation along the entire region was tropical evergreen (Nair 1991). Most of the moist forests in the regions have been cleared or converted into Cashew, Coconut, Arecanut and Teak plantations and have created a semi-deciduous vegetation where there used to be evergreen forests. Very few blocks of intact forest habitat now exist in the region, although several smaller forest fragments have been preserved by local people as sacred groves.

A total annual precipitation of 3964 mm, of which 73.98% was received during Jun-Aug (southwest monsoon), 17.52% during Sep-Nov (northeast monsoon), and 7.51% during Mar-May (summer) and the remaining 0.98% during Dec-Feb (pre-summer) (Fig.2.1a and b), of the study period 2002-2003. Comparatively high rainfall is recorded in this region than any other region in the Kannur forest division (Forest and Wildlife 2001). Branch breaking, green leaf falling and uprooting of trees due to strong winds are prevalent during the monsoon seasons. 4-9cm thick litter layer covers almost all the forest floor. The vegetation consists of three layers in addition to subordinate shrub and herb layers, with the abundance of epiphytes in the interior regions. The upper canopy of the forest is 18–25 m high and contains a number of tree species including *Artocarpus hirsutus, Bombax ceiba, Hopea parviflora, Palaquium ellipticum, Persea macarantha,* and *Vateria indica.* A second storey of small trees includes *Macaranga peltata, Elaeocarpus serratus, Nephelium longana, Knema attenuata, and Sterculia guttata.* A lower layer includes *Cinnamomum malabartrum, Aporosa lindleyana* and *Olea dioica.* Small shrubs in the study habitat include *Calamus* sp. and *Strobilanthus* sp. and herbs like *Elephantopus scaber* and *Molineria trichocarpa.* The common climbers found are *Acacia intsia, Entada scandens and Calycopteris floribunda.* Ferns and lichens with a lot of moss cover are found on tree boles and branches, exposed rocks and dead wood and along the boundary. A large number of deciduous trees belonging to species like *Terminalia tomentosa, Dalbergia latifolia, Grevia tiliaefolia, Terminalia bellirica, and Pterocarpus marsupium* are also found (Forest and Wildlife 2001; Personal observation).

Sampling: Random quadrates sampling method is followed in this study (Boinski and Fowler 1989). A fine grid was superimposed on the map, and the coordinates for ten quadrats each measuring 5 × 5 m were selected randomly at the evergreen part of the forest. The quadrats were initially positioned in the field, following distance and compass direction from pre-existing permanent markers like rivers and streams, and then the quadrats, were permanently marked, using plastic wires and iron rods. Litter arthropods were collected from the ten permanently marked quadrats in the field. Each sampling point within the quadrats was located and selected at random for monthly collection. All actual sampling was done on a day in the closing week of each month from December 2002 to November 2003. The time of sampling was between 8-10 am. During rainy season sampling was done three days after the rain, to minimise the direct effect of rain on various fauna (Burgess *et al.* 1999). During June and July, we could not strictly adhere to this pattern of collections following three consecutive rainless days and sampling was done on any non-rainy day in the last week of the month.

Each sample was collected by placing a 50 × 50 cm (¼ m^2) wooden quadrant frame onto the litter and then scraping out all leaves, twigs, fruits, and loose humus from within the frame area, with a thin wooden scraper, into a large polythene bag. Samples were collected as quickly as possible to avoid arthropods escaping by flying, running, or digging away. No arthropods were observed escaping and I believe that minor cases of escape, if any, are insignificant. The litter thus collected for analysis consists of the upper organic litter and the loose humus layer. No underlying compacted soil was taken. One hundred and twenty (120) samples were collected for data analysis during one year at the rate of ten samples a month. An average of 3 months' data was conceived as the seasonal data (30 samples, for each season). Fauna was extracted with Berlese funnel apparatus (30.5cm diameter 35.6cm height, 25w bulb). The extracted fauna were sorted under a stereo zoom trinocular microscope (Labmode-ZM45 TM) and the adult organisms were identified to order level using keys of Borror *et al.* (1996). After this preliminary identification, the arthropods were placed in small-labelled vials (Tarson, model no: 510000) containing 70% ethyl alcohol. The adults were assigned to morphospecies and sent to taxonomic authority for identification. The collected fauna, which enjoy representation in all seasons and have more than 10, mean No./50 × 50 cm at any season were categorised as major fauna and the other taxa as minor fauna.

The forest vegetation type is based on the working plan of the forest department, (Forest and Wildlife 2001) Kannur forest division. The rainfall data was collected from the meteorological station of the Electricity Board at Kottiyoor. Humidity and litter temperature were assessed with thermo-hygrometer (Barigo; Barigo Barometer fabric GmbH; Villingen-Schwenningen; Germany), and litter depth was measured using Boinski and Fowler method (Boinski and Fowler 1989) (measured in each corner of the quadrant, 5cm inside the permanent wire marker). Four values of litter depths from each corner were then averaged for each sample. The slope of the terrain was calculated using the Trigonometric formula 'tan θ' (where 'θ' is the angle of inclination) (Jacobs and Meyer 1972). Litter humidity, temperature, slope of the terrain and litter depth were calculated as the mean of the 10 sampling spots each month (Table 2.1.).

Data Analysis: Since data was normally distributed, no data transformation was carried out for any statistical data analysis. Community diversity was assessed in terms of parametric Fisher's alpha diversity index (α) and the nonparametric indices *viz.*, Shannon-Wiener (H'), Simpson's dominance (D), Pielou's evenness (J'), Margalef's richness (d), Fisher's alpha (α diversity index). Community similarity was assessed with Bray Curtis similarity index followed by Cluster Analysis.

1) Fisher's alpha diversity (α)

Fisher's alpha diversity (Parametric diversity index) is widely used in literature because we can calculate the index knowing only the species richness (S) and the total number of individuals (N). Fisher's alpha (α) diversity index involves a comparison of variations in the number of individuals (N) and is theoretically independent of sample size (Fisher *et al.* 1943).

$$a = N\,(1-x)/x$$

Estimate x from the iterative solution of:

$$S/N = (1-x)/x\,(-\mathrm{In}\,(1-x))$$

Where, S = number of species

N = total number of individuals.

2) Shannon diversity index (H')

One of the most enduring of all diversity measures is the Shannon index. This is the most traditionally used index. It is an index taking both richness and evenness into account i.e. high overall diversity occurs when the number of species (richness) and the evenness component are large (low dominance) (Magurran 2003).

The value of the Shannon index obtained from empirical data usually falls between 1.5 and 3.5 and rarely surpasses 4 (Margalef 1972). In general, mature and stable communities will have high diversity values and communities under severe stress would exhibit low diversity usually nearer to zero (Magurran 2003). It was calculated with the following equation (Shannon and Weaver 1949).

$$H' = -\sum_i P_i (\log (P_i))$$

Where, P_i is the proportion of the total count arising from the i^{th} species

$$P = S/N$$

Where, S = total individual number of a species

N = total individual numbers of all species.

Logarithms to the base of e (Natural logarithm) was used.

3) Simpson's Dominance index

Simpson's index (λ) is a measure of dominance whose maximum value is one. Simpson's index gave the probability of any two individuals drawn at random from an infinitely large community belonging to the same species. As 'λ' increases, diversity decreases, which are clearly seen in the case of a single species (complete dominance). Near zero values are obtained, when numerous species are present (no dominance). Each species representing a small fraction of the total value (Magurran 2003).

It was calculated with the following equation (Simpson 1949)

$$\lambda = \Sigma p_i^2$$

Where, p_i is the proportion of the total count arising from the ith species

4) Pielou's Evenness

Evenness refers to the area equitability of the taxa. It is expressed as Pielou's evenness index (J') (Magurran and Henderson 2003) in this study Pielou's equations (Pielou 1975) was used.

$$J' = H' / \log S$$

Where, H' is Shannon diversity index

S is the total number of taxa.

5) Margalef's richness index

It expresses the number of taxa / groups existing in the region studied. For analyzing taxa richness, Margalef's index (Clifford and Stephenson 1975; Magurran 2004) is used. It is calculated by the following formula.

$$d = S - 1 / \log (N)$$

Where, d is Margalef's index,

S is the total number of taxa

N is the total number of individuals

6) Cluster Analysis.

Cluster Analysis: Bray-Curtis similarity index (Bray and Curtis 1957) was used to compare the similarity between the assemblages arriving at different seasons followed by Cluster analysis (Clarke and Warwick 2001)

The seasons were grouped and the groups themselves were formed into clusters on levels of similarity. Clarke and Warwik (2001) tested goodness of all similarity indices using six criterions (Magurran 2003) and found that Bray-Curtis index is a comparatively better index than all other widely used index as it meets all the following requirements of a good index. 1. The value will be 1 (or 100) when two samples are identical; 2. The value will be zero when samples have no species in common; 3. A change of measurement unit does not affect the value of the index; 4. The value is unchanged by the inclusion or exclusion of a species that occurs in neither sample; 5. The inclusion of a third sample makes no difference to the similarity of the initial pair of the samples; 6. The index reflects difference in total abundance (and not just relative abundance). It is calculated by the following formula.

$$BC_{jk} = 100\left\{1 - \frac{\sum_{i=1}^{p}\left|y_{ij} - y_{ik}\right|}{\sum_{i=1}^{p}\left(y_{ij} + y_{ik}\right)}\right\}$$

Where, BC_{jk} is the similarity between the j^{th} and k^{th} season, and Y_{ij} represents the abundance for the i^{th} species in the j^{th} season. Y_{ik} represents the abundance for the i^{th} species in the k^{th} season.

All diversity analysis was done with Primer statistics package (Clarke and Gorley 2001)

Statistical analysis: The extent of causality of abiotic factors (climatic and habitat variables *viz.*, rainfall, humidity, litter temperature, and litter depth), on major arthropod fauna (responding variable) was assessed using multiple regression analysis (Zar 2003). Inherent collinearity (multicollinearity) of explanatory variables was analysed with simple and partial correlation (Neter *et al.* 1996).

Relationship between faunal abundance and climatic and habitat physical factors and among faunal groups was analysed, with Pearson (multiple) correlation (Zar 2003; Goehring *et al.* 2002).

The significance levels of the variations in the abundance and diversity (Five α index) of arthropod groups during the different seasons were tested with One way Analysis of Variance (ANOVA). Pair wise significance differences were further compared using Tukey's HSD, (Zar 2003). Significance levels were determined at $P<0.05$. ANOVA and Tukey's HSD analysis were carried out by using KY Plot software. (Yoshioka 2000). All other statistical analysis was done with GRETL open source software version 1.1 (Cottrell 2006).

RESULTS

SECTION I: **ABUNDANCE, DIVERSITY AND FEEDING GUILD COMPOSITION**

1. Overall faunal abundance, diversity and feeding guild: Forty-Six arthropod taxa belonging to 17 arthropod orders have been identified from Kottiyoor forest litter stands (Fig.2.2). List includes thirteen insect orders (Table 2.2 and 2.3). Collembola, followed by Acari, Hymenoptera and Araneae were the major arthropod orders (Fig.2.3). Nine arthropod orders (including five insect orders) were found throughout the year (all months) (>38%). Mantodea, Psocoptera and Lepidoptera (each taxa contributed 0.1%) were found to be the lowest abundant arthropod orders (Fig.2.4; Table 2.3a,b and 2.4). Exceptionally high abundance and richness (51 species) of spiders have been noticed (Table 2.5). Predators (ants, spiders and mites) were the dominant arthropod feeding guild with an overall abundance of 49.7% of total faunal collection.

2. Seasonal variation in abundance, diversity and feeding guild composition.

2a. Seasonal variation in the abundance: Overall arthropod faunal abundance showed significant seasonal variation. High faunal abundance was recorded during northeast monsoon season. Only nine (Collembola, Coleoptera, Orthoptera, Isoptera, Blattaria, Hymenoptera, Acaridae and Araneidae, Isopoda) out of 17 orders were present in all the four seasons

(Table 2.2). Collembolans were the dominant arthropod order found during southwest monsoon (45.9%) and summer season (19.7%) (Fig.2.3). During pre-summer season, Hymenoptera (28%) dominated and Acari (22%) during the northeast monsoon season (Fig.2.3).

Major Fauna: Collembola (Hypogastruridae, Onychiuridae, Isotomidae), Coleoptera (Staphylinidae), Hymenoptera (Ants), Araneae, Acari (Oribatidae, Mesostigmata, Prostigmata) and larvae were the major litter arthropods. Their seasonal abundance pattern is as follows:

Collembola: Highest abundance of Collembola was recorded during southwest monsoon followed by northeast monsoon. More than 39% of the total collection of Collembola was recorded during the southwest monsoon season. Lowest occurrence was recorded during pre-summer and summer seasons (Table 2.2). Five families of Collembola were identified from the litter stands. Hypogastruridae and Onychiuridae were the dominant families. Both these collembolan families recorded the highest abundance during northeast monsoon season (Table 2.5).

Coleoptera: Beetles were dominant during northeast monsoon with three times higher abundance than during summer season (Fig.2.3). Eighteen families of coleopterans were identified from the samples collected. A list of the identified family and species is given in table (Table 2.5). Staphylinidae dominated during all seasons.

Hymenoptera: Ants and chalcids are the two faunal elements identified under the order Hymenoptera. Abundance of ants showed considerable increase during pre summer season (48%).

Araneidae: The highest population density of spiders was recorded during winter season (27/ 50 × 50 cm) and the lowest during southwest monsoon season (Table 2.2). Difference in the abundance between these two seasons was more than 20%.

Acari: The highest mite abundance was recorded during the northeast monsoon season (population density 58/ 50 × 50 cm) contributing to more than half (56%) of the total mite population recorded during the study period. Oribatids, Prostigmatids and Mesostigmatids were the dominant mite families in this litter stand (major fauna).

Larva: The larval abundance peak recorded during the northeast monsoon season (40%). The lowest larval abundance noticed during the summer season (Fig.2.3).

Minor fauna: Abundance of Thysanoptera was high during the summer season. Thysanopterans were not recorded during southwest and northeast rainy season. *Apelaunothrips cosimilis* was the abundant species. Orthoptera was dominant during the pre-summer season. Mantoids were present only in the pre-summer season. Members of psuedoscorpions, Hemiptera, Psocoptera, Lepidoptera and chalcids were noticed only during northeast monsoon. There is no record of Dermaptera during pre-summer and summer seasons. The highest abundance of Diptera was recorded during northeast monsoon. Highest abundance of termites (Isoptera) was recorded during northeast (9/50×50 cm) monsoon season followed by winter season. The lowest isopteran abundance was recorded during summer season (Fig.2.4). *Odontotermes anamallensis* was the dominant species. Blattids peaked during northeast monsoon and their (6/50×50 cm) lowest during the heavy rainy southwest monsoon season (Fig.2.4). The highest isopodan abundance (population density) was recorded during southwest monsoon season (9.3/50×50 cm) and the lowest during summer season

2b. Seasonal variation in diversity: Community diversity of litter arthropod fauna as per the parametric Fisher's alpha diversity index was highest during summer (F = 19.30) season and the lowest during presummer season (F = 11.41). Nonparametric Shannon diversity index (H' = 3.04) and Margalef's richness index (d = 7.74) recorded the highest values during the northeast monsoon season. The lowest Simpson's dominance index (λ = 0.06) was recorded during the same season. The highest evenness index (J' = 0.83) was found during southwest monsoon and summer season. (Table 2.6)

Cluster analysis showed high similarity between the communities present during northeast monsoon and pre-summer seasons. Lowest similarity was recorded between northeast monsoon and summer faunal assemblage (42.52) (Fig.2.5).

2c. Seasonal variation in feeding guild composition: Detritivores dominated during summer and southwest monsoon seasons and predators during pre-monsoon and northeast monsoon season. Fungivores were present in all seasons except during southwest monsoon season (Table 2. 2).

2d. Statistical analysis: Arthropod faunal abundance ($F_{3,\ 180} = 3.1$; $P = 0.03$), evenness ($F_{3,\ 116} = 36.54$, $P < 0.000$), Shannon diversity ($F_{3,\ 116} = 17.24$, $P < 0.000$), and Simpson's index ($F_{3,\ 116} = 31.20$, $P < 0.000$) showed significant seasonal variation. Margalef's richness ($F_{3,\ 116} = 0.82$, $P>0.05$) and Fisher's alpha ($F_{3,\ 116} = 2.29$, $P>0.05$) showed no significant seasonal difference. Pair wise seasonal Tukey analysis of arthropod abundance revealed significant seasonal variation between northeast monsoon and summer season. Seasonal Tukey analysis on Pielou's index has borne out significant difference between all seasonal pairs except northeast monsoon and pre-summer season. Shannon diversity showed significant variation in three seasonal pairs *viz.* southwest monsoon season and pre-summer season; southwest monsoon season and summer season; northeast monsoon and southwest monsoon season. Simpson's dominance index showed significant difference between all seasons except between northeast monsoon and summer; and northeast monsoon and pre-summer seasons (Table 2.7).

SECTION II: **ABIOTIC FACTORS AND RECIPROCAL RELATIONSHIPS BETWEEN FAUNA**

Multiple regression analysis of the major fauna showed that abiotic factors *viz.* rainfall, temperature, humidity, and litter depth have significant influence on the faunal abundance of Collembola (Hypogastruridae, Onychiuridae), Hymenoptera (ants), Araneae (spiders), Acari (Oribatidae, Prostigmata) and larva, while the climatic and habitat factors remain non significant with regard to the coleopteran (Staphylinidae) abundance (Table 2.8). Presence of multicollinearity between explanatory variables does not permit the analysis of the influence of individual climatic and physical habitat factors on faunal abundance (Table 2.9 and 2.10).

Pearson's correlation analysis showed significant positive correlation between physical factors (humidity and rainfall) and collembolan abundance. Most of the faunal groups (more than 55%) showed insignificant relationship with temperature. Litter depth and the abundance of blattids and isopterans (detritivore) showed significant positive relation (Table 2.9).

Acari abundance showed significant positive correlation with 34 fauna and negative correlation with 4 faunal groups. Ants showed significant positive correlation with 29 faunal groups and negative correlation with 7 faunal groups. Abundance of larva showed significant positive correlation with 34 other faunal group abundance and significant negative correlation with four faunal groups. Abundance of Collembola showed significant positive correlation with 14 faunal groups and negative significant relation with 13 faunal groups. Abundance of Coleoptera showed significant positive relation with 35 faunal groups and significant negative relation with three (Entomobryidae, Mantodea, ticks) faunal groups. Spiders showed significant positive correlation with 32 faunal abundance and significant negative correlation with four faunal groups (Collembola, Isotomidae, Onychiuridae, Sminthuridae). Reciprocal relationships among all faunal groups are tabulated (Table 2.9).

DISCUSSION

Abundance of litter fauna shows distinct seasonal variation. These findings are in concurrence with the observations made in the evergreen forests of Panama (Wolda 1983) and eastern Tanzania (Burgess *et al.* 1999) but contradictory to the absence of seasonality recorded from the nearby high elevational wet evergreen litter stands of Periya (Anu and Sabu 2006). High faunal abundance during the low rainy (transitional period) period in the litter stands of Kottiyoor coincides with the results from upland tropical rain forests at Australia (Frith and Frith 1990) and the coastal forests of Tanzania (Burgess *et al.* 1999). Taxa specific behavioural response to various biotic (inter-faunal abundance relations) and abiotic factors (temperature, humidity, rainfall, litter depth) were identified as the reason for seasonal disparity of arthropod fauna in this region. (Levings and Windsor 1985; Raghavendra 2001; Lensing *et al.* 2005) (Table 2.8 and 2.9). This conclusion has been supported by the various early works undertaken on the other part of the Western Ghats and elsewhere (Frith and Frith 1990; Burgess *et al.* 1999; Ferguson and Joly 2002; Sanders *et al.* 2003; Lensing *et al.* 2005; Vineesh *et al.* 2007). Seasonal diversity analysis showed higher values during summer (Fisher's alpha diversity) and northeast monsoon season (Table 2.6) when, comparatively moderate rainfall and temperature were recorded. These results of faunal diversity pattern support the theory that climatic extremes badly affect the faunal diversity (Frith and Frith 1990; Olson 1994).

Collembola is the dominant taxa (total faunal abundance 21.1% contributed) and mite occupies the second place in abundance. This ratifies the widely accepted concept about arthropod abundance in the earlier studies. "Mites and springtails are the most numerous arthropods in the soil and litter layers of tropical forests" (Wallwork 1976; Plowman 1979) and this observation of collembolan dominance were contradictory to the study results from the litter stands of the evergreen forests in Periya where ptiliidae dominated (Anu 2006; Anu and Sabu 2006). This disparity can be attributed to the comparatively less intense rainfall in Kottiyoor than in Periya during the southwest monsoon season and also to the high abundance of ptillids in the Periya forest leading to the competition for food resources, since both are fungivores (Borror *et al.* 1996).

Mantodea, Psocoptera and Lepidoptera are minimal and marginal contributors towards the total faunal abundance in Kottiyoor forest litter. This could be related to the collection method and the group specific behavioural patterns *i.e.*: - Mantids are fast moving insects and may escape from litter samples. Lepidoptera, in general are not litter dwelling, though their larva and the case worms in samples denote their high abundance in that season. Psocoptera abundance in litter is associated with the algal and lichen growth in litter (Borror *et al.* 1996) during the end of north east monsoon and at the onset of pre-summer (*personal observation*).

The impact of climatic and habitat physical factors vary in accordance with the specific characteristic features of that order. Abundance of ants is negatively related to litter humidity and rainfall, (Olson 1994; Vineesh *et al.* 2007) while, the collembolan abundance shows positive relation with rainfall and humidity. (Swift *et al.* 1979; Lensing *et al.* 2005). Dipterans are abundant in August (Southwest monsoon season) while Lepidoptera and Orthoptera show low abundance during this month.

A direct linear relationship between abundance and environmental factors is absent in most of the arthropod orders, but the combination of factors seems better to explain abundance fluctuations (Table 2.8). Fluctuations in abundance at the family level or in lower groups are more prominent than at the order level (Table 2.3). However, for a thorough understanding of the mechanism and the factors involved in seasonality, species-specific studies on long-term basis are a must. Multiple regression results of climatic and habitat physical factors show a direct impact on all major arthropods except Coleoptera (Table 2.8). Thus, this study offers an empirical support to the hypothetical classification of arthropod orders of Novotny and Basset (1998), based on the influence of climatic factors on abundance. (Arthropods are classified into two categories, the first group consists of those whose abundance has linear relationship with environmental factors and the second group includes the arthropods whose abundance is either independent or indirectly dependent on environmental factors) (Levings and Windsor 1985).

All arthropods from the litter stands of Kottiyoor forest showed higher seasonal fluctuations in their abundance than in their incidence (Table 2.2). The highest Fisher's diversity (Table 2.6) was recorded in summer. Leaf fall during summer and the occasional summer rains offer the appropriate refuge for litter insects by providing optimum moisture. The higher diversity can be explained by the lower dominance, and the high evenness and richness indices in the same season (summer). On the other hand in the high elevational wet evergreen forest in Periya -highest seasonal diversity of fauna was recorded during southwest monsoon season (Anu and Sabu 2006). This disparity in arthropods' seasonality testifies to the physico-climatic seasonal variation in the Western Ghats as reported by Nair (1991).

The highest arthropod abundance, richness and Shannon diversity index were recorded during northeast monsoon season; following months of heavy out pour (southwest monsoon season) (Levings and Winsor 1982, 1985; Frith and Frith 1990; Ferguson and Joly 2002). The comparatively lower rains during northeast monsoon season provide a transitional effect after the long and intense southwest rain. During northeast monsoon season in November, the month of lowest rainfall (<27 mm), arthropod total abundance was found to be more than four times as high as that recorded in

March, the first month of the summer season. Rain forest (tropical rain forests) insects attain their peak abundance mostly in the wet season (Boinski and Fowler 1989; Frith and Frith 1990; Anu 2006; Anu and sabu 2006). However Kottiyoor litter stands have shown high richness, abundance and Shannon diversity index during the period of comparatively low rains recorded in northeast rainy season and the highest abundance was perceived during the last month of northeast monsoon, (November) just after the rainy seasons (southwest and northeast monsoons) (Table 2.6). The highest faunal richness was found in Kottiyoor litter stands during low rain northeast monsoon and summer season (Fig.2.2 and Table 2. 2) (Frith and Frith 1990; Burgess *et al.* 1999).

Rainfall showed a direct influence on the abundance of collembolans, mites, ants and spiders (Table 2.8 and 2.9). Fall in the number of litter fauna (most of the fauna) during seasons of heavy rain, in this site, is due to springheads and flooding, and the consequent heavy run-off water and washout of litter. This result substantiates the previous studies on litter arthropod seasonality (Wolda 1978, 1988; Boinski and Fowler 1989; Novotny and Basset 1998; Burgess *et al.* 1999; Brose and Martinez 2004).

High abundance of Collembola recorded during the southwest monsoon and during the northeast monsoon is attributable to the influence of humidity, rainfall (Table 2.9) and the conducive temperature (21°C temperature is a limiting factor for attaining sexual maturity after moulting of sixth instars larva) during this season (Joosse 1981; Ferguson and Joly 2002). Lowest abundance of Collembola during pre-summer and summer, and fall in abundance during dry season can be ascribed to the tendency of vertical migration of collembolans into soil during the dry season (Frith and Frith 1990; Hopkin 1997; Lensing *et al.* 2005). Abundance of Collembola during southwest and northeast monsoon seasons,and its significant positive correlation results confirms to the interrelationship between mite and collembola and their similar climatic requirements.

Mite population peaked during the northeast monsoon season. It can be attributed to the association of arachnids with moist habitat and the prey resource availability (Johnston 2000). Various studies and observations have supported the correlation between wetness and mite abundance (Ferguson and Joly 2002). Mite abundance may partially be attributed to the conditions of temperature, since temperature influences the life cycle of mites (Wright and Chambers 1994).

Ants are one of the most numerous (third abundant of the total faunal collection) arthropod fauna in Kottiyoor litter stand. Ant abundance has a negative relation with rainfall and moisture and positive relation with temperature and prey resources especially isopteran and larval abundance (Table 2.9). These facts are supported by various earlier workers (Janzen and Schoener 1968; Andersen 1992; Vineesh *et al.* 2007). The highest abundance of ants was found during the last month of northeast monsoon and first month of pre-summer season (total ant abundance 48% recorded during this period) is attributed to the comparatively dry conditions in the last month of Northeast monsoon and first month of pre-summer season and the abundance of prey resource like collembola and larvae (Table 2.3 a and b).

Predatory Staphylinidae, Carabidae and the fungivorous Ptiliidae were the most abundant coleopteran families. Their abundance is related to the availability of food resources (Table 2.9). Significant positive correlation results of Staphylinidae and Carabidae with larvae and Isoptera, substantiate this prey-predator relationships (Borror *et al.* 1996). The presence of fungivorous Ptiliidae during the last month of summer season is attributed to the suitability of climatic condition for the fungal growth.

Spiders enjoy high abundance in this study area compared to the other parts of the Western Ghats (Sabu 2005) and this can be attributed to the suitable climatic factors (Crouch and Lubin 2000; Raghavendra 2001; Lensing *et al.* 2005) (Table 2.8 and 2.9). Positive correlation between spiders and another predator, ant and the positive correlation of both these fauna with prey resources *viz.* larva, Isoptera and climatic factor temperature, have been recorded elsewhere (Olson 1994; Crouch and Lubin, 2000; Anu 2006). The presence of same pattern in this region again, necessitates serious analysis of the positive correlation between the abundance of spiders and ants. Two possible reasons are attributed for this relationship. Availability of prey resource may be the first reason (Table 2.9). Since both belongs to virtually the same feeding guild (on the basis of literature, field observation-and significant positive correlation of both fauna with isopteran and larva) (Olson 1994; Barberena-Arias and Aide 2002; Vineesh *et al.* 2003; Anu and Sabu 2006; Vineesh *et al.* 2007) and the second must be the similar climatic requirements of both the groups, (Olson 1994; Raghavendra 2001; Lensing *et al.* 2005) (Table 2.8 and 2.9)

Higher abundance of mantids (generally hatchlings) was noticed in Kottiyoor forest litter in pre-summer season. Pre-summer is their egg hatching season (Borror *et al.* 1996) and this might be the reason for their presence confirmed abundance in the sample collected during middle of the pre-summer-period.

Most members of the Super family Chalcidoidea (order-Hymenoptera) are parasites on other insects, sponging chiefly on the egg or larval stages of their hosts belonging to the orders Lepidoptera, Diptera and Coleoptera and the order Lepidoptera is identified as the prime host (Borror *et al.* 1996). Though the correlation between Chalcidae and Lepidoptera could be explained as a parasite- host relationship, for others (*viz.* Diptera and Coleoptera) no such relationship could be conclusively arrived from the correlation analysis.

Higher abundance of Thysanoptera during the last month of summer exactly matched with the study results from the litter stands of Barro Colorado Island – Panama (Levings and Windsor 1985). The identified thrips from Kottiyoor litter substrates were fungus spore feeders. This attributed to the extremely conducive weather for fungal growth (Table 3), because of moderate humidity due to the summer rain (Hassal *et al.* 1986).

Hemipterans (both predatory and detritivore (phytophagous) feeding guild) were recorded only in the northeast monsoon season (last month of northeast monsoon season) and their higher abundance is related to the higher abundance of tender fruits during this period, which is staple for sap feeding phytophagous hemipterans (Murali and Sukumar 1993; Krishnon 2002) and for the peak in larval populations during the period. Positive correlation between predatory hemipterans and larval population is attributed to the prey-predator relationship (Borror *et al.* 1996).

Conclusion:

Litter arthropod abundance and diversity showed significant seasonal variation. Higher abundance of fauna is recorded during northeast monsoon season. Only 38% arthropod orders (including five insect orders) were found throughout the year (all months). Exceptionally high abundance of Araneae (spiders) was a special feature noticed in the region. Abiotic factors showed significant influence on the abundance of all major fauna except Coleoptera abundance. To clearly establish the influence of inter-group faunal abundance, further detailed study of the confirmation of derived relationships is necessary.

Table 2.1. Physical characteristics of litter floor in the evergreen forest at Kottiyoor during Dec 2002 to Nov 2003 study period.

Parameters	**Mean** [a]	**± SE**
Litter temperature (^{0}C)	28.25	± 0.53
Litter humidity (%)	71.92	± 3.35
Litter depth (cm)	6.67	± 0.42
Slope of the terrain	10° 67'	± 0°.33'
Rainfall (mm)	330.3	± 141

[a] Mean of twelve monthly samples.

Table 2.2. Seasonal abundance of litter arthropod fauna in the evergreen forest at Kottiyoor during December 2002 to November 2003.

SEASON		PS	S	SW	NE
TAXA	**Guild**	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**
Entomobryidae	M	4 ± 2.52	3.3 ± 0.9	7 ± 0.58	6.3 ± 2.6
Hypogastruridae	M	6 ± 2.31	4 ± 1.5	6.67 ± 2.73	14 ± 6.1
Isotomidae	M	0.33 ± 0.33	0 ± 0	20.3 ± 4.98	18 ± 7.3
Onychiuridae	M	3 ± 1.15	5 ± 0.6	13.3 ± 4.41	11 ± 2.3
Sminthuridae	M	0.33 ± 0.33	4 ± 1	6.7 ± 3.3	3 ± 1.3
Curculionidae	D	0.33 ± 0.33	1 ± 0	0 ± 1	1 ± 0.6
Tenebrionidae	D	0 ± 0	0.7 ± 0.3	0.33 ± 0.33	1 ± 0.6
Meloidae	D	0.67 ± 0.33	0.3 ± 0.3	0 ± 0	0.7 ± 0.3
Lampyridae	D	0.67 ± 0.33	0 ± 0	0 ± 0	0.3 ± 0.3
Rhyncophoridae	D	0 ± 0	0.3 ± 0.3	0 ± 0	0.7 ± 0.3
Scarabaeidae	D	0 ± 0	0.3 ± 0.3	0.67 ± 0.33	1.3 ± 0.9
Anthribidae	D	0 ± 0	0.3 ± 0.3	0 ± 0	0.3 ± 0.3
Bostrichidae	D	0.33 ± 0.33	0.7 ± 0.3	0.33 ± 0.33	1 ± 0.6
Cerambycidae	D	0.33 ± 0.33	0.7 ± 0.3	0 ± 0	0.3 ± 0.3
Chrysomelidae	D	0 ± 0	0.3 ± 0.3	0.33 ± 0.33	0.3 ± 0.3
Elateridae	D	0 ± 0	0.7 ± 0.3	0 ± 0	0.7 ± 0.3
Hydrophilidae	D	0 ± 0	0 ± 0	0.33 ± 0.33	1 ± 0.6
Carabidae	P	0.67 ± 0.67	0.7 ± 0.3	1.67 ± 0.33	4 ± 2.1
Histeridae	P	0.33 ± 0.33	0 ± 0	1.33 ± 0.33	3 ± 1.5
Scydmaenidae	P	0.33 ± 0.33	0.3 ± 0.3	1.33 ± 0.33	2.7 ± 1.2
Staphylinidae	P	2.67 ± 1.67	2 ± 0	5.33±0.33	10 ± 5.5
Ptiliidae	F	3.33 ± 3.33	0 ± 0	0 ± 0	1 ± 0.6
PSOCOPTERA	F	0 ± 0	0 ± 0	0 ± 0	0.3 ± 0.3
THYSANOPTERA	F	0.67 ± 0.67	5.7 ± 5.7	0 ± 0	0 ± 0
DIPTERA	D	0.67 ± 0.33	0 ± 0	0.67 ± 0.33	2.3 ± 1.2
LEPIDOPTERA	D	0 ± 0	0 ± 0	0 ± 0	0.3 ± 0.3
ORTHOPTERA	D	2.3 ± 0.88	1.7 ± 0.7	1 ± 0.58	2 ± 2

Table 2.2. continued

DERMAPTERA	D	0 ± 0	0 ± 0	0.67 ± 0.67	1.3 ± 0.3
ISOPTERA	D	5 ± 1.53	1.7 ± 0.3	2 ± 0.58	8.7 ± 5.8
BLATTARIA	P	2.6 ± 1.2	2.7 ± 0.9	1.67 ± 0.33	5.7 ± 1.5
MANTODEA	P	0.33 ± 0.33	0 ± 0	0 ± 0	0 ± 0
Ants	P	45 ± 10.4	13 ± 1.5	1.67 ± 0.67	28 ± 16
Chalcidae	P	0 ± 0	0± 0	0 ± 0	5.3 ± 5.3
Reduviidae	P	0 ± 0	0± 0	0 ± 0	1.7 ± 1.7
Other Hemiptera	D	0 ± 0	0± 0	0 ± 0	1 ± 1
Larva	D	26 ± 7.86	8.3 ± 1.7	14.7 ± 1.33	33 ± 24
Millipede	D	0.33 ± 0.33	0.3 ± 0.3	0 ± 0	0.3 ± 0.3
ISOPODA	D	2 ± 2	0.3 ± 0.3	9.33 ± 7.33	7.3 ± 6.3
Oribatida	D	14 ± 8.5	6.3 ± 3	2.33 ± 0.88	5 ± 1.5
Astigmata	P	5.33 ± 3.93	1.3 ± 0.3	4 ± 1	8 ± 1
Prostigmata	P	3.33 ± 3.33	0.7 ± 0.3	2.67 ± 0.67	14 ± 1.5
Mesostigmata	P	2 ± 2	0.3 ± 0.3	5 ± 0	31 ± 1.4
Ticks	P	1 ± 0.58	5 ± 1.5	0 ± 0	0.3 ± 0.3
PSEUDOSCORPION	P	0 ± 0	0 ± 0	0 ± 0	1 ± 1
Spider	P	26 ± 3.33	10 ± 3.5	4.67 ± 0.88	20 ± 5.4

PS: Pre-summer; S: Summer; SW: Southwest monsoon; NE: Northeast monsoon

^{M,} Microbidetritivore; ^{D,} Detritivore; ^{F,} Fungivore; ^{P,} Predator

Table 2.3a. Abundance of litter fauna per (¼) m^2 in the evergreen forest at Kottiyoor during Dec 2002 to May 2003 study period.

	DEC	JAN	FEB	MAR	APR	MAY
COLLEMBOLA	12±0.9	5±1.0	24±1.8	20±1.8	18±1.1	11±1.4
Entomobryidae	1±0.3	2±0.6	9 ± 0.7	3±0.5	5±0.3	3±0.7
Hypogastruridae	6±0.4	2±0.5	10±1.1	7±0.5	3±0.4	2 ± 0.3
Isotomidae	1±0.2	0±0	0±0	0±0	0±0	0±0
Onychiuridae	3±0.7	1±0	5±0.6	7±0.6	4±0.3	4.7±0.9
Sminthuridae	1±0.4	0±0	0±0	5±0.5	6±0.6	2±0.5
COLEOPTERA	20±1.0	4±0.6	5±1.0	6±0.8	9±0.7	10±1.2
Curculionidae	1±0.3	0±0	0±0	1±0.1	1±0.8	1±0.4
Tenbrionidae	0±0	0±0	0±0	0±0	1±0.4	1±0
Meloidae	0±0	1±0.2	1±0.2	0±0	0±0	1±0.2
Lampyridae	1±0.3	1±0.2	0±0	0±0	0±0	0±0
Rhyncophoridae	0±0	0±0	0±0	0±0	0±0	1±0.2
Scarabaeidae	0±0	0±0	0±0	0±0	0±0	1±0.2
Anthribidae	0±0	0±0	0±0	1±0.4	0±0	0±0
Bostrichidae	0±0	0±0	1±0.4	0±0	1±0	1.1±0.2
Cerambycidae	0±0	0±0	1±0.4	0±0	1±0	1.1±0.1
Chrysomelidae	0±0	0±0	0±0	1±0.3	0±0	0±0
Elateridae	0±0	0±0	0±0	0±0	1±0.2	1±0.2
Hydrophilidae	0±0	0±0	0±0	0±0	0±0	0±0
Carabidae	2±0.4	0±0	0±0	1±0.2	1±0.2	0±0
Histeridae	0±0	0±0	1±0.2	0±0	0±0	0±0
Scydmaenidae	0±0	1±0.3	0±0	0±0	1±0.2	0±0
Staphylinidae	6±0.9	1±0.2	1±0.1	1.8±0.4	2±0.8	2±0.6
Ptiliidae	9.9±0.9	0±0	0±0	0±0	0±0	0±0
PSOCOPTERA	0±0	0±0	0±0	0±0	0±0	0±0
THYSANOPTERA	0±0	2±0.4	0±0	0±0	0±0	17±1.7
DIPTERA	1±0.3	1±0.3	0±0	0±0	0±0	0±0

Table 2.3a. continued

LEPIDOPTERA	0±0	0±0	0±0	0±0	0±0	0±0
ORTHOPTERA	4±0.4	2±0.3	1±0.2	1±0	1±0.2	3±0.5
DERMAPTERA	0±0	0±0	0±0	0±0	0±0	0±0
ISOPTERA	8±0.7	4±0.5	3±0.5	2±0	2±0.5	1.1±0.1
BLATTARIA	5±0.2	1.1±0.3	2±0.5	3±0	4±0.8	1.2±0.1
MANTODEA	0±0	1±0.2	0±0	0±0	0±0	0±0
HYMENOPTERA	65±1	30±2.7	40±4.3	15±1.3	10±1.7	13±1.5
Ants	65±1	30±2.7	40±4.3	15±1.3	10±1.7	13±4.7
Chalcidae	0±0	0±0	0±0	0±0	0±0	0±0
HEMIPTERA	0±0	0±0	0±0	0±0	10±0	13±0
Reduviidae	0±0	0±0	0±0	0±0	0±0	0±0
Other Hemiptera	0±0	0±0	0±0	0±0	0±0	0±0
Larva	42±1.1	21±1.2	16±1.5	10±0.7	5±0.4	10±1.0
Millipede	0±0	1±0.3	0±0	0±0	0±0	1.2±0.4
ISOPODA	6±0.7	0±0	0±0	0±0	0±0	1±0.2
ACARI	61±1.3	6±1	10±1.2	8±0.9	14±0.7	16±1.4
Oribatida	61±0	6±1	5±1.0	2±0.3	5±0.5	11±1.1
Astigmata	13±0	0±0	3.4±0.5	1.4±0.3	1±0.2	2±0.1
Prostigmata	10±0	0±0	0±0	1.4±0.3	0±0	2.1±0.6
Mesostigmata	6±0	0±0	0±0	0±0	0±0	1±0
Ticks	1±0	0+0	2±0.6	3.9±0.9	8±0.6	3±0.6
PSEUDOSCORPION	0±0	0±0	0±0	0±0	0±0	0±0
Spider	30±1.0	20±0.7	30±0.8	4.1±1	10±1.5	16±1.8
Centipede	0±0	0±0	0±0	0±0	0±0	1±0.2

Table 2.3b. Abundance of litter fauna per (¼) m^2 in the evergreen forest at Kottiyoor during the study period from June 2003 to November 2003.

	JUN	JUL	AUG	SEP	OCT	NOV
COLLEMBOLA	7±2.5	62±3.3	30±2.3	55±2.7	84±1.4	20±0.8
Entomobryidae	8±0	7±0.8	6±1.0	6±0.6	11±0.8	2±0.5
Hypogastruridae	12±0	5±0.6	3±0.4	12±1	25±0.8	4 ± 0.4
Isotomidae	28±2.4	22±1.5	11±1.0	20±0.8	30±0.4	5±0.3
Onychiuridae	20±0.5	15±0.7	5±0.8	15±1.0	12±0.4	7±0.5
Sminthuridae	2±0	13±0.9	5±0.8	2±0.7	6±0.8	2±0.4
COLEOPTERA	12±0.7	8±0.8	15±2.0	18±0.7	10±0.7	60±1.1
Curculionidae	0±0	0±0	0±0	1±0	0±0	2±0.3
Tenebrionidae	1±0.1	0±0	0±0	1±0	0±0	2±0.3
Meloidae	0±0	0±0	0±0	0±0	1.3±0.2	1±0.2
Lampyridae	0±0	0±0	0±0	0±0	0±0	1±0.2
Rhyncophoridae	0±0	0±0	0±0	0±0	1±0.3	1±0.2
Scarabaeidae	1±0.2	0±0	1±0	1±0	0±0	3±0.5
Anthribidae	0±0	0±0	0±0	0±0	0±0	1±0.2
Bostrichidae	0±0	0±0	1±0	1±0	0±0	2±0.4
Cerambycidae	0±0	0±0	0±0	0±0	0±0	1±0.2
Chrysomelidae	0±0	0±0	1±0.2	0±0	0±0	1±0.2
Elateridae	0±0	0±0	0±0	0±0	1±0.2	1±0.2
Hydrophilidae	0±0	0±0	1±0.15	1±0	0±0	2±0.2
Carabidae	2±0.3	1±0.2	2±0.4	3±0.4	1±0.1	8±0.3
Histeridae	1±0.4	1±0.2	2±0.7	2±0	1±0.2	6±0.3
Scydmaenidae	1±0.2	1±0.2	2±0.6	2±0.3	1±0.2	5.2±0.2
Staphylinidae	8±0.3	5±0.7	5±1.0	5±0.42	4±0.7	21±0.9
Ptiliidae	0±0	0±0	0±0	1±0.2	0±0	2±0.2
PSOCOPTERA	0±0	0±0	0±0	0±0	0±0	1.3±0.2
THYSANOPTERA	0±0	0±0	0±0	0±0	0±0	0±0
DIPTERA	1±0.2	1±0.3	0±0	3±0.5	0±0	4.4±0.5

Table 2.3b. continued

LEPIDOPTERA	0±0	0±0	0±0	1±0.2	0±0	0±0
ORTHOPTERA	2±0.3	1±0.2	0±0	0±0	0±0	6±0.9
DERMAPTERA	0±0	0±0	2±0.4	1.1±0.2	2±0.37	1±0.3
ISOPTERA	1±0.1	2±0.3	3±0.7	0.8±0.2	5±0.6	20±0.7
BLATTARIA	2±0.5	1±0.2	2±0.6	2.9±0.4	6±0.4	8±0.7
MANTODEA	0±0	0±0	0±0	0±0	0±0	0±0
HYMENOPTERA	1±0.4	1±0.2	3±0.4	29±1.7	10±0.6	60±1.4
Ants	1±0.4	1±0.2	3±0.3	13±1.3	10±0.6	60±1.4
Chalcidae	0±0	0±0	0±0	16±0.8	0±0	0±0
HEMIPTERA	0±0	0±0	0±0	0±0	0	8±0.768
Reduviidae	0±0	0±0	0±0	0±0	0±0	5±0.39
Other Hemiptera	0±0	0±0	0±0	0±0	0±0	3±0.86
Larva	16±1.2	12±1.5	16±0.7	12±1.2	6±0.3	80±1.1
Millipede	0±0	0±0	0±0	0±0	1±0.3	0±0
ISOPODA	2±0.6	2±0.5	24±1.6	20±0.9	1±0.2	1±0.3
ACARI	18±1.6	10±0.6	14±1.0	68±2. 8	64±1.0	43±1.0
Oribatida	4±0.2	1±0.1	2±0.3	7±0.5	6±0.4	2±0.2
Astigmata	5±0.6	2±0.3	5±1.1	9±0.4	9±0.4	6±0.4
Prostigmata	4±0.5	2±0.3	2±0.2	14±1.5	16±0.7	11±1.0
Mesostigmata	5.3±0.6	5±0.52	5±0.3	38±0.5	33±0.7	23±1.4
Ticks	0±0	0±0	0±0	0±0	0±0	1±0
PSUEDOSCORPION	0±0	0±0	0±0	0±0	0±0	3±0.42
Spider	5.9±0.9	3±0.5	4.6±0.5	14±0.7	16±1.0	31±0.7
Centipede	0±0	0±0	1±0	3±0.6	0±0	0±0

Table 2.4. Abundance of litter fauna per (¼) m^2 and relative abundance (%) in evergreen forest litter stands during the study period of December 2002 to November 2003.

TAXA	Mean	±	SE	%
COLLEMBOLA	34	±	11.13	22
Entomobryidae	5.2	±	0.887	3.3
Hypogastruridae	7.6	±	2.11	4.9
Isotomidae	9.8	±	5.55	6.3
Onychiuridae	8.2	±	2.47	5.2
Sminthuridae	3.6	±	1.3	2.3
COLEOPTERA	15	±	4.91	9.5
Curculionidae	0.6	±	0.25	0.4
Tenebrionidae	0.5	±	0.22	0.3
Meloidae	0.4	±	0.16	0.3
Lampyridae	0.3	±	0.16	0.2
Rhyncophoridae	0.3	±	0.16	0.2
Scarabaeidae	0.6	±	0.285	0.4
Anthribidae	0.2	±	0.10	0.1
Bostrichidae	0.6	±	0.16	0.4
Cerambycidae	0.3	±	0.14	0.2
Chrysomelidae	0.3	±	0.08	0.2
Elateridae	0.3	±	0.19	0.2
Hydrophilidae	0.3	±	0.24	0.2
Carabidae	1.8	±	0.79	1.1
Histeridae	1.2	±	0.67	0.7
Scydmaenidae	1.2	±	0.55	0.7
Staphylinidae	5	±	1.82	3.2
Ptiliidae	1.1	±	0.79	0.7
PSOCOPTERA	0.1	±	0.08	0.1
THYSANOPTERA	1.6	±	1.37	1
DIPTERA	0.9	±	0.50	0.6

Table 2.4. continued

LEPIDOPTERA	0.1	±	0.08	0.1
ORTHOPTERA	1.8	±	0.29	1.1
DERMAPTERA	0.5	±	0.32	0.3
ISOPTERA	4.3	±	1.63	2.8
BLATTARIA	3.2	±	0.87	2
MANTODEA	0.1	±	0.08	0.1
HYMENOPTERA	23	±	9.77	15
Ants	22	±	9.41	14
Chalcidae	1.3	±	1.33	0.9
HEMIPTERA	0.7	±	0.67	0.4
Reduvidae	0.4	±	0.42	0.3
Other hemiptera	0.3	±	0.25	0.2
Larva	21	±	5.5	13
Millipede	0.3	±	0.08	0.2
ISOPODA	4.8	±	2.1	3
ACARI	26	±	11.07	17
Oribatida	6.9	±	2.5	4.4
Astigmata	4.7	±	1.38	3
Prostigmata	5.1	±	2.92	3.3
Mesostigmata	9.7	±	7.29	6.2
Ticks	1.6	±	1.16	1
PSEUDOSCORPION	0.3	±	0.25	0.2
Spider	15	±	4.96	9.9
Centipede	0.4	±	0.21	0.3

Table 2.5. List of family/species identified from the evergreen forest litter stand at Kottiyoor during December 2002 to November 2003 study period.

COLEOPTERA	*Ompra pilosa*
CURCULIONIDAE	*Perigona* sp.
Alcidoves sp.	*Pheropsophus* sp.
Microlarinus sp.	*Perigona nigriceps*
Ochyronera sp.	*Syntomus cymindulus*
Rhadinomerus sp.	*Tachyina* sp.
TENEBRIONIDAE	*Tachys* sp.
Gonocephalum sp.2	*Tichotichnus limprus*
Gonocephalum sp.1	SCARABAEIDAE
Gonocephalum vilineatum	*Copris davisoni*
Lagriini sp.	*Copris repertus*
Luprops gracilior	*Copris signatus*
Sphingocorse keralaensis	*Drepanocerus setosus*
Uloma loevli	*Oniticellus cinctus*
HISTERIDAE	*Onthophagus* sp.3
Atholus dentipes	OTHER BEETLE FAMILIES
Pachylister lutarius	Anthribidae
PTILIIDAE	Bostrichidae
Bambara sp.	Cerambycidae
SCYDMAENIDAE	Chrysomelidae
Euconnus sp.	Elateridae
RHYNCOPHORIDAE	Hydrophilidae
Aridius nodifer	Lampyridae
Scitophilus rugicollis	Meloidae
CARABIDAE	Staphylinidae
Clivina extensicollis	**ORTHOPTERA**
Diplocheila polita	*Gryllus* sp.
Macrocheilus sp.	*Scapsipedus* sp.

Table 2.5.continued

Tristria sp.
HYMENOPTERA
ANTS
Aenictus sp.1
Camponotus natis
C.radiatus
Camponotus sp.1
Cardiocondyla sp.2
Crematogaster sp.
Diacamma sp.1
Diacamma sp.2
Lepisiota sp.
Leptogenys sp.
Monomorium pharaonis
Monomorium sp.
Myrmicaria sp.1
Myrmicaria brunnea
Odontomachus sp.
Ponera sp.
Paratrechina sp.2
Phidole sp.
Sacronigenys sp.
Solenopsis geminata
Solenopsis sp.1
Solenopsis sp.2
Strumigenys sp.
Tapinoma indicum
Tapinoma melanocephalum
Tapinoma sp.1
Tapinoma sp.2
Tetramorium sp.1
Tetramorium sp.2
Tetramorium sp.3
CHALCIDAE
Aphanogmus sp.1
Aphanogmus sp.2
Barconid sp.
Ceratobaeus sp.
Dichoteleas sp.
Halcopilte sp.
Molotelia sp.
Phanerotomella sp.
Probaryconus sp.
ISOPTERA
Odontotermes anamallenssis
Odontotermes obesus
HEMIPTERA
REDUVIIDAE
Sycanus collaris
OTHER HEMIPTERA
Miridae
Pyrrhocoridae
COLLEMBOLA
Entomobryidae
Hypogastruridae
Isotomidae
Onychuridae
Sminthuridae

Table 2.5.continued

THYSANOPTERA	*Lycosa quadrifer*
Apelaunmunothrips consimili	*Lycosa* sp.
SPIDERS	*Mallinella maculata*
Amaurobius sp.	*Mallinella* sp.
Argyrodes sp.	*Nephila kuhlii*
Argyrodes gazedes	*Nephila maculata*
Atypena adelineae	*Neriena birmanica*
Atypus sp.	*Neriena* sp.
Carhottus sp.	*Oedignatha* sp.
Castianeira sp.	*Opadomata fastigata*
Castianeira zetes	*Opopaea* sp.
Chrysso sp.	*Pardosa* sp.
Corinnomma rufofuscum	*Phintella* sp.
Corinnomma sp.	*Pholcus* sp.
Cryptotceles sp.	*Poecilotheria* sp.
Ctenus sp.	*Runcinia* sp.
Dolomedus sp.	*Scytodes thoracica*
Drassodes andamanenssis	*Siler* sp.
Drassodes sp.	*Tamgrinia alveolifera*
Gamasomorpha celypeolaria	*Tamgrinia* sp.
Gamasomorpha sp.	*Telamonia* sp.
Gasteracantha geminata	*Tetragnathae virmiformis*
Hahnia sp.	*Thalassius* sp.
Hetropoda nilgiriensis	*Theridion* sp.
Hippasa sp.	*Thomisus* sp.
Hyllus sp.	**MITES**
Ischnothyreus sp.	*Cantharozetes* sp
Leucauge pondae	*Cephus* sp
Linyphia sp.	*Damaeus* sp

Table 2.5.continued

Diarthrophallus quercus	*Diplogynium* sp.
Galumna sp.	*Parasitus* sp..
Histiostoma sp.	**PSEUDOSCORPIONS**
Microtrombidium sp.	*Calocheiridius* sp.
Smaris sp.	*Chthonius* sp.
PHORETIC MITES	*Lamprochernes* sp.
Amblycius indicus	

Table 2.6. Seasonal variations in the diversity of litter arthropods in the evergreen forest at Kottiyoor during the study period (2002 - 03).

Season	Abundance (N)	Fisher's Diversity (α)	Shannon diversity (H')	Simpson's dominance Lambda'	Pielou's evenness (J')	Margalef's richness (d)
P-S	162.00	11.41	2.40	0.14	0.70	5.90
S	82.00	19.30	2.87	0.07	0.83	7.03
S-W	116.00	11.70	2.77	0.08	0.83	5.68
N-E	259.00	15.19	3.04	0.06	0.80	7.74

Table 2.7. Results of Tukey (pair wise significance) test for abundance, Pielou's evenness, Shannon diversity and Simpson's dominance indices on the seasonal variation of arthropods in the evergreen forest floor during the study period (2002 - 03).

Seasons	PRESUMMER	SUMMER	SOUTHWEST
Abundance			
SUMMER	N.S		
SOUTHWEST	N.S	N.S	
NORTHEAST	N.S	*	N.S
Pielou's Evenness			
SUMMER	***		
SOUTHWEST	***	***	
NORTHEAST	N.S	***	***
Shannon Diversity			
SUMMER	N.S		
SOUTHWEST	***	***	
NORTHEAST	N.S	N.S	***
Simpson's dominance			
SUMMER	**		
SOUTHWEST	***	***	
NORTHEAST	N.S	N.S	***

N.S- Not significant; $*P \leq 0.05$; $**P \leq 0.01$; $***P \leq 0.001$.

Table 2.8. Multiple regression analysis of abundance of major litter arthropod fauna, as a function of litter climatic and habitat physical factors in the evergreen forest floor during the study period (2002 – 2003).

Dependent Variable	$F_{4, 115}$	R^2	P
COLLEMBOLA	28.45	0.50	0.000
HYPOGASTRURIDAE	3.43	0.11	0.011
ONYCHIURIDAE	29.04	0.502	0.000
COLEOPTERA	1.98	O.O7	O.101
STAPHYLINIDAE	0.86	0.03	0.49
HYMENOPTERA	72.96	0.72	0.000
ANTS	101.4	0.78	0.000
SPIDER	54.95	0.66	0.000
ACARI (MITES)	7.23	0.20	0.000
ORIBATIDA	33.69	0.54	0.000
PROSTIGMATA	3.56	0.11	0.009
LARVA	10.56	0.27	0.000

NB: Independent variable- Litter depth, Rainfall, Temperature, Humidity
N.S- Not significant; $*P \leq 0.05$; $**P \leq 0.01$; $*** P \leq 0.001$.

Table 2.9. Pearson Correlation analysis of the reciprocal relationship between fauna and abiotic (bold) factors of evergreen forest litter stands (Left side below r- correlation coefficient; right side above P – significance).

	ACARIDAE	ANTHRIBIDAE	ANTS	ASTIGMATA	BLATTARIA	BOSTRICHIDAE	CARABIDAE	CENTIPEDES	CERAMBYCIDAE	CHALCIDAE	CHRYSOMELIDAE	COLEOPTERA	COLLEMBOLA	CURCULIONIDAE	DERMAPTERA	DIPTERA	ELATERIDAE	ENTOMOBRYIDAE
ACARIDAE	1	N.S	***	***	***	N.S	***	***	N.S	***	N.S	***	***	N.S	***	***	N.S	N.S
ANTHRIBIDAE	0	1	**	N.S	**	**	***	N.S	N.S	N.S	***	***	N.S	**	N.S	**	N.S	**
ANTS	0.3	0.2	1	***	***	*	***	*	**	N.S	N.S	***	***	***	N.S	***	N.S	***
ASTIGMATA	0.9	-0.1	0.4	1	***	N.S	***	*	**	***	*	***	***	*	***	***	N.S	N.S
BLATTARIA	0.6	0.3	0.5	0.5	1	N.S	***	N.S	N.S	N.S	**	***	N.S	***	***	***	***	N.S
BOSTRICHIDAE	0.1	0.3	0.2	-0.1	0.2	1	***	*	***	N.S	*	***	**	*	N.S	**	**	N.S
CARABIDAE	0.4	0.4	0.4	0.3	0.6	0.5	1	N.S	N.S	N.S	***	***	N.S	***	**	***	*	N.S
CENTIPEDE	0.4	-0.1	-0.2	0.2	-0.1	0.2	0.1	1	N.S	***	N.S	N.S	N.S	N.S	**	**	N.S	N.S
CERAMBICIDAE	-0.2	0.1	0.3	-0.3	0.1	0.7	0.2	-0.1	1	N.S	N.S	**	***	**	*	N.S	***	N.S
CHALCIDAE	0.5	-0.1	-0.1	0.3	0	0.2	0.2	0.8	-0.2	1	N.S	N.S	**	N.S	*	***	N.S	N.S
CHRYSOMELIDAE	-0.1	0.6	0.1	-0.1	0.2	0.2	0.4	0	0	-0.1	1	***	N.S	**	**	N.S	N.S	N.S
COLEOPTERA	0.4	0.4	0.6	0.4	0.7	0.5	0.9	0	0.3	0.1	0.4	1	N.S	***	**	***	***	*
COLLEMBOLA	0.4	-0.2	-0.5	0.3	0.1	-0.3	0	0.1	-0.3	0.2	-0.2	-0.1	1	**	***	N.S	N.S	***
CURCULIONIDAE	0.2	0.2	0.3	0.1	0.4	0.2	0.4	0.1	0.3	0.1	0.3	0.5	-0.2	1	N.S	***	***	**
DERMAPTERA	0.4	-0.1	-0.1	0.4	0.4	0.1	0.3	0.4	-0.2	0.2	0.3	0.3	0.4	0	1	N.S	N.S	***
DIPTERA	0.4	0.3	0.4	0.3	0.4	0.3	0.8	0.3	0	0.4	0.2	0.7	0.1	0.3	0.2	1	N.S	*
ELATERIDAE	0.2	0.1	0	0	0.4	0.2	0.2	-0.1	0.4	-0.2	0	0.3	0	0.3	0.1	0	1	N.S
ENTOMOBRYIDAE	0.1	-0.3	-0.4	0	0	-0.1	-0.1	0	0	0.1	-0.1	-0.2	0.7	-0.3	0.4	-0.2	0	1
HEMIPTERA	0.2	0.4	0.5	0.1	0.6	0.5	0.8	-0.1	0.3	-0.1	0.4	0.9	-0.2	0.4	0.2	0.7	0.3	-0.2
HISTERIDAE	0.3	0.3	0.3	0.2	0.5	0.5	0.8	0.1	0.2	0.1	0.4	0.8	0.1	0.2	0.4	0.7	0.2	0.01
HUMIDITY	**-0.1**	**-0.2**	**-0.8**	**-0.1**	**-0.2**	**-0.2**	**-0.1**	**0.2**	**-0.3**	**0.1**	**0**	**-0.2**	**0.7**	**-0.3**	**0.3**	**-0.1**	**0**	**0.5**
HYDROPHILIDAE	0.3	0.3	0.3	0.2	0.5	0.5	0.8	0.3	0.1	0.3	0.5	0.8	-0.1	0.3	0.5	0.7	0.2	-0.1
HYMENOPTERA	0.4	0.2	1	0.4	0.5	0.3	0.4	0	0.2	0.1	0.1	0.6	-0.4	0.4	-0.1	0.5	0	-0.4
HYPOGASTRURIDAE	0. 6	-0.1	-0.2	0.4	0.3	-0.2	0	0	-0.2	0.2	-0.2	-0.1	0.7	-0.2	0.4	0	0.1	0.6
ISOPODA	0.3	-0.2	-0.2	0.4	0	0.2	0.2	0.6	-0.3	0.6	0.2	0.1	0.2	-0.1	0.5	0.2	-0.3	0.1
ISOPTERA	0.3	0.4	0.7	0.3	0.7	0.4	0.8	-0.2	0.2	-0.2	0.5	0.9	-0.2	0.3	0.2	0.6	0.3	-0.2
ISOTOMIDAE	0.4	-0.2	-0.5	0.3	0.1	-0.2	0.1	0.2	-0.4	0.3	-0.2	0	1	-0.3	0.4	0.1	0	0.6
LAMPYRIDAE	0.2	0.2	0.6	0.2	0.3	0.1	0.3	-0.2	0.1	-0.1	0	0.4	-0.4	0.2	-0.1	0.3	0	-0.5
LARVA	0.3	0.4	0.8	0.3	0.6	0.4	0.8	-0.2	0.2	-0.1	0.3	0.9	-0.3	0.3	0.1	0.7	0.1	-0.4
LEPIDOPTERA	0.5	-0.1	-0.1	0.3	0	0.1	0.2	0.7	-0.1	0.9	-0.1	0.1	0.2	0.1	0.2	0.5	-0.2	0.1
LITTER DEPTH	**0.1**	**0.2**	**0.4**	**-0.1**	**0.4**	**0.2**	**0.2**	**-0.2**	**0.2**	**-0.1**	**0.2**	**0.2**	**-0.4**	**0.2**	**0.1**	**0.1**	**0.2**	**-0.2**
MANTODEA	-0.2	-0.1	0.1	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3	-0.1	-0.1	0.05	-0.1	-0.2
MELOIDAE	0	0	0.3	-0.1	0.1	0.3	0	-0.2	0.3	-0.2	-0.1	0.1	-0.1	0	0	0	0.4	0.1
MESOSTIGMATA	0.8	0	0	0.6	0.5	0.1	0.6	0.5	-0.2	0.7	0	0.4	0.6	0.1	0.6	0.5	0.2	0.3
MILLIPEDES	0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.3	0	0.1	-0.1	-0.2	-0.2	0	-0.1	0	-0.2	0.3	0
ONYCHURIDAE	0.2	-0.1	-0.4	0.2	0	-0.2	0.1	0.2	-0.3	0.3	-0.1	0	0.9	-0.1	0.1	0.2	-0.1	0.5
ORIBATIDAE	0.5	-0.2	0.5	0.6	0.2	-0.1	-0.1	0	0	0	-0.3	0	-0.3	0.1	-0.2	0	-0.1	-0.3
ORTHOPTERA	0.1	0.2	0.7	0.1	0.5	0.2	0.5	-0.2	0.3	-0.3	0.2	0.7	-0.4	0.4	-0.1	0.5	0.2	-0.4
OTHER HEMIPTERA	0.2	0.2	0.4	0.1	0.5	0.2	0.7	-0.1	0.2	-0.1	0.4	0.7	-0.1	0.4	0.3	0.6	0.2	-0.1
PROSTIGMATA	0.9	0.1	0.2	0.7	0.6	0.1	5	0.3	-0.2	0.5	0	0.5	0.5	0.2	0.5	0.5	0.2	0.1
PSOCOPTERA	0.2	0.4	0.5	0.1	0.6	0.5	0.8	-0.1	0.3	-0.1	0.4	0.8	-0.1	0.4	0.2	0.7	0.2	-0.2
PSUEDOSCORPION	0.2	0.4	0.5	0.1	0.6	0.5	0.8	-0.1	0.3	-0.1	0.4	0.9	-0.1	0.4	0.2	0.7	0.3	-0.2
PTILIIDAE	0.5	0	0. 7	0.7	0.4	-0.1	0.2	-0.1	-0.1	0	-0.1	0.3	-0.3	0.2	-0.1	0.2	-0.1	-0.4
RAIN	**-0.2**	**-0.2**	**-0.6**	**-0.1**	**-0.3**	**-0.2**	**-0.1**	**0**	**-0.3**	**-0.1**	**-0.1**	**-0.2**	**0.6**	**-0.3**	**0.1**	**-0.1**	**-0.2**	**0.4**
REDUVIIDAE	0.2	0.5	0.5	0.1	0.5	0.6	0.9	-0.1	0.3	-0.1	0.4	0.9	-0.2	0.4	0.1	0.7	0.4	-0.3
RHYNCOPHORIDAE	0.2	0.2	0.1	0.1	0.3	0.3	0.3	0	0.3	-0.1	0.1	0.4	0.1	0.2	0.2	0.1	0.6	0
SCARABAEIDAE	0.2	0.2	0.2	0.1	0.4	0.4	0.7	0.2	0.2	0.1	0.4	0.8	0	0.3	0.3	0.6	0.2	-0.1
SCYDMAENIDAE	0.2	0.3	0.2	0.1	0.4	0.5	0.8	0.1	0.1	0.1	0.4	0.8	0.1	0.2	0.3	0.6	0.2	0
SMINTHURIDAE	-0.1	0	-0.5	-0.1	-0.1	-0.2	-0.1	-0.1	-0.2	-0.1	0	-0.1	0.5	-0.1	0.1	-0.1	0.1	0.3
SPIDER	0.4	0.1	0.9	0.4	0.5	0.3	0.3	-0.1	0.4	0	0	0.5	-0.4	0.3	0	0.4	0.2	-0.2
STAPHYLINIDAE	0.4	0.3	0.5	0.3	0.7	0.4	0.9	0	0.1	0	0.4	1	0.1	0.4	0.3	0.7	0.2	-0.1
TEMPERATURE	**-0.3**	**0.5**	**0.1**	**-0.4**	**0.2**	**0.2**	**0.1**	**-0.2**	**0.4**	**-0.2**	**0.3**	**0.1**	**-0.2**	**0.3**	**-0.2**	**0**	**0.2**	**-0.1**
TENEBRIONIDAE	0.2	0.1	0.1	0	0.4	0.4	0.6	0.2	0.4	0.2	0.1	0.6	0	0.4	0	0.5	0.4	-0.1
THYSANOPTERA	-0.2	-0.1	-0.1	-0.2	-0.3	0.2	-0.2	0.1	0.5	-0.1	-0.1	-0.1	-0.3	0.2	-0.2	-0.2	0.3	-0.2
TICKS	-0.4	0.2	0.1	-0.5	-0.1	0.1	-0.2	-0.2	0.3	-0.2	0	-0.2	-0.5	0.1	-0.4	-0.2	0.2	-0.2

Table 2.9 continued

	HEMIPTERA	HISTERIDAE	HUMIDITY	HYDROPHILIDAE	HYMENOPTERA	HYPOGASTRURIDAE	ISOPODA	ISOPTERA	ISOTOMIDAE	LAMPYRIDAE	LARVA	LEPIDOPTERA	LITTER DEPTH	MANTODEA	MELOIDAE	MESOSTIGMATA	MILLIPEDES	ONYCHIURIDAE
ACARIDAE	*	**	N.S	***	***	***	***	***	***	*	**	***	N.S	*	N.S	***	N.S	**
ANTHRIBIDAE	***	**	*	**	*	N.S	N.S	***	*	N.S	***	N.S	*	N.S	N.S	N.S	N.S	N.S
ANTS	***	***	***	**	***	N.S	*	***	***	***	***	N.S	***	N.S	**	N.S	N.S	***
ASTIGMATA	N.S	**	N.S	**	***	***	***	***	***	*	***	***	N.S	**	N.S	***	N.S	*
BLATTARIA	***	***	**	***	***	**	N.S	***	N.S	**	***	N.S	***	*	N.S	***	N.S	N.S
BOSTRICHIDAE	***	***	N.S	***	**	*	N.S	***	**	N.S	***	N.S	*	N.S	**	N.S	N.S	*
CARABIDAE	***	***	N.S	***	***	N.S	N.S	***	N.S	***	***	*	N.S	N.S	N.S	***	**	N.S
CENTIPEDE	N.S	N.S	*	***	N.S	N.S	***	*	N.S	*	N.S	***	*	N.S	N.S	***	N.S	**
CERAMBICIDAE	***	*	***	N.S	*	**	***	**	***	N.S	*	N.S	**	N.S	***	*	N.S	**
CHALCIDAE	N.S	N.S	N.S	***	N.S	*	***	*	**	N.S	N.S	***	N.S	N.S	*	***	N.S	***
CHRYSOMELIDAE	***	***	N.S	***	N.S	N.S	*	***	N.S	N.S	***	N.S	*	N.S	N.S	N.S	*	N.S
COLEOPTERA	***	***	*	***	***	N.S	N.S	***	N.S	***	***	N.S	*	N.S	N.S	***	*	N.S
COLLEMBOLA	N.S	N.S	***	N.S	***	***	N.S	*	***	***	***	*	***	**	N.S	***	N.S	***
CURCULIONIDAE	***	**	**	***	***	*	N.S	***	**	N.S	***	N.S	*	N.S	N.S	N.S	N.S	N.S
DERMAPTERA	*	***	***	***	N.S	***	***	*	***	N.S	N.S	N.S	N.S	N.S	N.S	***	N.S	N.S
DIPTERA	***	***	N.S	***	***	N.S	N.S	***	N.S	***	***	***	N.S	N.S	N.S	***	*	**
ELATERIDAE	***	N.S	N.S	N.S	N.S	N.S	***	**	N.S	N.S	N.S	N.S	*	N.S	***	*	**	N.S
ENTOMOBRIDAE	*	N.S	***	N.S	***	***	N.S	**	***	***	***	N.S	N.S	*	N.S	**	N.S	***
HEMIPTERA	1	***	**	***	***	N.S	N.S	***	N.S	***	***	N.S	**	N.S	*	***	N.S	N.S
HISTERIDAE	0.8	1	N.S	***	***	N.S	**	***	N.S	*	***	N.S	N.S	N.S	N.S	***	*	*
HUMIDITY	-0.3	0	1	N.S	***	*	***	***	***	***	***	N.S	***	**	***	*	N.S	***
HYDROPHILIDAE	0.8	0.8	0	1	***	N.S	***	***	N.S	**	***	**	*	N.S	N.S	***	*	N.S
HYMENOPTERA	0.5	0.34	-0.8	0.4	1	N.S	N.S	***	***	***	***	N.S	***	N.S	*	N.S	N.S	***
HYPOGASTRURIDAE	-0.2	0	0.2	-0.1	-0.1	1	N.S	N.S	***	**	**	*	N.S	N.S	*	***	N.S	***
ISOPODA	-0.1	0.2	0.4	0.5	-0.1	0	1	N.S	**	N.S	N.S	***	N.S	N.S	***	***	*	N.S
ISOPTERA	0.9	0.7	-0.4	0.7	0.7	-0.1	-0.1	1	N.S	***	***	N.S	***	N.S	**	**	N.S	*
ISOTOMIDAE	-0.1	0.2	0.7	0.03	-0.4	0.7	0.3	-0.2	1	***	*	**	***	*	N.S	***	N.S	***
LAMPYRIDAE	0.4	0.2	-0.5	0.3	0.6	-0.2	-0.1	0.5	-0.3	1	***	N.S	***	**	*	N.S	N.S	***
LARVA	0.8	0.7	-0.5	0.7	0.7	-0.2	-0.1	0.9	-0.2	0.6	1	N.S	**	N.S	N.S	*	N.S	N.S
LEPIDOPTERA	-0.1	0.1	0.1	0.3	0.1	0.2	0.5	-0.2	0.2	-0.1	-0.1	1	N.S	N.S	N.S	***	N.S	***
LITTER DEPTH	0.3	0.1	-0.4	0.2	0.4	-0.1	-0.1	0.4	-0.5	0.3	0.3	-0.1	1	**	N.S	N.S	N.S	***
MANTODEA	-0.1	-0.2	-0.3	-0.1	0.1	-0.2	-0.1	0	-0.2	0.2	0.03	-0.1	0.2	1	*	N.S	*	**
MELOIDAE	0.2	0.1	-0.3	0	0.2	0.2	-0.4	0.2	-0.1	0.2	0.2	-0.2	0.2	0.2	1	N.S	***	**
MESOSTIGMATA	0.3	0.5	0.2	0.5	0.2	0.6	0.4	0.3	0.6	0	0.3	0.6	0	-0.2	0.1	1	N.S	***
MILLIPEDES	-0.1	-0.2	-0.1	-0.2	-0.1	0.1	-0.2	-0.1	0	0.1	-0.2	-0.1	-0.1	0.2	0.4	0	1	N.S
ONYCHIURIDAE	-0.1	0.2	0.6	0	-0.4	0.5	0.2	-0.2	0.8	-0.4	-0.2	0.3	-0.6	-0.3	-0.2	0.4	-0.2	1
ORIBATIDAE	-0.2	-0.3	-0.5	-0.2	0.6	0	0	0.1	-0.3	0.4	0.2	0	0	0	-0.1	0	0.1	-0.3
ORTHOPTERA	0.7	0.4	-0.5	0.4	0.6	-0.3	-0.3	0.7	-0.3	0.4	0.7	-0.2	0.1	0	0.2	-0.1	0	-0.2
OTHER HEMIPTERA	0.9	0.7	-0.2	0.6	0.4	-0.1	-0.1	0.7	-0.1	0.2	0.7	-0.1	0.2	-0.1	0.1	0.3	-0.1	0
PROSTIGMATA	0.3	0.4	0	0.4	0.3	0.6	0.2	0.4	0.5	0.2	0.3	0.5	0	-0.2	0.1	0.9	0.03	0.3
PSOCOPTERA	0.9	0.8	-0.2	0.7	0.5	-0.1	-0.1	0.8	-0.1	0.3	0.8	-0.1	0.2	-0.1	0.2	0.3	-0.1	0
PSUEDOSCORPION	1	0.8	-0.3	0.7	0.5	-0.1	-0.1	0.9	-0.1	0.3	0.8	-0.1	0.2	-0.1	0.2	0.3	-0.1	0
PTILIIDAE	0.1	0	-0.5	0	0.7	-0.1	0.1	0.4	-0.2	0.4	0.5	0	0.1	-0.1	-0.2	0.04	-0.2	-0.2
RAIN	-0.2	0.01	0.8	-0.1	-0.6	0.1	0.2	-0.3	0.6	-0.3	-0.3	-0.1	-0.4	-0.2	-0.3	0	-0.1	0.5
REDUVIDAE	0.9	0.8	-0.3	0.7	0.5	-0.2	-0.1	0.9	-0.1	0.4	0.9	-0.1	0.3	-0.1	0.2	0.3	-0.1	-0.1
RHYNCOPHORIDAE	0.4	0.3	-0.2	0.2	0.1	0.2	-0.2	0.4	0.1	0.1	0.3	-0.1	0	-0.1	0.5	0.3	0.3	0
SCARABAEIDAE	0.8	0.7	0	0.8	0.2	-0.1	0.2	0.6	0.1	0.1	0.6	0.1	-0.1	-0.1	0.1	0.33	-0.1	0.2
SCYDMAENIDAE	0.7	0.7	0.1	0.8	0.2	-0.1	0.2	0.7	0.2	0.3	0.6	0.1	0.2	0	0.1	0.5	-0.2	0.1
SMINTHURIDAE	-0.1	0	0.7	-0.1	-0.5	0.03	0.02	-0.2	0.4	-0.3	-0.3	-0.1	-0.1	-0.2	-0.2	0	-0.1	0.4
SPIDER	0.5	0.3	-0.8	0.2	0.9	0	-0.2	0.6	-0.4	0.5	0.6	0	0.4	0.1	0.5	0.2	0.1	-0.4
STAPHYLINIDAE	0.9	0.8	-0.1	0.8	0.5	0	0.1	0.9	0.1	0.4	0.8	0	0.1	-0.2	0	0.4	-0.2	0.2
TEMPERATURE	0.3	0.1	-0.3	0	0.1	0	-0.5	0.2	-0.3	-0.2	0.1	-0.2	0.1	-0.1	0.2	-0.2	-0.1	-0.1
TENEBRIONIDAE	0.6	0.5	-0.1	0.5	0.2	-0.1	0	0.4	0.1	0.1	0.4	0.2	0	-0.2	0	0.3	-0.1	0.2
THYSANOPTERA	-0.1	-0.2	-0.1	-0.2	-0.1	-0.3	-0.2	-0.2	-0.3	-0.1	-0.2	-0.1	-0.3	0	0.2	-0.2	0.4	-0.2
TICKS	-0.1	-0.3	-0.3	-0.3	0	-0.4	-0.4	-0.1	-0.6	0.1	-0.2	-0.2	0.5	0.4	0.1	-0.5	0.1	-0.5

Table 2.9 continued

	ORIBATIDAE	ORTHOPTERA	OTHER HEMIPTERA	PROSTIGMATA	PSOCOPTERA	PSUEDOSCORPION	PTILIIDAE	**RAIN**	REDUVIIDAE	RHYNCOPHORIDAE	SCARABAEIDAE	SCYDMAENIDAE	SMITHURIDAE	SPIDER	STAPHYLINIDAE	**TEMPERATURE**	TENEBRIONIDAE	THYSANOPTERA	TICKS
ACARIDAE	***	N.S	N.S	***	*	*	***	*	*	**	*	**	N.S	***	***	**	N.S	*	***
ANTHRIBIDAE	*	*	*	N.S	***	***	N.S	*	***	*	*	***	N.S	N.S	***	***	N.S	N.S	N.S
ANTS	***	***	***	**	***	***	***	***	***	N.S	*	*	***	***	***	N.S	N.S	N.S	N.S
ASTIGMATA	***	N.S	N.S	***	N.S	N.S	***	N.S	N.S	N.S	N.S	N.S	N.S	***	***	***	N.S	N.S	***
BLATTARIA	N.S	***	***	***	***	***	***	**	***	**	***	***	N.S	***	***	N.S	***	**	N.S
BOSTRICHIDAE	N.S	*	*	N.S	***	***	N.S	*	***	***	***	***	N.S	***	***	*	***	N.S	N.S
CARABIDAE	N.S	***	***	***	***	***	N.S	N.S	***	**	***	***	N.S	***	***	N.S	***	**	**
CENTIPEDE	N.S	**	N.S	**	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	*
CERAMBICIDAE	N.S	**	*	N.S	***	**	N.S	***	***	**	*	N.S	N.S	***	N.S	***	***	***	***
CHALCIDAE	N.S	**	N.S	***	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	*	N.S	*
CHRYSOMELIDAE	**	N.S	***	N.S	***	***	N.S	N.S	***	N.S	***	***	N.S	N.S	***	***	N.S	N.S	N.S
COLEOPTERA	N.S	***	***	***	***	***	**	*	***	***	***	***	N.S	***	***	N.S	***	N.S	*
COLLEMBOLA	**	***	N.S	***	N.S	N.S	**	***	N.S	N.S	N.S	N.S	***	***	N.S	*	N.S	**	***
CURCULIONIDAE	N.S	***	***	N.S	***	***	N.S	***	***	N.S	***	*	N.S	**	***	***	***	N.S	N.S
DERMAPTERA	*	N.S	**	***	*	*	N.S	N.S	N.S	N.S	***	***	N.S	N.S	***	**	N.S	N.S	***
DIPTERA	N.S	***	***	***	***	***	*	N.S	***	N.S	***	***	N.S	***	***	N.S	***	*	**
ELATERIDAE	N.S	*	*	*	*	**	N.S	*	***	***	*	*	N.S	N.S	*	**	***	***	N.S
ENTOMOBRYIDAE	***	***	N.S	N.S	*	*	***	***	**	N.S	N.S	N.S	**	N.S	N.S	N.S	N.S	*	*
HEMIPTERA	N.S	***	***	**	***	***	N.S	*	***	***	***	***	N.S	***	***	**	***	N.S	N.S
HISTERIDAE	**	***	***	***	***	***	N.S	N.S	***	**	***	***	N.S	***	***	N.S	***	*	***
HUMIDITY	***	***	*	N.S	**	**	***	***	**	N.S	N.S	N.S	***	***	N.S	***	N.S	N.S	***
HYDROPHILIDAE	*	***	***	***	***	***	N.S	N.S	***	*	***	***	N.S	**	***	N.S	***	N.S	**
HYMENOPTERA	***	***	***	***	***	***	***	***	***	N.S	**	**	***	***	***	N.S	N.S	N.S	N.S
HYPOGASTRURIDAE	N.S	***	N.S	***	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	**	***
ISOPODA	N.S	**	N.S	**	N.S	N.S	N.S	*	N.S	*	*	*	N.S	*	N.S	***	N.S	N.S	***
ISOPTERA	N.S	***	***	***	***	***	***	**	***	***	***	***	N.S	***	***	N.S	***	N.S	N.S
ISOTOMIDAE	**	***	N.S	***	N.S	N.S	*	***	N.S	N.S	N.S	N.S	***	***	N.S	***	N.S	**	***
LAMPYRIDAE	***	***	*	N.S	***	***	***	***	***	N.S	N.S	**	**	***	***	N.S	N.S	N.S	N.S
LARVA	*	***	***	***	***	***	***	**	***	**	***	***	**	***	***	N.S	***	N.S	N.S
LEPIDOPTERA	N.S	*	N.S	***	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*
LITTER DEPTH	N.S	N.S	*	N.S	*	**	N.S	***	**	N.S	N.S	*	N.S	***	N.S	N.S	N.S	**	***
MANTODEA	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S	N.S	***
MELOIDAE	N.S	N.S	N.S	N.S	*	*	N.S	***	*	***	N.S	N.S	**	***	N.S	*	N.S	**	N.S
MESOSTIGMATA	N.S	N.S	**	***	**	**	N.S	N.S	**	***	***	***	N.S	N.S	***	N.S	**	*	***
MILLIPEDES	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	***	N.S	*	N.S	N.S	*	N.S	N.S	***	N.S
ONYCHIURIDAE	***	N.S	N.S	***	N.S	N.S	*	***	N.S	N.S	N.S	N.S	***	***	N.S	N.S	*	*	***
ORIBATIDAE	1	**	N.S	**	N.S	N.S	***	***	N.S	N.S	*	***	***	***	N.S	***	N.S	N.S	N.S
ORTHOPTERA	0.3	1	***	N.S	***	***	***	***	***	**	***	***	**	***	***	N.S	***	**	N.S
OTHER HEMIPTERA	-0.1	0.7	1	*	***	***	N.S	N.S	***	*	***	***	N.S	***	***	*	***	N.S	N.S
PROSTIGMATA	0.3	0.1	0.2	1	**	**	***	N.S	**	***	**	***	N.S	**	***	*	*	N.S	***
PSOCOPTERA	-0.2	0.7	0.9	0.3	1	***	N.S	*	***	***	***	***	N.S	***	***	**	***	N.S	N.S
PSUEDOSCORPION	-0.2	0.7	0.9	0.3	1	1	N.S	*	***	***	***	***	N.S	***	***	**	***	N.S	N.S
PTILIIDAE	0.8	0.4	0.1	0.3	0.1	0.1	1	**	N.S	N.S	N.S	N.S	**	***	*	***	N.S	N.S	N.S
RAIN	**-0.3**	**-0.3**	**-0.2**	**-0.1**	**-0.2**	**-0.2**	**-0.3**	**1**	*	N.S	N.S	N.S	***	***	N.S	***	*	*	***
REDUVIDAE	-0.2	0.6	0.7	0.3	0.8	0.9	0.1	**-0.2**	1	***	***	***	N.S	***	***	**	***	N.S	N.S
RHYNCOPHORIDAE	-0.1	0.3	0.2	0.4	0.3	0.4	-0.1	**-0.1**	0.4	1	**	**	N.S	**	***	*	**	***	N.S
SCARABAEIDAE	-0.2	0.6	0.8	0.3	0.7	0.8	0	**-0.1**	0.75	0.3	1	***	*	*	***	N.S	***	N.S	**
SCYDMAENIDAE	-0.3	0.3	0.6	0.3	0.7	0.7	-0.1	**0**	0.8	0.3	0.6	1	N.S	*	***	N.S	***	*	N.S
SMINTHURIDAE	-0.3	-0.3	-0.1	-0.1	-0.1	-0.1	-0.2	**0.8**	-0.1	0	-0.2	0	1	***	N.S	N.S	*	N.S	N.S
SPIDER	0.5	0.6	0.4	0.3	0.4	0.4	0.5	**-0.6**	0.4	0.2	0.2	0.2	-0.5	1	***	N.S	*	N.S	N.S
STAPHYLINIDAE	-0.1	0.7	0.7	0.4	0.8	0.9	0.2	**0**	0.9	0.3	0.7	0.8	0	0.4	1	N.S	***	N.S	**
TEMPERATURE	**-0.4**	**0.2**	**0.2**	**-0.2**	**0.3**	**0.3**	**-0.3**	**-0.4**	**0.3**	**0.2**	**0.1**	**0**	**-0.1**	**0.1**	**0.1**	**1**	*	N.S	**
TENEBRIONIDAE	-0.1	0.5	0.5	0.2	0.5	0.6	-0.1	**-0.2**	0.5	0.2	0.7	0.5	-0.2	0.2	0.6	**0.2**	1	N.S	N.S
THYSANOPTERA	0.1	0.2	-0.1	-0.2	-0.1	-0.1	-0.1	**-0.2**	-0.1	0.4	0.1	-0.2	-0.2	0.1	-0.2	**0.1**	0.2	1	N.S
TICKS	0	0	-0.1	-0.5	-0.1	-0.1	-0.1	**-0.4**	-0.1	-0.1	-0.2	-0.2	-0.1	0.1	-0.3	**0.3**	0	0.2	1

Table 2.10. Partial correlation analysis of the relation between climatic and habitat physical factors and major arthropod fauna in the evergreen forest litter stand during the study period.

VARIABLES	D.F.	R	*P*
Ants – Humidity	115	-0.81	***
Ants - Litter Depth	115	0.18	*
Ants – Rain	115	0.45	***
Ants – Temperature	115	-0.20	*
Blattaria – Humidity	115	0.00	N.S
Blattaria - Litter Depth	115	0.27	**
Blattaria – Rain	115	-0.07	N.S
Blattaria - Temperature	115	0.07	N.S
Coleoptera - Humidity	115	-0.1	N.S
Coleoptera - Litter Depth	115	0.14	N.S
Coleoptera – Rain	115	0.003	N.S
Coleoptera - Temperature	115	0.050	N.S
Coleoptera - Humidity	115	0.46	***
Coleoptera - Litter Depth	115	-0.19	*
Coleoptera – Rain	115	-0.05	N.S
Coleoptera - Temperature	115	0.0139	N.S
Isopoda - Humidity	115	0.47	***
Isopoda - Litter Depth	115	0.068	N.S
Isopoda - Rain	115	-0.34	***
Isopoda - Temperature	115	-054	***
Isoptera - Humidity	115	0.068	N.S
Isoptera - Litter Depth	115	0.2857	**
Isoptera - Rain	115	0.234	*
Isoptera - Temperature	115	0.086	N.S
L - Humidity	115	-0.428	***
Larva - Litter Depth	115	0.111	N.S
Larva - Rain	115	0.236	**
Larva - Temperature	115	-0.033	N.S
Mite - Humidity	115	0.166	N.S
Mite - Litter Depth	115	-0.01	N.S
Mite - Rain	115	-0.32	***
Mite - Temperature	115	-0.393	***
Spider - Humidity	115	-0.658	***
Spider - Litter Depth	115	0.059	N.S
Spider - Rain	115	0.150	N.S
Spider - Temperature	115	-0.272	**

N.S., Not significant; *$P \leq 0.05$; **$P \leq 0.01$; *** $P \leq 0.001$
(Independent variables: Litter depth, Rain, Temperature, Humidity)

INTRODUCTION

The Western Ghats in South-West India, experiences variations in both altitudinal and latitudinal climatic factors, such as the total annual rainfall, peak rainy season and its duration, the number of rainy days, the maximum temperature and the seasons when the rise in temperature occurs. The Western face of the Ghats receives higher rainfall than the eastern face, leading to sharper floristic difference between the western and eastern slopes. The forests in the eastern slopes are predominantly dry-deciduous and those along the western slopes are moist-deciduous scattered with undisturbed climax evergreen and shola forests, which remain as the isolated islands of the original residual forests. Most of the low and mid land deciduous forests in the windward western slopes have been fragmented and are prone to disturbances because of the conversion of the landscape into agricultural and monoculture plantation forests (Nair 1991; WWF 2001).

Deciduous forests are composed primarily of broad-leaved trees that shed their leaves prior to the dry season and bear new shoots and leaves at the begining of the rainy season (Santiago and Mulkey 2005; Sundarapandian *et al.* 2005). Seasonality in litter shedding leads to seasonal variations in the litter habitat structure and litter thickness in deciduous forests. Studies elsewhere have shown that variations in the litter habitat structure, litter fall, litter thickness, litter moisture and decomposition rates, along with climatic factors, *viz.* rainfall and temperature lead to seasonal variations in the abundance and community-structure of litter arthropod fauna (Holt 1985; Levings and Windsor 1982, 1984, 1985; Hassall *et al.* 1986; Wolda 1988; Frith and Frith 1990; Burgess *et al.* 1999; Wakelin 2000; Barberena-Arias and Aide 2003) and the influence of these factors may be direct or indirect, in the form of food availability, habitat suitability and foraging area. (Olson 1994; Brühl *et al.* 2003; Lensing *et al.* 2005). Litter arthropods are broadly classified into four feeding guilds *viz.* microbial-detritivores, detritivores, fungivores and predators (Seastedt 1984; Moore *et al.* 1988, Ananthakrishnan 1996). The Seasonality of each faunal group ensures not merely the seasonality in climatic factors, but also the prey availability and predator abundance (Tanaka *et al.* 1987; Wolda and Tanaka 1987; Barberena-Arias and Aide 2003; Wise 2004; Anu 2006).

Very limited data exists in literature to understand the abundance, community-structure and seasonality of litter arthropod fauna and also to ascertain how the seasonality of various ecological factors do influence the distribution pattern of litter invertebrates in the moist deciduous forests of Western Ghats.

The main objective of this study is to provide data on the following aspects of litter arthropod faunal dynamics in a deciduous forest in the western slope of south Western Ghats.

1. Seasonal variations in the abundance, diversity and feeding guild composition,

2. Influence of habitat physical factors (temperature, rain, humidity, litter depth) on litter arthropod abundance; and,

3. Reciprocal relationships between the fauna.

MATERIAL AND METHODS

Site: Paithalmala, according to forest records- "Vaithalmala", is a vested forest under the jurisdiction of Kannur forest division. It consist of an area of 20 km^2 of forest (12°N and 75°50'E) situated at 1372 m above sea level near the Kerala-Karnataka border in Brahmagiri slope in Kannur district. It is virtually the northern limit of the western slope of the Ghats in Kerala (Plate 1). No biological surveys have been conducted in this region, to assess the forest floor arthropod biodiversity of the region (Nair 1991). The forests are of deciduous type except for the small evergreen patches in the higher regions. The deciduous forest in Paithalmala (Plate 2) is a degraded forest due to severe anthropogenic influences, forest fire and extensive grazing. The average slope of the terrain is above 25° and the forest is mostly of the deciduous type. In certain small mountain pockets near hilltops, small evergreen patches with small streams are present (Forest and Wildlife 2001). An annual precipitation of 3110 mm was received during the study period 2002-03, of which 85.1% was received during June - Aug (southwest monsoon), 10.68 % during Sep-Nov (northeast monsoon), 4.2% during Mar-May (summer) and the remaining 0.02% during Dec-Feb (pre-summer) (Fig. 3.1a and b). Heavy rainfall occurred during June and July and January recorded no rain at all. Branch breaking and uprooting of trees due to strong winds and landslides were prevalent during June-Aug (s-w monsoon season). Litter thickness was 2-6 cm (Table 3.1). The principal upper storey species are *Terminalia* species (such as Maruth, Kadukka and Thanni), *Lagerstroemia lanceolata* (Venthekku, known as the naked maiden of the forest), *Dalbergia latifolia, Grevia tiliaefolia, Tectona* sp. (teak) and *Cassia fistula*. The leaves of these trees are characteristically light green, in contrast to the dark green leaves of trees in the tropical evergreen forests.

Sampling: Random quadrates sampling method is followed in this study (Boinski and Fowler 1989). A fine grid was superimposed on the site map and the coordinates for ten quadrates each measuring 5 X 5 m were selected randomly at the deciduous part of the forest. The quadrates were initially positioned in the field, following distance and compass direction from pre-existing permanent markers like rivers and streams. Then the quadrates were permanently marked using plastic wires and iron rods. Litter arthropods were collected from the ten permanently marked quadrates in the field every month. Each sampling point within the quadrates was located and selected at random for monthly collection. All actual sampling was done on a day in the closing week of each month from December 2002 to November 2003. The time of sampling was between 8-10 am. During rainy season sampling was done three days after the rain, to minimise the direct effect of rain on various fauna (Brühl *et al.* 2003). This pattern of sampling could not be strictly adhered during June and July and sampling was done on any non-rainy day in the last week of the month.

Each sample was collected by placing a 50 x 50 cm (1/4 m^2) wooden quadrant frame onto the litter and then scraping out all leaves, twigs, fruits, and loose humus from within the frame area with a thin wooden scraper into a large polythene bag. Samples were collected as quickly as possible to avoid arthropods escaping by flying, running or digging away. No arthropods were observed escaping and I believe that minor cases of escape, if any, are insignificant. The litter thus collected for analysis consists of the upper organic litter and the loose humus layer. No underlying compacted soil was taken. One hundred and twenty (120) samples were collected for data analysis during one year at the rate of ten samples a month. An average of 3 months data was conceived as the seasonal data (30 samples for each season). Fauna was extracted with Berlese funnel apparatus (30.5cm diameter 35.6cm height, 25w bulb). The extracted fauna were sorted under a stereo zoom trinocular microscope (Labmode-ZM45 TM) and the adult organisms were identified to order level (family level for coleopteran and collembola) using keys of Borror *et al.* (1996). After this preliminary identification, the arthropods were placed in small-labelled vials (Tarson, model no: 510000) containing 70 % ethyl alcohol. The adults were assigned to morphospecies and sent to taxonomic authority for identification. The fauna were categorised as major fauna and minor fauna. (Major Fauna: the taxa which enjoy representation in all seasons and have more than 10 mean

No. / (1/4) m^2 at any season and the other taxa were considered as minor fauna)

Categorisation of forest vegetation type is based on the working plan of the forest department (Forest and Wildlife 2001), Kannur forest division. The rainfall data was collected from the meteorological station of the District agricultural farm Taliparamba. Humidity and litter temperature were assessed with thermo-hygrometer (Barigo; Barigo Barometer fabric GmbH; Villingen-Schwenningen; Germany) and litter depth was measured using Boinski and Fowler (1989) method: measures in each corner of the quadrant, 5 cm inside the permanent wire marker. Four values of litter depths from each corner were then averaged for each sample. The slope of the terrain was calculated using the Trigonometric formula 'tan θ' (where 'θ' is the angle of inclination) (Jacobs and Meyer 1972). Litter humidity, temperature, slope of the terrain and litter depth were calculated as the mean of the 10 sampling spots each month (Table 3.1).

Data Analysis: Since data was normally distributed, no data transformation was carried out for any statistical data analysis. Community diversity was assessed in terms of parametric Fisher's alpha (α) diversity index and the nonparametric indices *viz.*, Shannon diversity (H'), Simpson's dominance (D), Pielou's evenness (J'), Margalef's richness (d), (alpha diversity index). Community similarity was assessed with Bray Curtis similarity index followed by Cluster Analysis.

1) Fisher's Alpha diversity (α)

Fisher's Alpha diversity (Parametric diversity index) is widely used in literature because we can calculate the index knowing only species richness (S) and the total number of individuals (N). Fisher's Alpha (α) diversity index involves a comparison of variations in number of individuals (N); and is theoretically independent of sample size (Fisher *et al.* 1943).

$$a = N\,(1-x)/x$$

Estimate x from the iterative solution of:

$$S/N = (1-x)/x\,(-\ln\,(1-x))$$

Where, S = number of species,

N = total number of individuals.

2) Shannon diversity index (H')

This is the most traditionally used index and one of the most enduring of all diversity measures. It is an index taking both richness and evenness into account i.e. high overall diversity occurs when the number of species (richness) and the evenness component are large (low dominance) (Magurran 2004).

The value of the Shannon index obtained from empirical data usually falls between 1.5 and 3.5 and rarely surpasses 4 (Margalef 1972). In general, mature and stable communities will have high diversity values and communities under severe stress would exhibit low diversity usually nearer to zero (Magurran 2004). It was calculated with the following equation (Shannon and Weaver 1949).

$$H' = -\Sigma_i P_i (\log(P_i))$$

Where, P_i is the proportion of the total count arising from the i^{th} species

$$P = S/N$$

Where, S = total individual number of a species

N=total individual numbers of all species.

Logarithms to the base of e (Natural logarithm) was used.

3) Simpson's Dominance index

Simpson's index (λ) is a measure of dominance whose maximum value is one. Simpson's index gave the probability of any two individuals drawn at random from an infinitely large community belonging to the same species. As 'λ' increases, diversity decreases, which are clearly seen in the case of a single species (complete dominance). Near zero values are obtained, when numerous species are present (no dominance). Each species representing a small fraction of the total value (Magurran 2004).

It was calculated with the following equation (Simpson 1949)

$$\lambda = \Sigma p_i^2$$

Where, p_i is the proportion of the total count arising from the i^{th} species.

4) Pielou's Evenness

Evenness refers to the area equitability of the taxa. It is expressed as Pielou's evenness index (J') (Pielou 1975; Magurran and Henderson 2003)

$$J' = H' / \log S$$

Where, H' is Shannon diversity index

S is the total number of taxa.

5) Margalef's richness index

It expresses the number of taxa/groups existing in the region studied. For analyzing taxa richness, Margalef's index (Clifford and Stephenson 1975; Magurran 2004) is used. It is calculated by the following formula.

$$d = S - 1 / \log (N)$$

Where, d is Margalef's index,

S is the total number of taxa

N is the total number of individuals

6) Cluster Analysis

Bray-Curtis similarity index (Bray and Curtis 1957) was used to compare the similarity between the assemblages arriving at different seasons followed by Cluster analysis (Clarke and Warwick 2001)

The seasons were grouped and the groups themselves were formed into clusters on levels of similarity. Clarke and Warwick (2001) tested goodness of all similarity indices using six criterion (Magurran 2004) and found that Bray-Curtis index is a comparatively better index than all other widely used index as it meets all the following requirements of a good index. 1. The value will be 1 (or 100) when two samples are identical; 2. The value will be zero when samples have no species in common; 3. A change of measurement unit does not affect the value of the index; 4. The value is unchanged by the inclusion or exclusion of a species that occurs in neither sample; 5. The inclusion of a third sample makes no difference to the similarity of the initial pair of the samples; 6. The index reflects difference in total abundance (and not just relative abundance). It is calculated by the following formula.

$$BC_{jk} = 100\left\{1 - \frac{\sum_{i=1}^{p}\left|y_{ij} - y_{ik}\right|}{\sum_{i=1}^{p}\left(y_{ij} + y_{ik}\right)}\right\}$$

Where, BC_{jk} is the similarity between the j^{th} and k^{th} season, and Y_{ij} represents the abundance for the i^{th} species in the j^{th} season. Y_{ik} represents the abundance for the i^{th} species in the k^{th} season.

All diversity analysis was done with Primer v5 package (Clarke and Gorley 2001)

Statistical analysis: The extent of causality of abiotic factors (climatic and habitat variables *viz.*, rainfall, humidity, litter temperature and litter depth), on major arthropod fauna (responding variable) was assessed using multiple regression analysis (Zar 2003). Inherent collinearity (multicollinearity) of explanatory variables was analysed with simple and partial correlation (Neter *et al.* 1996).

Relationship between faunal abundance, and climatic and habitat physical factors and among faunal groups was analysed with Pearson (multiple) correlation (Zar 2003; Goehring *et al.* 2002).

Significance levels of the variations in the abundance and diversity (Five α index) of arthropod groups during the different seasons were tested with One way Analysis of Variance (ANOVA). Pair wise significance differences were further compared using Tukey's HSD (Zar 2003). Significance levels were determined at $P<0.05$. ANOVA and Tukey's HSD analysis were carried out by using KyPlot software (Yoshioka 2000). All other statistical analysis was done with GRETL open source software version 1.1 (Cottrell 2006).

RESULTS

SECTION I: **ABUNDANCE, DIVERSITY AND FEEDING GUILDS**

1. Overall faunal abundance, diversity and feeding guild: Fortytwo arthropod taxa, belonging to sixteen arthropod orders, have been recorded from the litter stands of Paithalmala deciduous forest (Table 3.2 and Fig. 3.2). Acari followed by Hymenoptera, Collembola, Coleoptera and Thysanoptera were the abundant arthropod orders (Fig. 3.3). Mantodea, Psocoptera, Diptera and Dermaptera (each taxa <0.5%) were the least abundant groups (Table 3.3 and Fig. 3.4). Members belonging to predatory feeding guild were found to be the most abundant (contributing 47 % of the total faunal abundance) and the fungivores the lowest.

2. Seasonal variation in abundance, diversity, and feeding guild composition

2a. Seasonal variation in the abundance: Ten out of the 16 orders were present during all the four seasons. (Table 3.2) Collembola dominated during southwest monsoon, Acari during pre-summer and northeast monsoon and Hymenoptera during summer (Fig.3.3). No significant variation in seasonal arthropod faunal abundance was found. Overall faunal abundance was highest during northeast monsoon season and lowest during the southwest monsoon season.

Major Fauna: Collembola (Entomobryidae, Hypogastruridae, Onychiuridae), Coleoptera (Staphylinidae), Thysanoptera, Hymenoptera (ants), larvae, spiders, mites (Oribatida, Astigmata, Prostigmata, Mesostigmata) were the major litter arthropods. Their seasonal abundance pattern is as follows:

Collembola: Highest abundance of collembola was observed during southwest monsoon season followed by northeast monsoon season. Lowest occurrence was found during the pre-summer period. Abundance during summer season was twice than that in the pre-summer season. More than 48% of the total collection of the collembolans was recorded during the southwest monsoon. Four families of collembolans were identified from this site. Onychiuridae was the dominant collembolan family (Table 3.2).

Coleoptera: Fourteen coleopteran families were recorded. Staphylinidae was the most abundant coleopteran family. The highest abundance of Coleoptera was recorded during northeast monsoon season and minimal occurrence during the summer season (Table 3.2).

Thysanoptera: Highest abundance of Thysanoptera (46%) was noted during the northeast monsoon season and lowest abundance was recorded during the southwest monsoon period (Table 3.2).

Hymenoptera: Eleven species of ants were identified from Paithalmala litter stands (Table 3.4). Their highest abundance (35%) was recorded during the pre-monsoon season. Lowest abundance was observed during the southwest monsoon season (less than 10% of the total collection) (Table 3.2).

Larvae: Highest larval abundance was found during northeast monsoon season (50 per (¼) m^2) and the lowest during southwest monsoon season (32 per (¼) m^2) (Table 3.2 and Fig. 3.3).

Spiders: Highest abundance of spiders was observed, during the pre-monsoon season followed by summer season and the lowest recorded during the southwest monsoon season (Fig. 3.3).

Mites: Their highest abundance pertains to the northeast monsoon season followed by the pre-monsoon season. Least occurrence was recorded during the southwest monsoon season. Twentyone species of mites were identified during this study tenure (Table 3.4).

Minor fauna: Sminthuridae, Curculionidae, Tenebrionidae, Lampyridae, Scarabaeidae, Anthribidae, Bostrichidae, Nitidulidae, Chrysomelidae, Elateridae, Hydrophilidae, Carabidae, Scydmaenidae, Endomychidae, Psocoptera, Diptera, Orthoptera, Dermaptera, Isoptera, Blattaria, Mantoidea, Chalcidae, Reduviidae, Hemiptera, Isopoda, millipedes, ticks, Pseudoscorpion and centipedes were the minor faunal groups (Fig. 3.4). Highest abundance of isopterans was observed during the pre-monsoon season followed by the northeast monsoon season. Blattids were richly abundant (5 per (¼) m^2) during the summer season, followed by northeast monsoon season. Lowest abundance of blattids was during the southwest monsoon season. Highest abundance of Pseudoscorpions was recorded during the Northeast monsoon and the lowest during the summer season. Highest occurrence of orthoptera was during the summer season (4 per (¼) m^2) followed by the pre-summer season and the lowest during southwest monsoon. Dermaptera was absent during the summer months. The presence of mantids was confined to the pre-summer season and that of psocopterans and hemipterans during the northeast and southwest monsoon seasons. Diptera was found during all seasons except in summer. Millipedes were found during all seasons. Centipedes were present during all seasons except pre-summer (Fig. 3.4). Chalcids were found only in northeast monsoon season and pre-summer season (Table 3.2).

2b. Seasonal variation in diversity (alpha and beta)**:** Community diversity of litter arthropod fauna showed the highest Shannon diversity index (H'=3.61) during the northeast monsoon season. Lowest Simpson's dominance index (λ = 0.03) was found during the northeast monsoon season. The highest evenness index (J' = 0.97) also observed during northeast monsoon. Highest Fisher's Alpha diversity index was recorded during pre-summer (α = 7.88) and followed by northeast monsoon season (α = 7.21). Lowest Fisher (α = 5.84) and Shannon (H' = 3.24) diversity indices values were recorded during summer season (Table 3.5).

Bray Curtis similarity index showed high similarity between summer and pre-summer seasons (80.80) followed by summer and northeast monsoon season (68.59). Lowest similarity was recorded between southwest monsoon and summer seasons (58.30) (Fig. 3.5).

2c. Seasonal variation in feeding guild composition: All feeding guilds were present during all seasons, but their relative abundance varied. During pre-summer, summer and northeast monsoon seasons, predatory feeding guild was dominant. The least abundant feeding guild during pre-summer and summer seasons was microbial detritivores and fungivores during northeast and southwest seasons. During southwest monsoon, microbial detritivores was the dominant feeding guild (Table 3.2). Staphylinidae, predatory Acari (Astigmata, Prostigmata and Mesostigmata) and ants were the dominant predatory taxa in all seasons. Thysanopterans were the dominant fungivore. Isopterans, larva, mites (Oribatida) were the dominant detritivores and the collembolans, the only recorded microbial detritivores.

2d. Statistical analysis: There was no significant variation in overall arthropod faunal abundance during the four seasons (ANOVA $F_{3,\ 168}$ = 1.206; $P > 0.05$). Evenness ($F_{3,\ 116} = 34.04$, $P < 0.000$), Shannon diversity ($F_{3,\ 116} = 56.92$, $P < 0.000$), Simpson's index ($F_{3,\ 116} = 34.52$, $P < 0.000$), richness (Margalef) ($F_{3,\ 116} = 72.41$, $P < 0.000$) and Fishers alpha value ($F_{3,\ 116} = 63.82$, $P < 0.000$) showed significant seasonal variation (ANOVA).

Tukey analysis showed significant seasonal variation in Margalef richness index, between the northeast and pre-summer; northeast and summer; northeast and southwest seasons (northeast monsoon season and all other season). Evenness index and Shannon diversity index showed a similar trend in Tukey analysis, which demonstrated significant seasonal variation in all seasonal pairs (index between the northeast and pre-monsoon; northeast and summer; northeast and southwest; southwest and pre-summer, southwest and summer seasons) except between the pre-summer and summer seasons. Significant seasonal variation in Simpson's dominance index showed significant variation in all pairs of season except the pre-summer and summer, southwest and northeast. Fisher's diversity index showed significant variation in all seasonal pairs except those of pre-summer and summer and pre-summer and southwest monsoon (Table 3.6).

SECTION II: **ABIOTIC FACTORS AND RECIPROCAL RELATIONSHIPS BETWEEN FAUNA**

Multiple regression analysis of major fauna showed that abiotic factors *viz.* rainfall, temperature, humidity and litter depth have shown significant influence on the faunal abundance of Collembola (Entomobridae, Hypogastrudidae, Onychiuridae), Coleoptera (Staphylinidae), Thysanoptera, Hymenoptera (ants), spiders, mites (Oribatida, Astigmata, Prostigmata, Mesostigmata), while all the abiotic factors remain non significant with regard to the larval abundance (Table 3.7). Presence of multicollinearity between explanatory variables does not permit the analysis of influences of individual abiotic factors on faunal abundance (Table 3.8 and 3.9)

Pearson's correlation analysis showed significant positive correlation between humidity and the abundance of Collembola, Anthribidae, Hydrophilidae and a significant negative correlation with the abundance of ants, spiders and blattarians. Rainfall establishes a significant positive correlation with abundance of collembolans and a relevant negative correlation with the abundance of ants, spiders and isopterans. Litter depth and the abundance of blattarians, ants and chrysomelids showed significant positive correlation. Mite and larval abundance showed significant negative relationship with temperature (Table 3.8).

Pearson's correlation analysis showed inter-group interactions of significant positive and negative interaction with other group's abundance. Acari order showed 25 positive and 13 negative significant relations, while ant abundance showed 11 negative and 11 positive correlations with other faunal abundance. The various correlations of each fauna tabulated (Table 3.8).

DISCUSSION

No significant seasonal variation is evident in the abundance of litter arthropod fauna in regional deciduous forests. However, arthropod diversity showed significant seasonal difference, which is attributed to the variations in richness and evenness during different seasons. High Shannon diversity was recorded during the northeast monsoon and is attributable to the high seasonal richness and abundance, which can be traced to the fact that it is a transitional season between rainy and non-rainy season. Suitability of transitional period between rainy and non rainy seasons for arthropods is supported by various earlier studies (Levings and Windsor 1985; Burgess *et al.* 1999). Highest arthropod faunal similarity between pre-summer and northeast monsoon can be related with the similar abiotic condition of litter, especially similar humidity and temperature. Compared to, nearby litter stands of deciduous forest in Thirunelli (Wayanad) (Sabu 2005), all fauna showed lesser abundance, except thysanoptera, which showed exceptionally high abundance in the region.

No seasonal variation in abundance of litter arthropods was explicit from the distribution pattern of arthropod fauna (Fig. 3.1b). Significant disparity in seasonal diversity obviously indicated variation in richness and evenness of litter arthropod fauna (Table 3.5). Relationship between the abundance of litter arthropod faunal groups and climatic factors, based on group specific behavioural pattern of arthropod fauna, has been recorded in the earlier studies on litter arthropod (Frith and Frith 1990; Raghavendra 2001; Lensing *et al.* 2005) and the regression analysis of current study conforms to the earlier records.

Correlation analysis reveals that abundance of individual groups are influenced by abundance of other faunal groups and abiotic factors *viz.* rainfall, temperature, humidity and litter depth. Inter-group faunal abundance, interactions and influence of litter abiotic factors on individual fauna, have been confirmed by various studies undertaken, in other regions (Rahbek 1995; Rosenzweig 1995; Lomolino 2001; Sanders *et al.* 2003; Sabu 2005; Vineesh *et al.* 2007).

Non-seasonal variation in faunal abundance is related to the mutual compensatory seasonal abundance patterns of abundant faunal groups *viz.* mites, collembola and ants (Table 3.2) and it leads to similar abundance pattern of overall fauna. High abundance of Collembola was observed during southwest and northeast monsoon season and of mites during pre-summer and northeast monsoon season, but ant abundance was lower during these seasons. When ant abundance was high in summer, collembolan and mite abundance were lower. These peculiar faunal abundance patterns are determined by the peculiarity of climatic factors of the region and is substantiated by the regression results. Low litter depth (low litter depth during pre-summer due to slope, decomposition and wind velocity) and the quick drying up of thick litter layer during summer, result in the vertical migration of the Collembola (Lensing *et al.* 2005). Significant positive correlation between the abundance of mites and rainfall established. Due to the pressure of persistent rain (seasonal and off-seasonal) and fog during southwest, northeast monsoon season and pre-summer seasons higher litter humidity, which helps abundance of mites (Ferguson and Joly 2002), occurs in this site (almost) through out the year. Contrastingly low ant abundance results from the rainfall mediated wetness of litter (Brühl *et al.* 2003).

High abundance of predatory feeding guild was noticed in the total collection and during the pre-summer, summer and northeast monsoon season, which is arising from the predominance of ants (20%), spiders and beetles (Eisenbeis and Wichard 1987; Fergusan 2001). During southwest monsoon season, microbial detritivore was the dominant feeding guild associated with the higher abundance of collembola.

Acari is the dominant fauna (>47% of the total faunal collection) within the total arthropod faunal collection (Petersen 1982; Wallwork 1983; Sabu *et al.* 1995; Pfieffer 1996; Vineesh *et al.* 2003; Richardson *et al.* 2005) from this deciduous forest.

Fog cover and mist prevails through out the day, in the region, except during two summer months and at noon during other seasons. These climatic conditions keep the site damp and moist, creating a suitable environment for the Acari (Ferguson and Joly 2002). Oribatid mites are considered K- selected organisms, since they do not quickly recover from the lowered population numbers (Norton 1990). They are useful in predicting forest disturbances and the fact has been confirmed, by various other studies (Norton 1990; Behan- Pelletier 1999). The higher abundance of Acari (especially the oribatids), indicates that ecological disturbance linked to the tourism activities have not, so far, affected the litter arthropod community of the region.

Low abundance of mantids, psocoptera, diptera and dermaptera could be attributed to the various group specific behavioural patterns. For example, the low abundance of mantids can be related to this habitat specificity, that of psocopterans and dipterans to unsuitable climatic variation and low prey resource, and that of dermapterans to the high predatory density. Psocoptera prefers hot climatic conditions (Levings and Windsor 1985) and their abundance depends on altitude, vegetation and climatic factors (García Aldrete 2002).

The unusual high abundance of Thysanoptera (thrips) can be explained in the light of cold and moist climate of the region on account of fog and summer rains. Cold climatic conditions, is in fact helpful for the fungal growth (Hassall *et al.* 1986), which is the major food resources for (Borror *et al.* 1996; Tenbrink *et al.* 2002) for Thysanoptera. Low presence of Thysanoptera was noticed during the high rainfall (June and July) and the dry months (March). Obviously these extreme variations in local habitat weather conditions do not provide a suitable condition for fungal growth (Hassal *et al.* 1986), leading to the fluctuations in Thysanoptera population.

Coleoptera consists of diverse families (fourteen) with different habits. The seasonal condition (abiotic and biotic factors) intolerable to one family is conducive to another. Of the fourteen identified families only five families of coleopterans (Curculionidae, Scaraeibidae, Carabidae, Scydmaenidae, Staphylinidae) are found in all seasons. Carabidae, Scydmaenidae and Staphylinidae are predatory organisms and their abundance depends on the availability of group specific prey resources in this site. Staphylinidae was the most abundant coleopteran family and showed high abundance in lower litter layers (H layer), where the physical conditions are more stable. Presence of dung beetles (Scarabaeinae), through out the year can be associated to the dung availability of elephants, bisons and the presence of domesticated grazers in the forest (Forest and wildlife 2001).

Coleopteran families *viz.* Anthribidae and Hydrophilidae showed a significant positive correlation with humidity. Humid climatic conditions support are conducive for the breeding of Anthribidae (Borror *et al.* 1996) and for fungi the major food item for Anthribidae (Hassal *et al.* 1986).

Hydrophylidae live in water or dung, and they may occasionally come out (Borror *et al.* 1996). The presence of Hydrophilidae, living in water or dung (Borror *et al.* 1996) in the seasonal litter samples, denotes their higher abundance in the surrounding water bodies in the region. Since their exact habitat is water or dung and not leaf litter, abundance of hydrophilidae during wet seasons is attributed the water logged litter conditions prevailed during many sampling occasions.

Collembola is the dominant order during southwest monsoon due to its affinity towards dampness and fungal feed availability (Hassall *et al.* 1986). Changes in wetness can directly affect collembolan behaviour and survival and can indirectly affect their density by influencing resource levels (Lensing *et al.* 2005).

Significant negative correlation of the abundance ants and spider with humidity and rainfall is an example for group specific behavioural response of faunal abundance to abiotic factors. High dominance of hymenopterans during summer season and of spiders during pre-summer season show that both the fauna flourish under the same climatic conditions (Swift *et al.* 1979; Devasahayam and Sunderaraju 1987; Olson 1991; Anderson 1992; Frampton *et al.* 2000; Raghavendra 2001). Negative relationship with rainfall and ant abundance, conforms to the results from studies elsewhere (Anderson 1991; Olson 1994; Anderson *et al.* 2002; Sabu 2005). In the present study, no distinct abundance during the summer season was detected though found in previous studies (Olson 1991; Brühl *et al.* 2003). Abundance of ants and their prey resources *viz.* isoptera and collembola recorded in the current study, supports the results from various other studies (Olson 1994; Anu *et al.* 2003; Barberena-Arias and Aide 2003). Significant positive correlation between the abundance of ants and spiders have been observed and the phenomenon can be attributed to the existence similar climatic requirements. Spiders are in high abundance during the pre-monsoon seasons, and gradually their number decreases during the monsoon season (Devasahayam and Sunderaraju 1987; Raghavendra 2001). Inverse correlation of spider abundance with humidity and rainfall is arising from group specific behaviour. High abundance of spiders during pre-summer season, confirms the conclusions arrived at, in early studies. Their high abundance during the pre-monsoon season (summer) and gradual decrease during monsoon cannot, however, be correlated with prey resource availability (Devasahayam and Sunderaraju 1987; Raghavendra 2001). Hence, from the correlation study, we can deduce that the population abundance of spiders and ants has been influenced more by abiotic factors than by prey resource. In fact, abundance of any prey resources shows significant relationship with the abundance of ants and spider, except for the positive relationship between ants and Isoptera (Table 3.8). However, multiple regression analysis of the relationship between relative abundance of ants and spiders shows a highly significant relationship with climatic factors, though the individual explanatory variable are insignificant, due to the strong multicollinearity among the explanatory variables (Table 3.8 and 3.9). Collembola, Coleoptera, Thysanoptera, Orthoptera, Isoptera, Blattaria, Hymenoptera (ants), larva, Pseudoscorpion and spiders, do not show any trace of seasonality in their incidence (present in all four seasonal samples). Though, they are present in all seasonal samples, divergence in the abundance pattern was noticed.

Round the year presence of Orthoptera, can be traced to the presence of grasslands and forest gaps near the collection spots. Presence of Isoptera, during all the seasons is attributed to their hardy nature to thrive in all adverse climatic conditions (Dawes-Gromadzhi 2005a and b). Moreover the suitability of the climate and the humid conditions are the factors leading to their abundance in the region and the want of floods are factors influencing the rapid growth of Isoptera.

Blattids are well known for their capacity to thrive in all adverse environments since they are general feeder (Borror *et al.* 1996). This could be the reason for the incidence of blattids in all seasonal samples. Occurrence of larvae in all seasons substantiate the fact that the life cycle of different arthropods requires different weather factors. Incidence of spider and psuedoscorpions in all seasons can be explained in the light of the abundance of prey resources (insect larvae, termites, Collembola) (Lensing *et al.* 2005).

Abundance of isopods was confined to southwest monsoon, northeast monsoon and pre-summer seasons, mainly from the second month of southwest monsoon to the first month of pre-summer season (Warburg *et al.* 1994; Zimmer and Topp 2000; Kwok and Corlett 2002). No evidence of the presence of isopods, from the second month of pre-summer to the end of the summer, has been recorded. This strange fluctuations in the population of isopods can be attributed to their tendency to hide themselves under the stones and in litter heaps to escape from dry and sultry weather, since they are moisture loving arthropods (Zimmer and Topp 1997, 2000; Zimmer 2002).

Presence of Psocoptera was observed during the last two months of southwest monsoon and throughout the northeast monsoon. This result was contradictory to the results from Panama (Levings and Windsor 1985). Their abundance is related to the presence of algal and fungal (lichens) growth in litter that act as food for Psocoptera (Borror *et al.* 1996). During the same period very high presence of lichens was observed in the leaf litter of this deciduous forest (Personal observation). However dipterans were conspicuously absent during the summer season probably because of the absence of breeding ground in summer since dipterans breed and rear in dung pats in larval stage (Borror *et al.* 1996).

Presence of mantids (mostly immature) was confined to pre-summer season (Jan), during which they showed the highest abundance. High incidence of mantids is related to hatching of their eggs during pre-summer season (Borror *et al.* 1996). Adult mantids generally are fast moving insects, which shun their litter habitats and hence were not reckoned as organisms in the litter (Borror *et al.* 1996). Presence of chalcids was observed during northeast monsoon and pre-summer seasons and this might be due to the reduced presence of their preferred host – Lepidoptera during the period, though a higher abundance of other hosts for chalcids *viz.* coleopterans and the dipterans, could be observed. Low larval abundance during the southwest monsoon is related to the low litter depth due to wash-off and the direct effect of monsoon rains and the low temperature which hinders the egg hatching and development of arthropods (Brown 1973; Boinski and Fowler 1989).

High Shannon diversity during the northeast monsoon season can be explained in the light of the ubiquitous presence of all identified taxa from this site (except the Mantodea) recorded during the northeast monsoon season and the lower dominance index duly observed during the season. This peculiar faunal distribution pattern is an indication of the high Shannon diversity during the northeast monsoon season, since northeast monsoon season is a transitional season between the heavy rainy season to rainless pre-summer season with comparatively low rainfall, which highlights the higher abundance of most of the arthropod groups in this study and establishes the fact of higher Shannon diversity as in the earlier work (Levings and Windsor 1985; Burgess *et al.* 1999). Results of Tukey tests show significant difference in the indices of northeast monsoon season and all the other seasons (Fisher's Alpha, Shannon diversity index, Simpson's dominance index, Margalef's richness index and Pielou's evenness index) except for Simpson's dominance index of southwest monsoon and northeast monsoon, which is due to the higher abundance of moisture preferring collembola (major fauna) in the southwest and northeast monsoon seasons. High dominance of other wet litter arthropods (Hydrophilidae and Isopods) during these two seasons leads to the nonsignificance of Simpson's dominance index. Higher abundance of most taxa (30/42) of the arthropods during northeast monsoon season, compared to their occurrence in the other seasons, leads to significant difference (Table 3.2). It clearly shows that the northeast monsoon season provides the most conducive physio-climatic condition for most of the arthropod fauna.

The lowest Shannon diversity and Fisher's diversity values, during the summer season, can be explained, analysing the arthropod taxa distribution *viz.* 18/42 taxa showed the lowest abundance and 14/42 taxa were absent during the summer season (Table 3.2). However, a high evenness could be observed during this season with no clear and specific abundance of any one arthropod taxa (except for ticks, Blattaria and Orthoptera) (Fig. 3.3 and 3.4).

Fisher's Alpha diversity index, based on the incidence of arthropods, showed a higher value during the pre-summer season, followed by the northeast monsoon season. This can be explained with the observed incidence of almost all fauna during these seasons. Out of 42 taxa, subjected to analysis, 38 taxa were present during pre-summer and 41 during northeast monsoon seasons (Table 3.2). This indicates that suitable climatic conditions with high humidity related to fog and moderate rainfall and better prey resource availability exists for fungivorous and predators (Hassal *et al.* 1986) during northeast monsoon and pre-summer seasons.

Value of Fisher's Alpha diversity index does not show any significant difference (Tukey test) between summer and southwest monsoon seasons. Generally, summer and southwest monsoon seasons provide two different climatic extremes- heavy rainfall and hot summer. During these climatic extremities, only the fauna with special adaptations can survive, leading to the low incidence of faunal groups in both the seasons (28 and 33 respectively), only less than 60% (59.46%) of the common taxa It is found that climatic extremes tend to cause a reduction of faunal abundance in this study site. This is supported by the earlier studies on tropical litter arthropod faunal abundance (McCoy 1990; Frith and Frith 1990; Olson 1994; Sanders 2002). Low rainfall during pre-summer and summer seasons in the study region is leading to the insignificant difference in Fisher's alpha diversity during these seasons.

Conclusions:

Litter arthropod abundance showed no significant seasonal variation. However diversity showed distinct seasonal variation due to the variation in richness and evenness. High abundance of Thysanoptera (thrips) was a special feature noticed in this region. Abiotic factors showed significant influence on the abundance all major faunal groups except larvae. Inter-group faunal influence requires detailed study for the conformation of derived relationships.

Table 3.1. Physical characteristics of litter floor in the deciduous forest at Paithalmala during Dec 2002 to Nov 2003 study period.

Parameters	**Mean** [a] **± SE**
Litter temperature (^{0}C)	27.30 ± 1.16
Litter humidity (%)	70.00 ± 4.7
Litter depth (cm)	4.83 ± 0.61
Slope of the terrain	37° 00' ± 0° 33'
Rainfall (mm)	260.00 ± 115.18

[a] Mean of twelve monthly samples.

Table 3.2. Seasonal abundance of litter arthropod fauna in the deciduous forest at Paithalmala during the study period of Dec 2002 to Nov 2003.

SEASON		**PS**	**S**	**SW**	**NE**
TAXA /	**Guild**	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**
Entomobryidae	M	3.3 ± 0.88	7 ± 2	12 ± 0	12 ± 0
Hypogastruridae	M	1.7 ± 0.33	5.3 ± 3.84	13.3 ± 2.91	9 ± 3.6
Onychiuridae	M	2.3 ± 1.33	3.3 ±0.67	28.7 ± 1.2	9.3 ± 3.7
Sminthuridae	M	1.7 ± 0.33	2 ± 1	8.3 ± 2.03	10 ± 3.33
Curculionidae	D	1 ± 0.58	0.3 ± 0.33	0.3 ± 0.33	1.3 ± 0.33
Tenebrionidae	D	0.7 ± 0.67	2 ± 0.58	0 ± 0	3.3 ± 1.33
Lampyridae	D	0.7 ± 0.33	0.3 ± 0.33	0 ± 0	1 ± 0
Scarabaeidae	D	1 ± 0.58	0.3 ± 0.33	1.3 ± 0.88	4 ± 1
Anthribidae	D	0.3 ± 0.33	0 ± 0	0.7 ± 0.33	1 ± 0
Bostrichidae	D	0.3 ± 0.33	1 ± 1	0 ± 0	2 ± 0.577
Nitidulidae	D	0.3 ± 0.33	0 ± 0	1.3 ± 0.88	2.3 ± 0.88
Chrysomelidae	D	0.7 ± 0.33	0 ± 0	0 ± 0	1.7 ± 0.667
Elateridae	D	0.3 ± 0.33	0.3 ± 0.33	0 ± 0	1.3 ± 0.33
Hydrophilidae	D	0.3 ± 0.33	0 ± 0	2 ± 1	2 ± 0.57
Carabidae	P	0.7 ± 0.33	1 ± 0	0.7 ± 0.33	2 ± 0.57
Scydmaenidae	P	1.7 ± 1.2	1 ± 0.58	1.3 ± 0.88	3 ± 1
Staphylinidae	P	3 ± 1	4.3 ± 0.88	3.3 ± 2.33	16.3 ± 5.548
Endomychidae	F	0.7 ± 0.33	0 ± 0	0 ± 0	2 ± 0.57
PSOCOPTERA	F	0 ± 0	0 ± 0	1.7 ± 0.88	1 ± 0
THYSANOPTERA	F	21 ± 6.89	21.7 ± 8.69	8.3 ± 2.03	23.7 ± 2.603
DIPTERA	D	0.3 ± 0.33	0 ± 0	3 ± 2.45	2 ± 0.577
ORTHOPTERA	D	2 ± 1	4 ± 0.58	1 ± 0.58	1.3 ± 1.33
DERMAPTERA	D	0.3 ± 0.33	0 ± 0	0.7 ± 0.67	3.72 ± 1.2
ISOPTERA	D	7 ± 1.53	4 ± 1.15	0.3 ± 0.33	5.7 ± 2.33
BLATTARIA	P	2.3 ± 0.33	5 ± 1	0.7 ± 0.33	4 ± 2
MANTODEA	P	0.3 ± 0.33	0 ± 0	0 ± 0	0 ± 0
Ants	P	72 ± 6.01	63.3 ± 4.84	20 ± 6.56	47.3 ± 8.95

Table 3.2. continued

Chalcidae	P	0.3 ± 0.33	0 ± 0	0 ± 0	2 ± 0.577
Reduvidae	P	0 ± 0	0 ± 0	0.67 ± 0.67	0.7 ± 0.33
Other Hemiptera	D	0 ± 0	0 ± 0	2 ± 2	2.3 ± 1.33
Larva	D	31 ± 4.91	31.7 ± 13.7	19.3 ±9.87	49.7 ± 3.283
Millipede	D	0.7 ± 0.67	0 ± 0	0.3 ± 0.33	0.3 ± 0.33
ISOPODA	D	0.7 ± 0.67	0 ± 0	7 ± 4.58	17.3 ± 3.18
Oribatida	D	38 ± 14	8.7 ± 3.33	17 ± 2.08	16.7 ± 5.364
Astigmata	P	16 ± 2.19	8.3 ± 3.84	7.7 ± 3.38	21.3 ± 0.667
Prostigmata	P	15 ± 2.08	8.3 ± 3.33	4 ± 1.53	31.3 ± 7.26
Mesostigmata	P	13 ± 5.2	8 ± 2.65	4.7 ± 1.86	34.7 ± 3.84
Ticks	P	2.3 ± 1.45	4 ± 1.53	0 ± 0	0.7 ± 0.33
PSEUDOSCORPION	P	1.7 ± 0.33	0.7 ± 0.33	2 ± 2	4 ± 1
Spider	P	15 ± 0.58	12 ± 1.53	4.3 ± 0.88	7.3 ± 0.882
Centipede	P	0 ± 0	0.3 ± 0.33	0.3 ± 0.33	1 ± 1

PS: Pre-summer; S: Summer; SW: Southwest monsoon; NE: Northeast monsoon

M, Microbidetritivore; D, Detritivore; F, Fungivore; P, Predator.

Table 3.3. Abundance of litter fauna per (¼) m^2 and relative abundance (percent) in the deciduous forest litter stand during the study period of Dec 2002 to Nov 2003.

TAXA	**Mean ± SE**	**%**
COLLEMBOLA	32.3 ± 12	5.48
Entomobryidae	8.6 ± 2.11	1.46
Hypogastruridae	7.3 ± 2.5	1.25
Onychiuridae	10.9 ± 6.12	1.85
Sminthuridae	5.4 ± 2.09	0.92
COLEOPTERA	19.2 ± 8.06	3.26
Curculionidae	0.75 ± 0.25	0.13
Tenebrionidae	1.50 ± 0.74	0.25
Lampyridae	0.50 ± 0.22	0.08
Scarabaeidae	1.67 ± 0.81	0.28
Anthribidae	0.50 ± 0.22	0.08
Bostrichidae	0.83 ± 0.44	0.14
Nitidulidae	1.00 ± 0.53	0.17
Chrysomelidae	0.58 ± 0.39	0.1
Elateridae	0.50 ± 0.29	0.08
Hydrophilidae	1.08 ± 0.53	0.18
Carabidae	1.08 ± 0.32	0.18
Scydmaenidae	1.75 ± 0.44	0.3
Staphylinidae	6.75 ± 3.21	1.15
Endomychidae	0.67 ± 0.47	0.11
PSOCOPTERA	0.67 ± 0.41	0.11
THYSANOPTERA	18.8 ± 3.51	3.19
DIPTERA	1.33 ± 0.71	0.23
ORTHOPTERA	2.08 ± 0.67	0.35
DERMAPTERA	1.17 ± 0.84	0.2
ISOPTERA	4.25 ± 1.44	0.72

Table 3.3. continued

BLATTARIA	3.00 ± 0.95	0.51
MANTODEA	0.08 ± 0.08	0.01
HYMENOPTERA	51.2 ± 11.4	8.69
Ants	50.6 ± 11.4	8.59
Chalcidae	0.58 ± 0.48	0.1
HEMIPTERA	1.42 ± 0.82	0.24
Reduviidae	0.33 ± 0.19	0.06
Other hemiptera	1.08 ± 0.63	0.18
Larva	33.0 ± 6.25	5.61
Millipede	0.33 ± 0.14	0.06
ISOPODA	6.25 ± 4.02	1.06
ACARI	63.5 ± 18.4	10.8
Oribatida	20.1 ± 6.28	3.41
Astigmata	13.3 ± 3.25	2.25
Prostigmata	14.7 ± 6	2.49
Mesostigmata	15.1 ± 6.75	2.56
Ticks	1.75 ± 0.9	0.3
PSEUDOSCORPION	2.08 ± 0.7	0.35
Spider	9.67 ± 2.38	1.64
Centipede	0.42 ± 0.21	0.07

Table 3.4. List of family/species identified from the deciduous forest litter stand of Paithalmala during December 2002 to November 2003 study period.

COLEOPTERA	OTHER BEETLE FAMILIES
CURCULINOIDAE	Anthribidae
Alcidodes sp.	Bostrichidae
Athensapeuta sp.	Nitidulidae
Ochyronera sp.	Chrysomelidae
TENEBRIOINIDAE	Elateridae
Gonocephalum sp.2	Hydrophilidae
Coelometopini sp.	Lampyridae
SCYDMAENIDAE	Endomychidae
Euconnus sp.	Staphylinidae
CARABIDAE	**ORTHOPTERA**
Clivina extensicollis	*Gryllus* sp.
Diplocheila polita	*Mecopoda* sp.
Tetragonoderus intermedius	
Scarites sp.	**HYMENOPTERA**
Phoropsophus sp.	ANTS
Caelostomus sp.	*Camponotus irritans*
Cymindoidea sp.	*C.angusticolis*
Apristus sp.	*Cardiocondyla* sp.2
Chaenius sp.	*Monomorium* sp.
SCARABAEINAE	*Monomorium* sp.2
Copris davisoni	*Mymicaria brunnea*
Copris repertus	*Odontomachus* sp.
Liatongus indicus	*Solenopsis geminata*
Drepanoceros setosus	*Solenopsis* sp.2
Oniticellus cinctus	*Strumigenys* sp.
Sisyphus longipe	*Tapinoma* sp.
Onitis siva	CHALCIDAE
Onthophagus sp.3	*Braconid* sp.

Table 3.4. continued

Probaryconus sp.	*Podothrombium* sp.
ISOPTERA (TERMITES)	*Podocinum pacificum*
Odontotermes anamallenssis	*Perlohmannia* sp.
Odontotermes obesus	*Pavlovskicheyla plattydemae*
COLLEMBOLA	*Oribatella* sp.
Entomobryidae	*Oribatula* sp.
Hypogastruridae	*Mesoplophors* sp.
Onychiuridae	*Hafenrefferias* sp.
Sminthuridae	*Eviphis stefaninianus*
THYSANOPTERA	*Epicrius mollis*
Stigmothrips limpidus	*Cephaeus* sp.
SPIDERS	*Cantharozetes* sp.
Castianeira sp.	*Cephus* sp.
Corinnomma rufofuscum	*Damaeus* sp.
Ctenus sp.	*Diarthrophallus quercus*
Oedignatha sp.	*Galumna* sp.
Opopaea sp.	*Histiostoma* sp.
Scytodes thoracica	*Microtrombidium* sp.
MITES	PHORETIC MITES
Xylobates sp.	*Amblycius indicus*
Uropodella sp.	*Macrocheles* sp.
Poecilochirus necrophorie	**PSEUDOSCORPIONS**
	Calocheiridius sp.

Table 3.5. Seasonal variations in the diversity of litter arthropods in the deciduous forest of Paithalmala during the study period (2002 - 03).

Season	Abundance (N)	Fisher's diversity (α)	Shannon diversity (H')	Simpson's dominance Lambda'	Pielou's evenness (J')	Margalef's richness (d)
P-S	853.	7.88	3.37	0.04	0.93	5.33
S	569	5.84	3.15	0.05	0.95	4.07
S-W	818	6.64	3.24	0.04	0.94	4.6
N-E	1840	7.21	3.61	0.03	0.97	5.2

Table 3.6. Tukey (Pair wise significance) test for abundance, Fisher's Alpha, Shannon diversity and Simpson's dominance, Pielou's evenness and Margalef's richness indices on the seasonal variation of arthropods in the deciduous forest floor during the study period of Dec 2002 to Nov 2003.

Seasons	PRESUMMER	SUMMER	SOUTHWEST
Fisher's Alpha			
SUMMER	N.S		
SOUTHWEST	N.S	*	
NORTHEAST	***	***	***
Shannon Diversity			
SUMMER	N.S		
SOUTHWEST	***	***	
NORTHEAST	***	***	***
Simpson's Dominance			
SUMMER	N.S		
SOUTHWEST	***	***	
NORTHEAST	***	***	N.S
Pielou's Evenness			
SUMMER	N.S		
SOUTHWEST	***	***	
NORTHEAST	***	***	*
Margalef's Richness			
SUMMER	N.S		
SOUTHWEST	N.S	N.S	
NORTHEAST	***	***	***

N.S.- Not significant; $*P \leq 0.05$; $**P \leq 0.01$; $***P \leq 0.001$.

Table 3.7. Multiple regression analysis of abundance of major litter arthropod fauna, as a function of litter climatic and habitat physical factors in the deciduous forest floor during the study period of Dec 2002 to Nov 2003.

Dependent Variable	$F_{4, 11}$	R^2	*P*
ANTS	34.4	0.545	***
COLLEMBOLA	44.5	0.607	***
ENTOMOBRYIDAE	44.0	0.605	***
HYPOGASTRURIDAE	21.89	0.43	***
ONYCHIURIDAE	25.59	0.47	***
LARVA	1.28	0.043	N.S
ISOPODA	46.2	0.617	***
SPIDERS	31.6	0.523	***
ACARI	16.0	0.358	***
ORIBATIDA	78.8	0.73	***
ASTIGMATA	0.33	13.91	***
PROSTIGMATA	3.08	0.10	***
MESOSTIGMATA	7.27	0.202	***
THYSANOPTERA	7.60	0.209	***
STAPHYLINIDAE	18.9	0.396	***

Independent variable: Litter depth, Rain, Humidity, Temperature
N.S.- Not significant; $*P \leq 0.05$; $**P \leq 0.01$; $***P \leq 0.001$.

Composition and seasonality of arthropods in a high land moist deciduous forest

Table 3.8 Pearson correlation analysis of the reciprocal relationship between fauna, and fauna and habitat physical (bold) factors of deciduous forest litter stands in Paithalmala (Left side below r- correlation coefficient; right side above P – significance).

	ACARIDAE	ANTHRIBIDAE	ANTS	ASTIGMATA	BLATTARIA	BOSTRICHIDAE	CARABIDAE	CENTIPEDES	CHALCIDAE	CHRYSOMELIDAE	COLEOPTERA	COLLEMBOLA	CURCULIONIDAE	DERMAPTERA	DIPTERA	ELATERIDAE	ENDOMICHIDAE	ENTOMOBRYIDAE	HEMIPTERA	**HUMIDITY**	HYDROPHILIDAE	HYMENOPTERA	HYPOGASTRURIDAE	ISOPODA	ISOPTERA	LAMPYRIDAE	LARVAE	**LITTER DEPTH**	MANTODEA	MESOSTIGMATA	MILLIPEDES	NITIDULIDAE	ONYCHIURIDAE	ORIBATIDAE	ORTHOPTERA	OTHER HEMIPTERA	PROSTIGMATA	PSUEDOSCORPION	PSOCOPTERA	**RAIN**	REDUVIIDAE	SCARABAEIDAE	SCYDMANIDAE	SMITHURIDAE	SPIDER	STAPHYLINIDAE	**TEMPERATURE**	TENEBRIONIDAE	THYSANOPTERA
ACARIDAE	1	**	*	***	**	N.S	N.S	N.S	***	***	***	***	***	***	N.S	***	***	N.S	N.S	N.S	N.S	*	***	**	***	***	***	**	N.S	***	N.S	***	***	***	N.S	N.S	***	N.S	N.S	***	N.S	***	***	N.S	N.S	***	***	***	***
ANTHRIBIDAE	0.3	1	N.S	***	N.S	N.S	***	N.S	**	***	***	**	***	***	***	**	***	**	***	**	***	*	**	***	N.S	*	N.S	**	N.S	***	*	***	*	*	*	***	N.S	**	***	N.S	**	***	***	*	N.S	***	N.S	N.S	N.S
ANTS	0.2	-0.2	1	N.S	***	N.S	N.S	N.S	N.S	N.S	N.S	***	N.S	*	*	*	N.S	***	N.S	***	***	***	***	***	**	***	*	***	***	N.S	N.S	***	***	N.S	***	N.S	*	N.S	***	***	N.S	N.S	N.S	***	***	N.S	N.S	N.S	**
ASTIGMATA	0.8	0.3	0.1	1	*	**	**	N.S	**	**	**	*	***	***	N.S	***	***	N.S	*	N.S	*	N.S	*	***	***	*	*	***	N.S	***	N.S	***	**	***	N.S	*	**	**	N.S	**	N.S	***	***	N.S	N.S	***	**	***	**
BLATTARIA	0.3	-0.1	0.4	0.2	1	**	N.S	N.S	N.S	N.S	N.S	**	N.S	N.S	*	***	N.S	N.S	N.S	**	**	***	***	N.S	***	N.S	***	**	N.S	***	*	N.S	**	N.S	*	N.S	**	N.S	**	N.S	N.S	N.S	N.S	**	N.S	N.S	**	**	***
BOSTRICHIDAE	0.1	-0.04	0.1	0.3	0.4	1	*	N.S	N.S	**	**	N.S	N.S	*	N.S	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	**	N.S	N.S	*	N.S	*	N.S	N.S	***	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	***	N.S	**	N.S
CARABIDAE	0.2	0.3	-0.1	0.3	-0.1	0.2	1	N.S	N.S	***	***	N.S	***	***	N.S	***	***	*	N.S	N.S	***	N.S	*	***	N.S	**	**	N.S	***	***	**	***	N.S	N.S	N.S	N.S	N.S	***	*	N.S	N.S	***	***	**	N.S	***	**	***	**
CENTIPEDES	-0.1	-0.1	-0.1	0.2	0.1	0.2	0.1	1	N.S	**	N.S	N.S	N.S	N.S	*	**	**	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	**	**	N.S	N.S	N.S	*	N.S	N.S	*	N.S	N.S	N.S	N.S	**	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
CHALCIDAE	0.7	0.2	0.02	0.5	0.1	0.03	0.1	-0.2	1	**	***	N.S	***	***	N.S	***	***	**	**	N.S	N.S	N.S	N.S	***	***	N.S	***	N.S	N.S	N.S	N.S	***	N.S	**	N.S	***	***	*	N.S	*	N.S	***	***	N.S	N.S	***	N.S	**	***
CHRYSOMELIDAE	0.5	0.4	-0.1	0.5	-0.1	0.3	0.6	-0.2	0.4	1	***	N.S	***	***	N.S	***	***	N.S	N.S	N.S	***	N.S	N.S	***	N.S	***	**	*	N.S	***	N.S	***	N.S	*	*	N.S	***	***	N.S	*	N.S	***	***	***	N.S	***	N.S	***	***
COLEOPTERA	0.5	0.5	-0.1	0.6	0.1	0.4	0.6	-0.1	0.5	0.8	1	N.S	***	***	*	***	***	***	***	N.S	***	N.S	N.S	***	N.S	***	***	N.S	N.S	***	N.S	***	N.S	N.S	N.S	***	***	***	**	*	*	***	***	***	N.S	***	N.S	***	***
COLLEMBOLA	-0.3	0.3	-0.8	-0.2	-0.4	-0.1	0.1	-.01	-04	0.1	0.2	1	N.S	**	***	N.S	N.S	***	**	***	***	***	***	***	***	**	***	**	**	N.S	N.S	***	***	N.S	**	**	**	*	***	***	N.S	*	*	***	***	N.S	N.S	N.S	***
CURCULIONIDAE	0.5	0.5	0	0.4	.04	0.1	0.4	-0.2	0.4	0.6	0.7	0.4	1	***	**	***	***	*	N.S	N.S	***	N.S	N.S	***	N.S	**	*	N.S	*	***	N.S	***	N.S	***	N.S	*	*	***	N.S	***	N.S	***	***	N.S	N.S	***	N.S	***	***
DERMAPTERA	0.5	0.4	-0.2	0.5	0.1	0.2	0.6	-0.1	0.4	0.8	0.8	0.2	0.5	1	**	***	***	***	***	N.S	***	N.S	N.S	***	N.S	**	***	N.S	N.S	***	N.S	***	N.S	N.S	*	***	***	***	***	*	*	***	***	***	*	***	N.S	***	**
DIPTERA	-0.02	0.5	-0.2	0.1	-0.2	-0.1	0.1	0.2	0.1	0.01	0.2	0.3	0.2	0.2	1	N.S	N.S	**	***	N.S	***	*	***	***	N.S	N.S	N.S	N.S	N.S	N.S	N.S	***	***	N.S	**	***	N.S	***	***	N.S	***	**	***	N.S	*	N.S	N.S	N.S	N.S
ELATERIDAE	0.5	0.3	0.2	0.3	0.4	0.1	0.3	-0.3	0.4	0.5	0.5	-0.1	0.4	0.4	0.1	1	***	***	***	*	N.S	*	N.S	***	***	*	**	N.S	N.S	***	*	***	***	N.S	N.S	***	***	N.S	N.S	***	N.S	***	*	N.S	N.S	***	***	***	***
ENDOMICHIDAE	0.6	0.3	0	0.6	0.1	0.2	0.5	-0.2	0.5	0.8	0.8	0.12	0.5	0.8	0.03	0.5	1	*	*	N.S	***	N.S	N.S	***	***	***	***	N.S	N.S	***	*	***	N.S	***	N.S	*	***	**	N.S	**	N.S	***	***	**	N.S	***	N.S	***	***
ENTOMOBRYIDAE	-0.06	0.3	-0.6	-0.1	-0.1	-.03	0.2	-0.1	0.3	0.2	0.4	0.8	0.2	0.4	0.3	0.3	0.2	1	***	***	***	***	***	***	***	N.S	N.S	N.S	***	*	N.S	***	***	*	N.S	***	N.S	*	***	*	**	***	***	***	***	***	**	N.S	N.S
HEMIPTERA	0.2	0.4	-0.1	0.2	0.1	-0.1	0.1	0.1	0.2	0.1	0.3	0.2	0.2	0.3	0.6	0.3	0.2	0.4	1	N.S	***	N.S	*	***	N.S	N.S	***	N.S	N.S	*	N.S	***	*	N.S	N.S	***	*	***	***	*	***	***	**	N.S	***	***	N.S	N.S	N.S
HUMIDITY	**0.1**	**0.2**	**-0.6**	**0.1**	**-0.2**	**0.02**	**-0**	**0.05**	**0.1**	**0.1**	**0.1**	**0.5**	**0.1**	**0.2**	**0.2**	**-0.2**	**0.2**	**0.3**	**0.1**	**1**	***	***	***	*	*	N.S	N.S	***	N.S	N.S	*	**	***	***	N.S	N.S	N.S	N.S	**	***	N.S	N.S	N.S	***	***	N.S	***	N.S	N.S
HYDROPHILIDAE	0.06	0.1	-0.4	0.2	-0.3	0.1	0.3	0.1	0.1	0.4	0.6	0.5	0.4	0.5	0.5	0.1	0.3	0.4	0.5	**0.3**	1	***	***	***	N.S	N.S	N.S	N.S	N.S	N.S	N.S	***	***	N.S	***	***	N.S	***	***	N.S	***	***	***	***	***	***	N.S	N.S	N.S
HYMENOPTERA	0.2	0.2	1	0.2	0.4	0.1	-0.1	-0.1	0.1	-.04	-0.1	-0.8	0	-0.2	-0.2	0.2	0.02	-1	-0.1	**-0.6**	-0	1	***	***	***	***	**	***	***	N.S	N.S	***	***	N.S	***	N.S	*	N.S	***	***	N.S	N.S	N.S	***	***	N.S	N.S	N.S	**
HYPOGASTRURIDAE	-0.4	-0.4	-0.7	-0.2	-0.4	-0.2	0.2	-.03	-0.1	0.03	0.1	0.9	0.1	0.2	0.3	-0	-.04	0.7	0.2	**0.3**	0.4	-1	1	***	***	***	***	N.S	*	N.S	N.S	***	***	*	***	*	***	*	***	*	N.S	*	**	***	***	N.S	N.S	N.S	N.S

Table 3.8 continued

	ACARIDAE	ANTHRIBIDAE	ANTS	ASTIGMATA	BLATTARIA	BOSTRICHIDAE	CARABIDAE	CENTIPEDES	CHALCIDAE	CHRYSOMELIDAE	COLEOPTERA	COLLEMBOLA	CURCULIONIDAE	DERMAPTERA	DIPTERA	ELATERIDAE	ENDOMICHIDAE	ENTOMOBRYIDAE	HEMIPTERA	**HUMIDITY**	HYDROPHILIDAE	HYMENOPTERA	HYPOGASTRURIDAE	ISOPODA	ISOPTERA	LAMPYRIDAE	LARVAE	**LITTER DEPTH**	MANTODEA	MESOSTIGMATA	MILLIPEDES	NITIDULIDAE	ONYCHUIRIDAE	ORIBATIDAE	ORTHOPTERA	OTHER HEMIPTERA	PROSTIGMATA	PSUEDOSCORPION	PSOCOPTERA	**RAIN**	REDUVIIDAE	SCARABAEIDAE	SCYDMAENIDAE	SMITHURIDAE	SPIDER	STAPHYLINIDAE	**TEMPERATURE**	TENEBRIONIDAE	THYSANOPTERA
ISOPODA	0.3	0.3	-0.4	0.4	-0.1	0.1	0.4	0.1	0.4	0.6	0.8	0.5	0.5	0.8	0.4	0.3	0.6	0.5	0.6	0.2	0.6	-0	0.4	1	N.S	N.S	**	N.S	N.S	***	N.S	***	***	N.S	***	***	*	***	***	N.S	***	***	***	***	***	***	N.S	***	N.S
ISOPTERA	0.6	0.6	0.5	0.5	0.3	0.1	0.04	-.02	0.3	0.2	0.1	-0.5	0.1	0.1	-0.2	0.4	0.3	-0	-.02	-0.2	-0	0.5	-0.5	-0.1	1	**	***	N.S	*	***	N.S	N.S	***	*	N.S	N.S	***	N.S	**	***	N.S	N.S	N.S	***	***	N.S	N.S	N.S	***
LAMPYRIDAE	0.4	0.4	0.3	0.2	0.03	-.02	0.2	-0.3	0.2	0.4	0.3	-0.3	0.3	0.3	-0	0.2	0.4	-0	0	-0.1	0.1	0.3	-0.3	0.1	0.2	1	N.S	N.S	**	***	N.S	*	**	***	N.S	N.S	**	N.S	N.S	***	N.S	**	**	N.S	**	*	N.S	N.S	N.S
LARVAE	0.6	0.6	0.2	0.7	0.5	0.4	0.2	0.5	0.3	0.3	0.4	-0.3	0.2	0.4	0.1	0.3	0.4	-0	0.3	0.1	0.1	0.2	-0.3	0.3	0.4	0	1	N.S	N.S	***	N.S	***	***	N.S	***	***	***	N.S	N.S	N.S	*	**	*	N.S	N.S	***	N.S	***	***
LITTER DEPTH	-0.2	-0.2	0.3	-0.3	0.2	-0.1	0.04	0.01	-0.1	-0.2	-0.1	-0.3	-0.1	-0.1	-0.1	0.1	-0.2	-0.1	0.02	-0.8	-0.2	0.3	-0.1	-0.1	-0	-0	-0.1	1	N.S	N.S	*	N.S	***	***	**	N.S	N.S	N.S	N.S	***	N.S	N.S	N.S	***	***	N.S	***	N.S	N.S
MANTODEA	0.04	0.04	0.3	0.03	-0.1	-0.1	-0.3	-0.1	-0.1	-0.1	-0.2	-0.3	-0.2	-0.1	-0.1	-0.2	0.03	-0	-0.1	0.04	-0	0.3	-0.2	-0.2	0.2	0.2	-0	-0.1	1	N.S	***	N.S	*	**	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	***	N.S	***	*	N.S
MESOSTIGMATA	0.9	0.9	0.03	0.7	0.3	0.2	0.4	-0.2	0.6	0.6	0.7	-0.1	0.5	0.6	-0	0.7	0.7	0.2	0.2	0.1	0.1	0.1	-0.2	0.4	0.4	0.3	0.5	-0.1	-0.2	1	N.S	***	**	**	N.S	**	***	N.S	N.S	N.S	N.S	***	***	N.S	N.S	***	N.S	***	***
MILLIPEDES	0.05	0.1	-0.4	-0.1	-0.2	-0.1	-0.2	-0.2	-0.1	-.01	-0.1	0.04	-0.2	-0	-0.2	-0.2	0.2	-0	-0.2	0.2	-0	-0	-0.1	-0.1	0.1	0.1	-0	-0.2	0.6	-0.1	1	N.S	N.S	***	***	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	***	N.S	*
NITIDULIDAE	0.3	0.3	-0.3	0.4	-0.1	0.2	0.5	0	0.3	0.6	0.8	0.4	0.5	0.7	0.4	0.3	0.6	0.5	0.5	0.2	0.7	-0	0.3	0.8	-0	0.2	0.3	-0.2	-0.2	0.4	0.03	1	***	N.S	***	***	N.S	***	***	N.S	***	***	***	***	**	***	N.S	***	N.S
ONYCHIURIDAE	-0.4	-0.4	-0.8	-0.3	-0.5	-0.1	-.01	0.1	-0.1	-0.1	-.01	0.9	-0.1	0.1	0.3	-0.3	-0.1	0.6	0.2	0.5	0.5	-1	0.7	0.4	-1	-0.3	-0	-0.3	-0.2	-0.3	0.1	0.3	1	N.S	***	*	***	N.S	***	***	*	N.S	N.S	***	***	N.S	N.S	**	***
ORIBATIDA	0.6	0.6	0.1	0.4	-0.1	-0.1	-0.1	-0.2	0.3	0.2	0.1	-0.2	0.4	0.1	0	-0.1	0.3	-0	-0.1	0.4	0	0.1	-0.2	-0	0.2	0.3	0.2	-0.4	0.3	0.3	0.4	0.1	-0.1	1	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	***	N.S	*	N.S	***	N.S	***
ORTHOPTERA	0.2	0.2	0.3	0.1	0.6	0.5	-0.2	0.1	0.1	-0.2	-0.1	-0.4	-0.1	-0.2	-0.3	0	-0.1	-0	-0.2	-0.1	-0	0.3	-0.4	-0.4	0.1	-0	0.4	-0.2	-0.2	0.1	-0.3	-0.3	-0.4	0.01	1	N.S	*	***	***	N.S	N.S	**	N.S	***	*	N.S	N.S	**	***
OTHER HEMIPTERA	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.1	0.4	0.2	0.2.	0.4	0.7	0.3	0.2	0.4	0.1	0.1	0.5	-0	0.2	0.7	0	0	0.3	0.01	-0.1	0.2	-0.2	0.5	0.2	-0.1	-0.2	1	**	***	***	*	***	***	**	N.S	***	***	N.S	N.S	N.S
PROSTIGMATA	0.8	0.8	0.2	0.7	0.3	0.2	0.1	-0.1	0.5	0.4	0.4	-0.3	0.2	0.3	-0.1	0.6	0.5	0	0.2	0.01	-0	0.2	-0.3	0.2	0.6	0.3	0.5	-0.1	-0	0.8	-0.1	0.2	-0.3	0.2	0.2	0.3	1	N.S	N.S	N.S	N.S	**	N.S	N.S	N.S	***	N.S	**	***
PSEUDOSCORPIONE	0.1	0.1	-0.1	0.2	-0.1	-0.1	0.3	-.04	0.2	0.4	0.4	0.2	0.4	0.4	0.4	0.1	0.3	0.2	0.6	0.02	0.4	-0	0.2	0.6	-0	0.1	0.2	-0	-0.1	0.1	0	0.6	0.2	0.1	-0.3	0.6	0.01	1	***	***	***	***	***	N.S	N.S	***	N.S	N.S	N.S
PSOCOPTERA	-0.2	-0.2	-0.4	0.1	-0.3	-0.1	0.2	0.2	0.1	0.05	0.3	0.6	0.1	0.3	0.6	-0	0.1	0.5	0.5	0.2	0.6	-0	0.6	0.6	-0	-0.1	0	-0.1	-0.1	-0.1	-0.1	0.5	0.5	-0.1	-0.4	0.5	-0.1	0.4	1	N.S	***	***	***	**	***	*	N.S	N.S	*
RAIN	-0.3	-0.1	-0.5	-0.3	-0.1	0.1	-0.1	0.2	-0.2	-0.2	-0.2	0.4	-0.4	-0.2	-0.2	-0.3	-0.2	0.2	-0.2	0.7	-.04	-0.5	0.2	-0.1	-0.3	-0.3	-0.1	-0.6	-0.2	-0.2	0.1	-0.1	0.5	-0.2	0.1	-0.2	-0.2	-0.3	-.03	1	N.S	*	***	***	***	*	***	N.S	***
REDUVIIDAE	0.1	0.1	-0.1	0.2	0.1	-0.1	0.02	0.2	0.04	-.03	0.2	0.2	0.1	0.2	0.3	0.2	0.1	0.2	0.9	0.1	0.4	-0	0.1	0.4	-0	-0	0.2	0.04	-0.1	0.1	-0.1	0.4	0.2	-0.1	-0.1	0.7	0.1	0.6	0.4	-0.2	1	*	N.S	N.S	**	**	N.S	N.S	N.S
SCARABAEIDAE	0.4	0.4	-0.2	0.4	-0.2	0.2	0.5	-0.1	0.4	0.6	0.8	0.2	0.6	0.7	0.3	0.4	0.7	0.3	0.4	0.1	0.7	-0	0.2	0.7	0	0.3	0.2	-0.1	-0	0.4	-0	0.7	0.1	0.1	-0.2	0.4	0.2	0.4	0.3	-0.2	0.2	1	***	**	N.S	***	N.S	***	N.S
SCYDMAENIDAE	0.4	0.4	-0.1	0.4	-0.1	0.1	0.5	-0.1	0.5	0.6	0.7	0.2	0.8	0.6	0.3	0.2	0.6	0.3	0.2	0.2	0.5	-0	0.3	0.6	-0	0.2	0.2	0	-0.1	0.4	-0	0.7	0.1	0.3	-0.2	0.3	0.1	0.4	0.3	-0.3	0.2	0.6	1	*	N.S	***	N.S	***	***
SMINTHURIDAE	-0.1	-0.1	-0.7	-0.1	-0.3	0.1	0.2	-0.1	0.1	0.4	0.4	0.8	0.1	0.4	0.1	0	0.3	0.6	0.03	0.5	0.4	-1	0.5	0.5	-0	-0.1	-0	-0.3	-0.2	0.1	0.2	0.5	0.7	-0.1	-0.4	0.1	-0.1	0.2	0.3	0.4	-0	0.3	0.2	1	***	***	N.S	*	N.S
SPIDERS	0.2	0.2	0.7	0.1	0.1	0.1	-0.1	-0.2	-0.1	0.05	-0.1	-0.7	0.1	-0.2	-0.2	-0	0.01	-1	-0.3	-0.4	-0	0.7	-0.6	-0.4	0.4	0.3	0	0.3	-0.4	-0.1	0.1	-0.3	-0.7	0.2	0.2	-0.3	0.01	-0.1	-0.5	-0.5	-0.3	-0.1	0.01	-0.6	1	N.S	N.S	N.S	*
STAPHYLINIDAE	0.5	0.5	-0.1	0.5	0.2	0.3	0.5	-0.1	0.6	0.8	0.9	0.2	0.5	0.8	0.2	0.6	0.8	0.4	0.4	0.1	0.4	-0	0.1	0.8	0.1	0.2	0.5	0	-0.2	0.7	-0.1	0.7	-0	0.03	-0.1	0.4	0.5	0.4	0.2	-0.2	0.2	0.7	0.7	0.34	-0.2	1	N.S	***	***
TEMPERATURE	-0.4	-0.1	0.1	-0.2	0.2	0.1	0.2	0.03	-0.1	0.01	0.1	0.1	-0.1	0.1	-.01	0.3	-0.1	0.2	0.1	-0.7	0	0.04	0.2	0.1	-0.1	-0.1	-0.1	0.7	-0.3	-.03	-0.3	0.1	-.02	-0.7	0.02	0.1	-0.1	0.02	0.1	-0.3	0.1	0.01	-0.1	0.03	-0.1	0.2	1	N.S	N.S
TENEBRIONIDAE	0.4	0.4	0.03	0.5	0.3	0.6	0.6	0.1	0.3	0.6	0.7	-0.1	0.4	0.6	-0.1	0.3	0.6	0.1	-0.1	0.02	0.2	0	-0.1	0.4	0.2	0.2	0.5	0.1	-0.2	0.5	-0.1	0.4	-0.2	-0	0.3	-0.1	0.3	0.1	-0.1	-.01	-0.1	0.5	0.4	0.2	0.1	0.7	0.1	1	***
THYSANOPTERA	0.5	0.5	0.3	0.5	0.5	0.2	0.2	0.01	0.4	0.3	0.4	-0.3	0.5	0.3	-0.1	0.4	0.3	0	0.04	0	-0	0.3	-0.1	0.1	0.4	0.1	0.6	0.1	-0.1	0.5	-0.2	0.1	0.5	0.4	0.5	0.1	0.4	0.1	-0.2	-0.3	0.02	0.2	0.4	-0.2	0.2	0.4	-0.1	0.1	1

Table 3.9. Partial correlation analysis of the relation between climatic and habitat physical factors and major arthropod fauna in the deciduous forest litter stand during the study period (2002-03).

VARIABLES	D.F.	R	*P*
Collembola - Humidity	115	.6807	***
Collembola - Litter Depth	115	-.0482	N.S
Collembola - Rain	115	-.2466	**
Collembola - Temperature	115	.6735	***
Entomobryidae - Humidity	115	0.72	***
Entomobryidae - Litter Depth	115	0.60	N.S
Entomobryidae - Rain	115	-0.42	N.S
Entomobryidae- Temperature	115	0.713	***
Hypogastruridae - Humidity	115	0.598	***
Hypogastruridae - Litter Depth	115	0.060	N.S
Hypogastruridae - Rain	115	-0.31	***
Hypogastruridae - Temperature	115	0.57	***
Onychiuridae - Humidity	115	0.53	***
Onychiuridae - Litter Depth	115	-0.05	N.S
Onychiuridae - Rain	115	-0.06	N.S
Onychiuridae - Temperature	115	0.50	***
Thysanoptera - Humidity	115	.2542	**
Thysanoptera - Litter Depth	115	.2508	**
Thysanoptera - Rain	115	-.3251	***
Thysanoptera - Temperature	115	-.1448	N.S
Hymenoptera - Humidity	115	-0.58	***
Hymenoptera - Litter Depth	115	-0.02	N.S
Hymenoptera - Rain	115	-0.11	N.S
Hymenoptera - Temperature	115	-0.51	***
Ants - Humidity	115	-.590	***
Ants - Litter Depth	115	-.0152	N.S
Ants - Rain	115	.0348	N.S
Ants - Temperature	115	-.5221	***
Larva - Humidity	115	.1013	N.S
Larva - Litter Depth	115	-.0337	N.S
Larva - Rain	115	-.1709	N.S
Larva - Temperature	115	-.0034	N.S
Acari - Humidity	115	.2097	*
Acari- Litter Depth	115	-.1618	N.S
Acari- Rain	115	-.5004	***
Acari- Temperature	115	-.1087	N.S
Oribatida - Humidity	115	0.37	***
Oribatida - Litter Depth	115	0.13	N.S
Oribatida - Rain	115	-0.62	***
Oribatida - Temperature	115	-0.63	***
Astigmata - Humidity	115	0.17	N.S

Table 3.9. continued

Astigmata - Litter Depth	115	-0.34	***
Astigmata - Rain	115	-0.49	***
Astigmata - Temperature	115	0.09	N.S
Prostigmata - Humidity	115	0.06	N.S
Prostigmata - Litter Depth	115	-0.19	*
Prostigmata - Rain	115	-0.26	**
Prostigmata - Temperature	115	0.076	N.S
Mesostigmata - Humidity	115	0.29	***
Mesostigmata - Litter Depth	115	-0.21	*
Mesostigmata - Rain	115	-0.42	***
Mesostigmata - Temperature	115	0.28	***
Isopoda - Humidity	115	.7131	***
Isopoda - Litter Depth	115	-.2895	**
Isopoda - Rain	115	-.7155	***
Isopoda - Temperature	115	.7117	***
Spider - Humidity	115	-.4982	***
Spider - Litter Depth	115	.1237	N.S
Spider - Rain	115	-.0352	N.S
Spider - Temperature	115	-.5986	***
Coleoptera - Humidity	115	0.57	***
Coleoptera - Litter Depth	115	-0.18	N.S
Coleoptera - Rain	115	-0.62	***
Coleoptera - Temperature	115	-0.54	***
Staphylinidae- Humidity	115	.5357	***
Staphylinidae - Litter Depth	115	-.1454	N.S
Staphylinidae - Rain	115	-.5657	***
Staphylinidae - Temperature	115	.5446	***

N.S.- Not significant; *$P \leq 0.05$; **$P \leq 0.01$; *** $P \leq 0.001$.
(Independent variables: Litter depth, Rain, Temperature, Humidity)

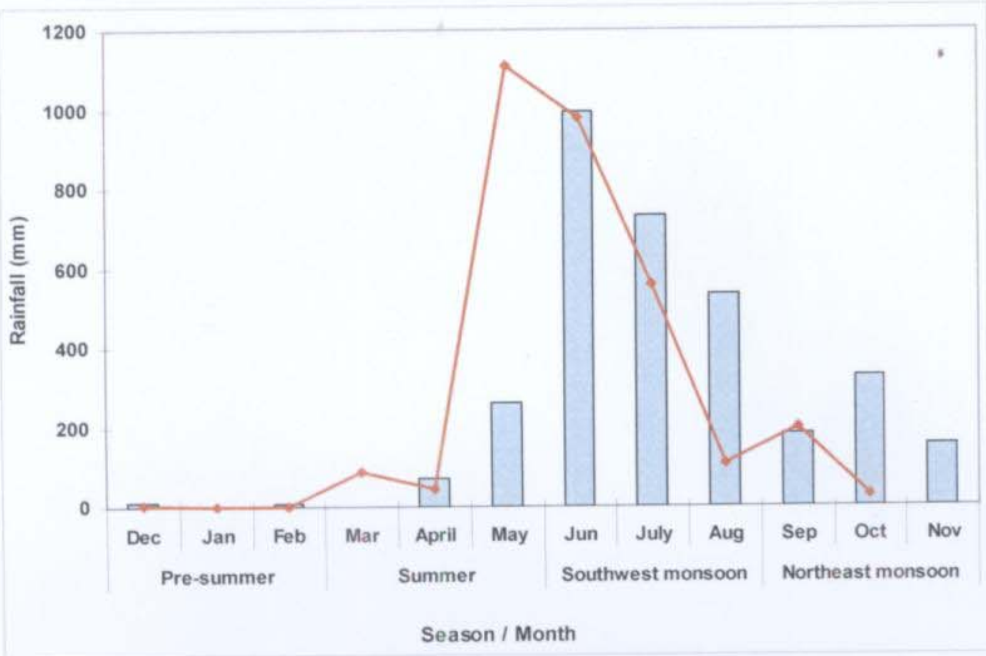

Figure 3.1a. Rainfall received during different seasons and months in the deciduous forest study region. Vertical bars represent monthly rainfall during Dec. 2002 to Nov. 2003. Line represents the monthly means during 2000 to 2005

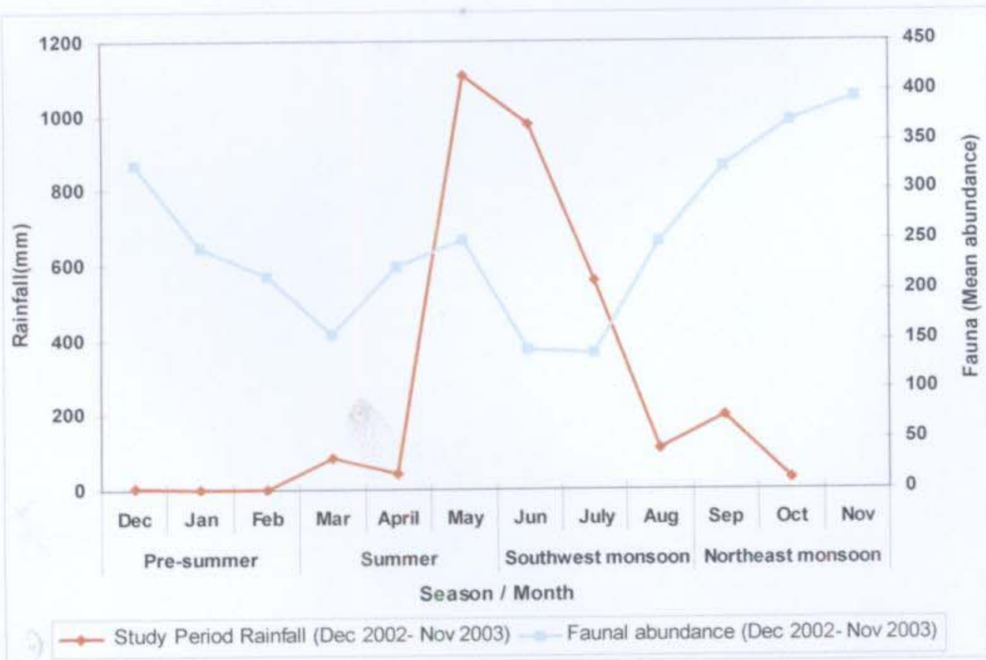

Figure 3.1b. Relationship between rainfall and faunal abundance in the deciduous study region during Dec. 2002 to Nov. 2003.

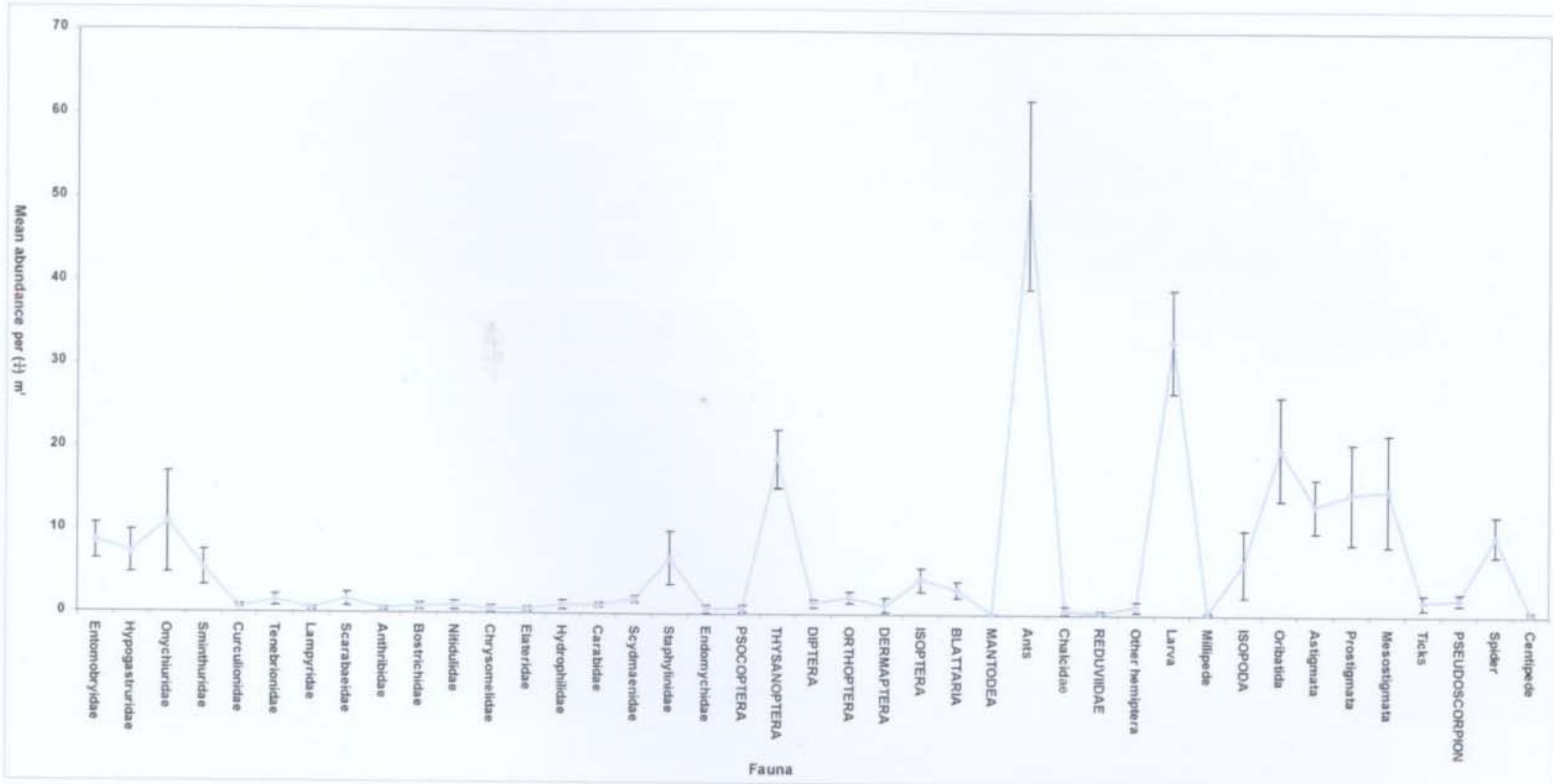

Figure 3.2. Abundance of litter arthropod fauna in the deciduous forest at Paithalmala during the study period of Dec 2002 to Nov 2003

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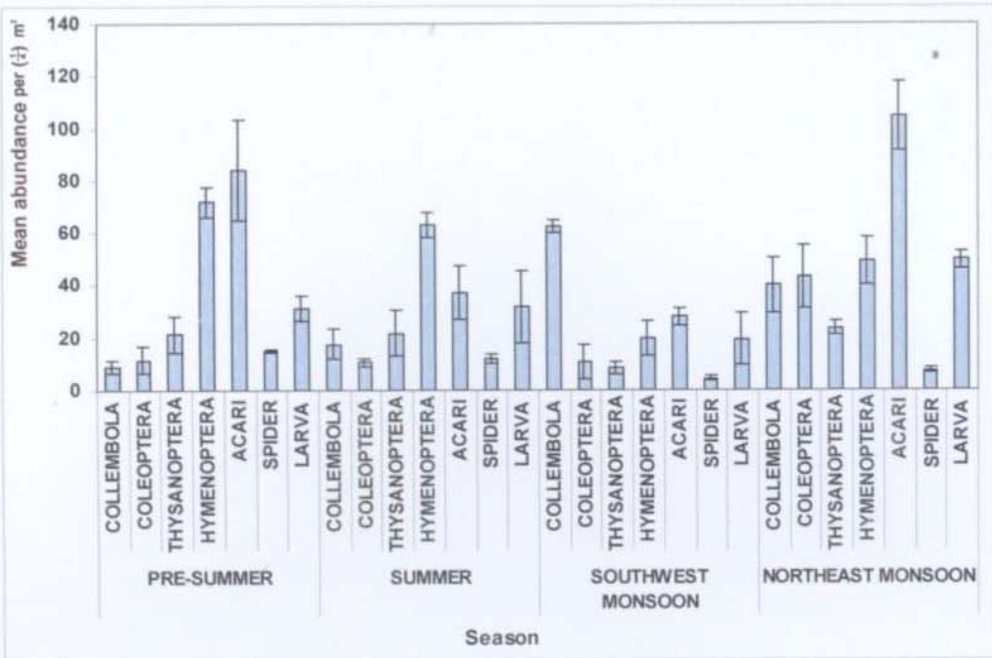

Figure 3.3. Seasonal distribution of major litter arthropod fauna in the deciduous forest at Paithalmala during the study period (2002-03).

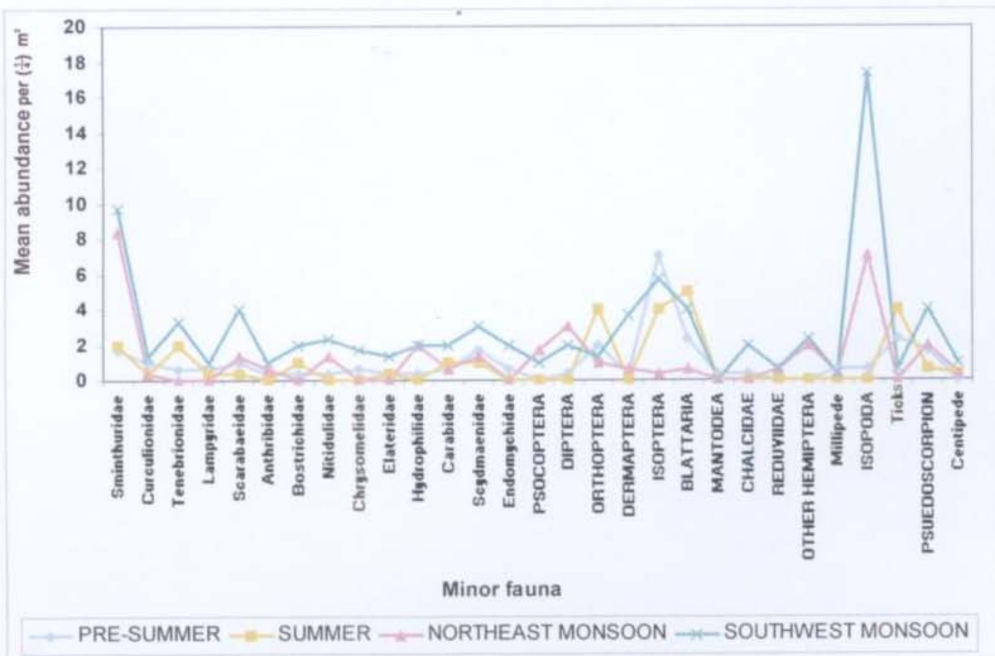

Figure 3.4. Seasonal distribution of minor litter arthropod fauna in the deciduous forest at Paithalmala during study period (2002-03).

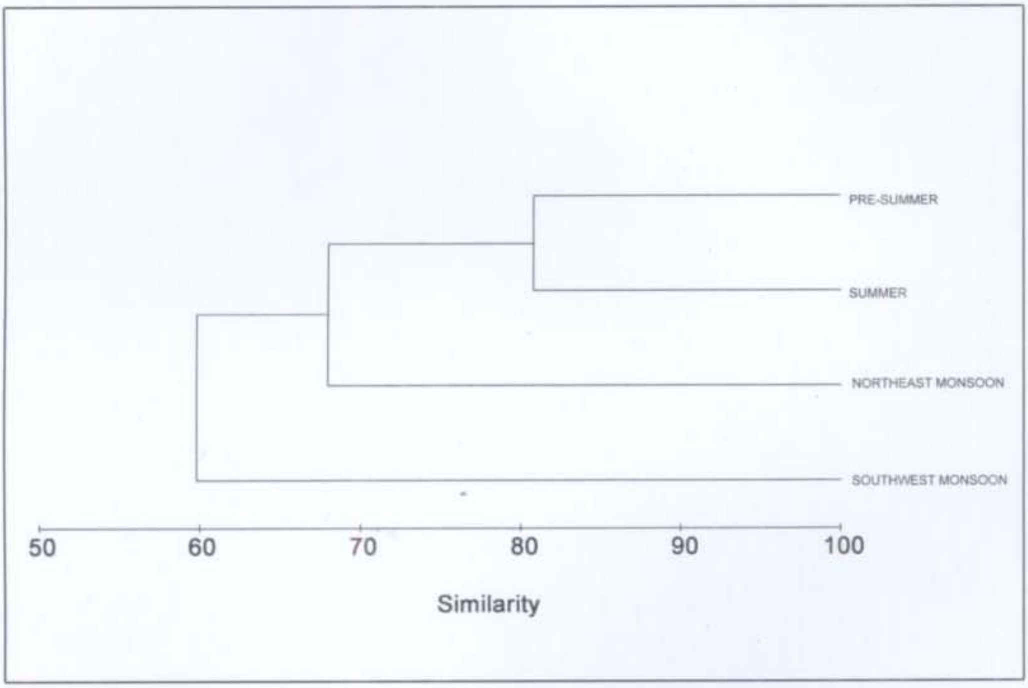

Figure 3.5. Dendrogram based on hierarchical agglomerative clustering (group-linking) of litter arthropod faunal assemblage during different seasons of the study period.

COMPOSITION AND SEASONALITY OF LITTER ARTHROPODS IN A RUBBER PLANTATION IN THE SOUTH WESTERN GHATS

Vineesh P.J “Ecology and diversity of Entomofauna in the litter stands of monoculture and natural forests in Kannur district ” Thesis. Department of Zoology, St. Jopseph'S College Devagiri University of Calicut, 2007

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COMPOSITION AND SEASONALITY OF LITTER ARTHROPODS IN A RUBBER PLANTATION IN THE SOUTH WESTERN GHATS

INTRODUCTION

Hevea brasiliensis Muell. Arg. belonging to the family Euphorbiacea, is the major source of natural rubber and was brought to India from the Amazon river basin during the second half of the nineteen century. Commercial plantations of the crop were first extended to Southeast Asia in areas with similar latitude and climate (Krishnakumar and Meenattoor 2000). Among the pioneer rubber growing countries in Asia, Malaysia and Sri Lanka have shown a gradual decline in natural rubber production during the period of 1970-1995, while Thailand, China, India and Vietnam have registered an increase in production (Gunatilleke 2002). In India, rubber cultivation was confined till 1960 to the South West part of the country, mainly Kerala state and Kanyakumari district of TamilNadu. However, due to the non-availability of land in the traditional belt, rubber cultivation was also extended to non-traditional regions (Menon 1980; Menon and Unny 1990; Verghese *et al.* 2001).

Of the 5.58 lakh hector of rubber cultivation in the country, Kerala has 4.8 lakhs hectares, 85% of the total cultivation. 12.36% of the total area of Kerala is used for rubber cultivation. Kannur district has 33944 hectares of rubber plantations (Kerala Govt. 2005) and this is nearly 10% of the total rubber plantation in Kerala. The area of rubber cultivation in Kerala has a ratio of 1:2.36 with the total forest in Kerala. Rubber plantations have replaced some of the most luxuriant low land rain forests in India (George and Panikker 2000).

RRI 105, RRI 207, RRI 414 and RRI 437 are the different clones of *Hevea brasiliensis* Muell. Arg. cultivated in Kerala. RRII 105 is the most widely cultivated clone in Kerala (Mercykutty *et al.* 1995). A group of plants derived by budding from a single mother plant is referred to as a clone. All the clones of rubber trees above three or four years are subject to annual shedding of senescent leaves which renders the trees wholly or partially leafless for a short period, under the influence of dry weather and rainfall (Webster and Baulkwill 1989).

The biomass stand of a *Hevea* plantation under normal agronomic practice reaches the status of a humid tropical forest in about 30 years (Shorrocks 1965; Kato *et al.* 1995). A mature rubber plantation is an excellent repository of mineral nutrients, comparable to a native forest (Shorrocks 1965; Samarappuli 1996). Annual litter addition in rubber plantation amounts to 7t per ha (RRII 1996) and nutrient recycling through litter decomposition is very high (Joseph 1991).

Seasonality in litter shedding leads to seasonal variations in the litter habitat structure and litter thickness in deciduous (rubber) forests. Studies elsewhere have shown that variations in the litter habitat structure, litter fall, litter thickness, litter moisture and decomposition rates along with climatic factors, (*viz.* rainfall and temperature) prey availability and predator abundance (Tanaka *et al.* 1987; Wolda and Tanaka 1987; Barberena-Arias and Aide 2003; Wise 2004; Anu 2006) have led to seasonal variations in the abundance and community-structure of litter arthropod fauna (Holt 1985; Levings and Windsor 1982, 1984, 1985; Hassall *et al.* 1986; Wolda 1988; Frith and Frith 1990; Burgess *et al.* 1999; Wakelin 2000; Barberena-Arias and Aide 2003). Even seemingly minor changes in the environment are important to individual arthropod and these differences may explain some of the litter arthropod-community structure variations (Greenslade and Greenslade 1984).

Among the many environmental factors that have been identified as the limiting elements of litter insect seasonality (Frith and Frith 1985, 1990; Kato *et al.* 1995; Wakelin 2000), rainfall is the most influential (Frith and Frith 1990). Even moderate fluctuations in rainfall can impose a distinct seasonality (Janzen and Pond 1975; Janzen 1983) and change in the resource availability of both plants and animals (Davis 1945; Fodgen 1972). Rainfall has a controlling effect (Holdridge 1967; Janzen 1983) on other limiting environmental factors such as moisture (Swift *et al.* 1979; Lensing *et al.* 2005), temperature (Hopkin 1997), humidity (Frith and Frith 1990) and litter depth (Webster and Baulkwill 1989). Ample moisture is required for decomposer organisms to operate efficiently, though, excessive moisture or anaerobic conditions resulting from prolonged inundation may hinder the activity of soil flora and fauna (Tate 1980; Paul and Clark 1989; Groffman *et al.* 1996). A deeper leaf-litter layer could provide more refuges and maintain moisture during the dry season (Frith and Frith 1990).

Though data is available on the diversity and abundance of litter arthropod dynamics in many monoculture plantations like *Shorea robusta, Eucalyptus* and *Tectona* (Ananthakrishnan *et al.* 1992; Annaduri *et al.* 1988; Hazra 1991; Reddy and Venkataiah 1990; Sabu *et al.* 1993; Sabu 1995), there is very limited information on the diversity and seasonality of litter arthropods in the traditional rubber plantations in south India, except for the analysis on the seasonality of litter fauna in the rubber plantations on the foothills of Wayanad region (Jobi 2006). No data exits on the diversity and seasonality of rubber litter fauna prevailing in the rubber plantations in the northern part of Kerala, where annual leaf shedding is completed by the second week of December (personal observations) in contrast to the delayed leaf shedding taking place during January- February in the more southern parts (Jobi 2006). No studies have analysed the influence of physio-climatic factors like litter temperature, humidity, rainfall and litter depth on rubber litter arthropod fauna and the reciprocal relationship with faunal abundance in north Kerala, where mean higher temperature, delayed southwest monsoon, and low aggregate rainfall during southwest and northeast monsoon were recorded (Nair 1991).

The main objective of this study is to provide data on the following aspects of litter arthropod faunal dynamics in a rubber plantation in Brahmagiri slopes in the northern region of South Western Ghats.

1. Seasonal variations in the abundance, diversity and feeding guild composition,
2. Influence of habitat physical factors (temperature, rain, humidity, litter depth) on litter arthropod abundance and
3. Rreciprocal relationships among the fauna.

MATERIALS AND METHODS

Site: The present study was conducted in a rubber plantation at Chemperi village, of Eruvessi 'Panchayath' (75° 34' East 12° 06' North) in Kannur district (Plate 1 and 3). Rubber (70%), coconut and cashew are the major crops in the locality. Formerly this was a thick forest forming the western or eastern continuity of Brahmagriri forests till 1950s (Kurup 1994). The boundaries of this panchayath are Coorg forests of Karnataka and Payyavoor panchayath in the northeast side, southwest side with Srikandapuram and Naduvil pachayath. The terrain is northeast sloping and composes an undulating hilly area with an altitude of 100 m a msl (Forest and Wildlife 2001). The study site was located at a distance of 53 km from Thalasseri seashore and is on the Chemperi-Iritti road, 1.5 km away from Chemperi town. The average slope of the terrain is below 10°. The rubber plantation subjected to study comprises an area of 2 km^2. "RRII 105" is the most widely planted clone in the region.

The climate is controlled by both southwest monsoon and northeast monsoon. An annual rainfall of 3110 mm was received during the study period (2002-03), of which 85.1% was received from Jun-Aug (southwest monsoon), 10.7% during Sep-Nov (northeast monsoon), 4.2% during Mar-May (summer) and the remaining 0.02% during Dec-Feb (pre-summer) (Fig. 4.1a). The average rainfall in five years (2001-2005) was 3280.45 mm. Branch breaking, green leaf falling and uprooting of trees due to strong winds are prevalent during the southwest monsoon seasons, when the trees are full of luxuriant dark green leaves and unripe but full sized fruits.

One to four cm thick litter (2.5 ± 1 cm) layer covers almost all the rubber plantation floor. Being deciduous rubber trees usually shed almost all the leaves annually during January- February (but in this study region it was observed that the trees shed their leaves completely by the second week of December) (Fig. 4.1b). This process is termed as wintering. The leaves are shed along with petioles (Jobi 2006). The vegetation in the plantation consists of single layers in addition to subordinate seasonal shrub and herb layers, with the abundance of pea plant (*Calapagonium sp.*) in the interior regions. The upper canopy of the plantation is 20-25 m high. Various shrubs and creepers have been identified in this plantation *viz. Phyllanthus niruri, Sida rhombifolia, Hemidesmus indicus, Asparagus officianalis, Chromolena odorata, Mimosa pudica, Cleome viscose, Cassia tora, Euphorbia hirta, Lantana camara* (Gamble 1921).

Sampling: Leaf litter samples were collected from 120 chosen plots each with an area of 50 × 50 cm. It was proposed to collect 10 samples each month from a transect line, each sample on a transect line remains at a distance of ten meters from another. There are twelve such transect lines each to be subjected to sample collection every month. Each of these transect lines exists at distance of 10 meters from each other. The sampling plots were selected one month prior to the first sampling. The selected sampling plot was one kilometer within the boundaries of the plantation. Within the permanently marked plot, each transect line allotted for monthly collection was marked and labelled permanently using plastic wire, iron rods and aluminium marking sheets (Frith and Frith 1990). All actual sampling was done on a day in the closing week of each month from December 2002 to November 2003. The time of sampling was between 8-10 am. During rainy season sampling was done three days after the rain, to minimise the direct impact of rain on various fauna (Brühl *et al.* 2003). This pattern of sampling could not be strictly adhered to during June and July and sampling was done on any non-rainy day in the last week of the month.

Each sample was collected by placing a 50 × 50 cm (¼ m^2) wooden quadrant frame onto the litter and then scraping out all litter (leaves, twigs, fruits and loose humus) from within the frame with a thin wooden scraper into a large polythene bag. Samples were collected as quickly as possible to avoid arthropods escape by flying, running or digging away. No arthropods were observed escaping and I believe that minor cases of escape, if any, were insignificant. The litter thus collected for analysis consisted of L, (freshly fallen), F (fermentation) and H (humus) layers. No underlying compact soil was taken. An average of 3 months data was conceived as the seasonal data (30 samples for each season). The fauna was extracted with Berlese funnel apparatus (30.5cm diameter 35.6cm height, 25w bulb). The extracted fauna were sorted under a stereo zoom trinocular microscope

(Labmode-ZM45 TM) and the adult organisms were identified to order level using keys of Borror *et al.* (1996). After this preliminary identification, the arthropods were placed in small-labelled vials (Tarson, model no: 510000) containing 70 % ethyl alcohol. The adults were assigned to a morphospecies and sent to taxonomic authority for identification. The fauna were categorised as major and minor fauna (Major Fauna: the taxa which enjoy representation in all seasons and have more than 10 mean no. per (¼) m^2 at any one of the seasons and the other taxa were considered as the minor fauna).

The rainfall data was collected from the meteorological station of the district agricultural farm at Taliparamba. Humidity and litter temperature were assessed with thermo-hygrometer (Barigo; Barigo Barometer fabric GmbH; Villingen-Schwenningen; Germany) and litter depth was measured using Boinski and Fowler (1989) method. The four value of litter depth from each of the corners of the 50 × 50 cm quadrant were then averaged for each sample. The slope of the terrain was calculated using the Trigonometric formula 'tan θ' (where 'θ' is the angle of inclination) (Jacobs and Meyer 1972). Litter humidity, temperature, slope of the terrain and litter depth was calculated as the mean of 10 sampling spots during each month (Table 4.1).

Data Aanalysis: Since data was normally distributed, no data transformation was necessary. Community diversity was assessed in terms of parametric Fisher's alpha diversity index (α) and the nonparametric indices *viz.*, Shannon-diversity (H'), Simpson's dominance (D), Pielou's evenness (J') and Margalef's richness (d) (α diversity index). Community similarity was assessed with Bray Curtis similarity index followed by Cluster Analysis.

1) Fisher's Alpha diversity (α)

Fisher's alpha diversity (parametric diversity index) is widely used in literature because we can calculate the index knowing only the species richness (S) and the total number of individuals (N). Fisher's alpha (α) diversity index involves a comparison of variations in the number of individuals (N) and is theoretically independent of sample size (Fisher *et al.* 1943).

$$A = N\,(1\text{-}x)/x$$

Estimate x from the iterative solution of:

$$S/N = (1\text{-}x)/x\,(\text{-In}\,(1\text{-}x))$$

Where, S = number of species

N = total number of individuals

2) Shannon diversity index (H')

One of the most enduring of all diversity measures is the Shannon index. This is the most traditionally used index. It is an index taking both richness and evenness into account i.e. high overall diversity occurs when the number of species (richness) and the evenness component are large (low dominance) (Magurran 2003).

The value of the Shannon index obtained from empirical data usually falls between 1.5 and 3.5 and rarely goes beyond 4 (Margalef 1972). Generally mature and stable communities will have high diversity values and communities under severe stress would exhibit low diversity usually tempting to zero (Magurran 2003). It was calculated with the following equation (Shannon and Weaver 1949).

$$H' = -\Sigma_i P_i (\log (P_i))$$

Where, P_i is the proportion of the total count arising from the i^{th} species

$$P = S/N$$

Where, S = total individual number of a species

N = total individual numbers of all species.

Logarithms to the base of 'e' (Natural logarithm) was used.

3) Simpson's Dominance index

Simpson's index (λ) is a measure of dominance whose maximum value is one. Simpson's index given the probability of any two individuals drawn at random from an infinitely large community belonging to the same species. As 'λ' increases, diversity decreases, which is clearly seen in the case of a single species (complete dominance). Near zero values are obtained, when numerous species are present (no dominance). Each species represents a small fraction of the total value (Magurran 2003).

It was calculated with the following equation (Simpson 1949)

$$\lambda = \Sigma\, p_i^2$$

Where, p_i is the proportion of the total count arising from the 'i'th species

4) Pielou's Evenness index

Evenness refers to the area equitability of the taxa. It is expressed as Pielou's evenness index (J') (Magurran and Henderson 2003).

$$J' = H' / \log S$$

Where, H' is Shannon diversity index

S is the total number of taxa.

5) Margalef's richness index

It expresses the number of taxa/groups existing in the region under observation. For analyzing taxa richness, Margalef's index (Clifford and Stephenson 1975; Magurran 2004) is used. It is calculated by the following formula.

$$d = S - 1 / \log (N)$$

Where, d is Margalef's index,

S is the total number of taxa

N is the total number of individuals

6) Cluster Analysis

Cluster Analysis: Bray-Curtis similarity index (Bray and Curtis 1957) was used to compare the similarity between the assemblages arriving at different seasons followed by Cluster analysis (Clarke and Warwick 2001)

Seasons were grouped and the groups themselves were formed into clusters on levels of similarity. Clarke and Warwick (2001) tested the efficiency of all similarity indices using six criteria (Magurran 2003) and found that Bray-Curtis index is a comparatively more accountable than all other widely used indices as it meets all the following requirements of a good index. 1. The value will be 1 (or 100) when two samples are identical; 2. The value will be zero when samples have no species in common; 3. A change of measurement unit does not affect the value of the index; 4. The value remained unchanged by an inclusion or exclusion of a species that occurs in neither sample; 5. The inclusion of a third sample makes no difference to the similarity of the initial pair of samples; 6. The index reflects the difference in total abundance (and not just relative abundance). It is calculated by the following formula.

$$BC_{jk} = 100\left\{1 - \frac{\sum_{i=1}^{p}\left|y_{ij} - y_{ik}\right|}{\sum_{i=1}^{p}\left(y_{ij} + y_{ik}\right)}\right\}$$

Where, BC_{jk} is the similarity between the j^{th} and k^{th} season, and Y_{ij} represents the abundance for the i^{th} species in the j^{th} season. Y_{ik} represents the abundance for the i^{th} species in the k^{th} season.

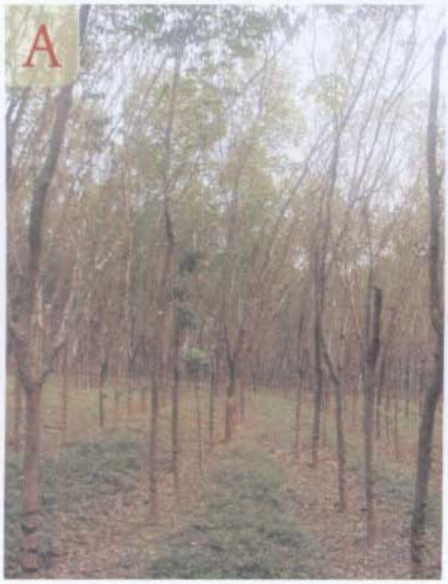
All diversity analysis was done with Primer v5 package (Clarke and Gorley 2001).

Statistical analysis: The extent of causality of abiotic factors (climatic and habitat variables *viz*. rainfall, humidity, litter temperature and litter depth), on major arthropod fauna (responding variable) was assessed using multiple regression analysis (Zar 2003). Inherent collinearity (multicollinearity) of explanatory variables was analysed with simple and partial correlation (Neter *et al.* 1996).

Relationship between faunal abundance and climatic and habitat physical factors among faunal groups was analysed, with Pearson's correlation (Zar 2003; Goehring *et al.* 2002).

Significant levels of the variations in the abundance and diversity (Five α index) of arthropod groups during the different seasons were tested with One way Analysis of Variance (ANOVA). Pair wise significance differences were further compared using Tukey's HSD (Zar 2003). Significance levels were determined at $P<0.05$. ANOVA and Tukey's HSD analysis were carried out by using KY Plot software (Yoshioka 2000). All other statistical analysis was done with GRETL open source software version 1.1 (Cottrell 2006).

Plate-3



Rubber plantation
(A) Leaf sprouting season (B) Leaf dense canopy

RESULTS

SECTION I: **ABUNDANCE, DIVERSITY AND FEEDING GUILDS**

1. Overall faunal abundance, diversity and feeding guild: Thirtyseven arthropod taxa belonging to seventeen arthropod orders were recorded from the litter stands of rubber plantation (Table 4.2). Faunal abundance evidenced no significant variation between four seasons. Acari, Collembola and Coleoptera were the dominant arthropod orders present. These three orders together contributed 69% of the total arthropod abundance (Table 4.3a, b and 4.4). Acari was the highest abundant order (41%) followed by Collembola (17%) and Coleoptera (11%) and Hymenoptera (8.6%) (Table 4.4). Mantodea, Isoptera and Psuedoscorpion contributed <0.1% each of the total collection (Fig. 4.2). Detritivores were the most abundant feeding guild contributing 54 % of the total faunal abundance and fungivores were the least abundant guild (Table 4.2).

2. Seasonal variation in abundance, diversity, and feeding guild composition

2a. Seasonal variation in the abundance: Overall fauna did not show any seasonal difference. An inversely proportional abundance pattern of various species with in the major fauna in different seasons was observed. Abundance was higher during summer than in rainy seasons. Of the seventeen orders identified, seven orders (Collembola, Coleoptera, Orthoptera, Hymenoptera, Isopoda, Acaridae and Araneae) were present in all the four seasons (Table 4.2 and 4.3a and b). Acaridae dominated during all seasons, with the exception of northeast monsoon season which was dominated by Hymenoptera (Fig. 4.3). Hydrophilidae, millipedes and centipedes were recorded only during the rainy season (southwest and northeast monsoon) and chalcids during the northeast monsoon season. Endomychidae was recorded during the presummer and summer seasons.

Major Fauna: Mites (Oribatidae, Astigmata) Collembola (Onychiuridae), Coleoptera, Larvae and Hymenoptera (Ants) were the major litter arthropods. Their seasonal abundance pattern is as follows:

Collembola: Highest abundance of Collembola was recorded during summer followed by pre-summer. Lowest abundance of Collembola was found during northeast monsoon season. Abundance during summer was two times higher than that in the northeast monsoon season. Five families of collembolans were identified from this site (Table 4.5 and Fig. 4.2) of which Entomobridae was the dominant family.

Coleoptera: Highest abundance of Coleoptera was recorded during northeast monsoon followed by summer. Lowest abundance was recorded during southwest monsoon. Nine families of Coleoptera were identified of which Tenebrionidae was the most abundant (4.2/ 50 × 50 cm), followed by Staphylinidae (3.82/ 50 × 50 cm). Tenebrionidae, Staphylinidae and Carabidae were noticed in all seasons.

Hymenoptera: Includes members of two families *viz.* ants (Formicidae) and chalcids (Chalcidae).

Ants: More than 50% of the total collection of ants was recorded during pre-summer season, followed by northeast monsoon season. Lowest abundance was recorded during the southwest monsoon season (< 15%). Chalcids were found only during northeast monsoon season.

Larvae: Highest larval abundance was recorded during pre-summer season ($13/50 \times 50$ cm) followed by northeast monsoon season. Lowest abundance was observed during the summer season ($8/50 \times 50$ cm).

Acari (Mites): Highest abundance of mites was recorded during summer season followed by pre-summer season. Their low abundance was found during northeast monsoon season.

Minor fauna: Abundance of Psocoptera was noticed only during two seasons (pre-summer and southwest monsoon season). Thrips (Thysanoptera) were found in all seasons except during the southwest monsoon season (Fig. 4.4).

Diptera was noticed during pre-summer and southwest monsoon season. Orthoptera was present in all seasons and their abundance peaked during northeast monsoon season. Abundance of Dermaptera and Blattaria were noticed only in two seasons (pre-summer and summer). Isoptera was recorded only during the summer season. Mantodea was recorded only during the presummer season. Presence of Hemipera was noticed in all seasons except summer season. Presence of Homoptera was found only during the pre-summer season. Spiders and isopods were present in all seasons. High abundance of spiders was noticed during summer season and the higher abundance of Isopoda recorded during the southwest monsoon season. Centipedes and millipedes were recorded only during southwest monsoon and northeast monsoon season. Psuedoscorpions and ticks were found during northeast monsoon season.

2b. Seasonal variation in diversity (alpha and beta)**:** Highest community diversity of litter arthropod fauna, *viz.* Fisher's alpha diversity, Shannon diversity and Margalef's richness were recorded during the northeast monsoon season. Highest Simpson's dominance recorded during pre-summer season. Highest evenness was recorded during southwest monsoon season. Margalef's richness and Fisher's alpha diversity indices were lowest during summer season (Table 4.6).

Highest Bray-Curtis similarity index was observed between the arthropod fauna during summer and pre-summer seasons (78.71).

2c. Seasonal variation in feeding guild composition: Fauna belonging to all the four guilds were present during all seasons. Relative abundance of feeding guilds varied with the season. Irrespective of the seasonal disparity, detritivore guild showed higher abundance, followed by predators. Isopterans, larvae, mites (Oribatids) and tenebrionids were the dominant detritivores. Staphylinidae, predatory Acaridae (Astigmata, Prostigmata and

Mesostigmata) and ants were the dominant predatory taxa in all seasons. Thysanoptera was the dominant fungivore. Highest abundance of microbidetritivore was noticed during the summer season followed by presummer. Lowest abundance of microbidetritivore was recorded during the northeast monsoon season.

2d. Statistical analysis: No significant variation in faunal abundance was recorded among the four seasons ($F_{3,\ 148}$ = 1.32, P = 0.27). Pielou's evenness ($F_{3,\ 116}$=32.61, P < 0.000), Shannon diversity ($F_{3,\ 116}$=26.47, P < 0.000), Simpson's dominance index ($F_{3,\ 116}$=31.35, P < 0.000), Margalef's richness ($F_{3,\ 116}$=31.35, P < 0.000) and Fisher's alpha ($F_{3,\ 116}$=26.47, P < 0.000) showed significant differences in all seasons. Pair-wise seasonal Tukey analysis evidenced significant seasonal variation in Margalef's richness index between all pairs except summer and presummer seasons. Pielou's evenness showed significant difference except for presummer and summer pair and northeast monsoon and southwest monsoon pair. Significant difference in Shannon diversity was present for all seasonal pairs except for summer and pre-summer pair and pre-summer and southwest monsoon. Simpson's dominance index and Fisher's alpha diversity index showed significant difference in all seasons paired with northeast monsoon (Table 4.7).

SECTION II. ABIOTIC FACTORS AND RECIPROCAL RELATIONSHIPS BETWEEN FAUNA

Multiple Regression analysis showed significant influence of physical factors (rainfall, temperature, humidity and litter depth) on major fauna. (Table 4.8). While the influence of individual environmental factors on faunal abundance could not be analysed in regression due to the multicollinearity in dependent variables (Table 4.9a, b and 4.10).

Pearson's correlation analysis of the relationship between faunal abundance and humidity showed significant positive correlation with eight fauna and significant negative correlation with 21 fauna. Litter depth showed significant negative correlation with nine fauna and significant positive correlation with 21 fauna including Acaridae, ants, Blattaria, Collembola, larva, Hydrophilidae and centipedes. Rainfall showed significant positive relation with the abundance of seven fauna including Hydrophilidae, Isopoda, Psocoptera, centipedes and dipterans and significant negative correlation with 19 faunal groups. Temperature showed significant positive correlation with 17 groups and significant negative correlation with ten groups (Table 4.9a and b).

Hymenoptera showed significant positive correlation with 14 faunal groups and significant negative correlation with 15 groups. Coleoptera showed significant positive correlation with nine orders and significant negative correlation with 15 fauna. Collembola showed significant positive correlation with 18 and significant negative correlation with eight fauna. Larval abundance showed significant positive correlation with 12 and significant negative correlation with eight fauna. Acaridae showed significant positive correlation with 13 fauna and negative correlation with six fauna (Table 4.9a and b).

DISCUSSION

Overall arthropod abundance showed no seasonal variation whereas all faunal groups showed significant variation individually. Detritivore feeding guild was dominant in all seasons followed by predatory guild. Abundance of detritivore is arising from the prevalence of Tenebrionidae (larvae and adult) in rubber litter. Mites and Collembola were the major litter arthropod fauna in the rubber plantations of the study region similar to the pattern recorded from the rubber plantations in the more southern region and deciduous forests of the region (Vineesh *et al.* 2003; Sabu 2005; Jobi 2006).

Fauna as a whole showed a much less pronounced seasonal variation in abundance than when the constituent groups are individually examined. For example, Collembola and mites showed nearly similar abundance in three seasons. Mutually compensatory abundance of the most faunal groups leads to a non-significant difference in abundance during different seasons (Table 2).

Acari contributed about 41% of the total faunal collection of rubber litter arthropod fauna and was the most abundant fauna in yearly collection. Higher abundance of acari is an accepted fact as per the results from studies on other rubber litter fauna in more southern regions (Jobi 2006). However it was higher than that in the rubber plantation more south to the study site (Jobi 2006). Decline in abundance of mites during rainy season and high abundance during pre-summer and summer season confirms to the data from the rubber plantation in south region (Jobi 2006). The physical effect of the high intensity of rainfall (Boinski and Fowler 1989; Frith and Frith 1990) and the low litter depth along with the presence of seasonal temporal springs are the probable reason for the remarkably drastic decrease in mite abundance (>70%) during the rainy season (Boinski and Fowler 1989; Frith and Frith 1990). High abundance of ants (>50%) during pre-summer season is a common phenomenon in this region (Jobi 2006) probably related to the dry habitat preference of ants (Olson 1994; Brühl *et al.* 1998). Summer rains and the prevalence of large bodied general predatory arboreal ant, *Oecophylla* sp. especilly in the summer season (>60% total ant collection), were the probable reasons for this drastic decrease in the abundance and richness of other ants during the summer season (Way 1954; Room 1971; Hölldobler 1979, 1983; Way and Khoo 1991). Seasonal abundance of arboreal *Oecophylla* sp. in plantations is probably arising from their attraction towards the flower and honeydew availability in plantations and the subsequent movement towards summer litter floor.

High abundance of ants (more than 50%) was recorded during pre-summer season when the prey resource availability especially the larval forms was very high. Nest site availability, food supply, microhabitat structure, resource capture and ideal temperature are particularly important for ants (Brühl *et al.* 1998). Low ant abundance recorded during southwest monsoon is related to the high intensity of rainfall, wet and soaked litter conditions which are not favourable for litter ants (Frith and Frith 1990; Anderson 1992).

Abundance of chalcids recorded only during northeast monsoon season is related to the high occurrence of their hosts *viz.* Lepidoptera, Diptera and Coleoptera (Borror 1996). Chalcids mainly sponge on their hosts in their egg and larval stage (Borror 1996) highest abundance of coleopterans was recorded in the same season. Dipterans were found to be abundant during the previous season. Larval abundance in rubber litter during the northeast monsoon season supports the high food availability for chalcids during this season.

Abundance of Collembola was observed in the summer season followed by the pre-summer season. These observations deviates from the high abundance of Collembola during southeast monsoon in the rubber litter stands at Calicut (Jobi 2006) where the highest abundance of collembola was recorded during the southwest monsoon season. Rise in abundance of Collembola during pre-summer and summer is attributed to the earlier leaf shedding in the plantations of north Kerala and availability of thick litter for a longer duration from December to June. Availabilty of leaf litter coupled with the heavy summer showers (4 cm rain during December and 130.6 cm during summer) would have contributed to the abundance of Collembola known for their preference for moist litter conditions for their reproduction (Swift *et al.* 1979; Joosse 1981; Ferguson and Joly 2002; Lensing *et al.*

2005). Low abundance of Collembola during the rainy season (southwest and northeast monsoon) is related to the low litter thickness and the direct physical effect of rain on fauna and the excessively wet and flooded litter conditions (Frith and Frith 1990).

Coleoptera occupied the third place on the abundance map of the fauna in rubber litter after mites and Collembola and is more abundant than in the rubber plantations in Calicut district (Jobi 2006).

Tenebrionidae (37.5% of total Coleoptera), Staphylinidae (34.5% of total Coleoptera) and Carabidae (7.5% of total Coleoptera) are the prominent coleopteran families present in all seasons. Dominance of Staphylinidae is a general pattern in all litter faunal studies from the region (Jobi 2006; Anu and Sabu 2006) and their high abundance during summer season can be related to the prey (Collembola) resource availability and thick litter conditions, characteristic of the season. The very high abundance of tenebrionids in rubber plantations requires further analysis. Peak in abundance of tenebrionids during the pre-summer season arises from the return of diapausing beetles to rubber plantations and subsequent breeding activities (Jobi 2006; Sabu *et al.* 2007).

The low abundance and richness of Coleoptera during the southwest monsoon season, as for other fauna is related to the direct effect of water drops in the absence of a thick litter cover and its buffering effect (Wakelin 2000; Kattan *et al.* 2006).

Comparatively low abundance and species richness of litter spiders was observed, in contrast to their high occurrence in the deciduous forest litter stands. The exact reasons for the generally low abundance of spiders in rubber litter floor is not understood, probably related to the high seasonality of prey resources (Eisenbeis and Wichard 1987; Ferguson 2001) and litter floor structural variations (litter depth) (Frith and Frith 1990).

Aseasonal presence of isopods was a special feature noticed only in the evergreen forest as testified to in the earlier chapters of the current study (evergreen forest litter stands). Higher abundance of isopods recorded during the wet southwest monsoon season bears out their fondness for moisture (Zimmer and Topp 1997, 2000; Zimmer 2002).

Presence of Homoptera (hoppers and scale insects) well known for their sap feeding and their association with specific host plants (Borror *et al.* 1996) observed only in the presummer. The collected scaly insects are purely attached forms and the Berlese collections get their exuvium (shell remnants). Their abundance/presence during presummer is arising from the premature fall of leaves and shoots, which is common in the region. Mantodea, Isoptera and Psuedoscorpion showed minimal abundance, which can be attributed to the taxa specific behaviour pattern and special climatic requirements. The overall low abundance of Mantids is due to their habitat peculiarity. Mantids are not in habit of wandering for their prey and are usually seen on the lower portion of the rubber tree trunk. Our collection consisted only juvenile forms mainly during the presummer period (Borror *et al.* 1996). Their highly seasonal presence that too as juvenile forms in presummer period and very rarely as adult forms are related to their life cycle peculiarities.

Overall low abundance of Isoptera is attributed to the abundance of predators *viz.* Hymenoptera, Staphylinidae, Carabidae and astigmatid mites recorded through out the year, but further studies are required to confirm it.

Isoptera peaked only during the summer season and it is related with low litter depth and dry conditions (Wang and Powell 2001). How the abundance of insectivorous birds (especially Warblers during pre-summer season) in morning hours in rubber plantation, and their feeding activities, control the presence of termites in rubber plantations is not known (Personal observation; Johnson and Sherry 2001).

During presummer season tender leaves sprout on the rubber plant and the short spell of rains lead to fungal infections (*Phytophthora* spp. or powdery mildew - *Oidium heveae*) and abnormal leaf fall (ALF) (Jacob 2002). The higher abundance of fungivores *viz.* Thysanoptera (Thrips) and Endomychidae (Handsome fungus beetle) during the presummer season is attributed to the availability of fungal infected immature tender leaves. Though thrips were recorded during all seasons except southwest monsoon season, their very high abundance was recorded during pre-summer season (more than 75% of the total abundance), when fungus infected fallen leaves are abundant in the litter floor. It is suggested that the premature leaf fall and the fungal resource availability is leading to the abundance of thrips.

Incidence of Psocoptera in rubber plantations is limited to pre-summer and southwest monsoon seasons. In pre-summer, the phenomenon of powdery-mildew fungal infected flower/leaf fall along with fungal hyphae (Borror *et al.* 1996) and the resultant food resource (fungal spores) availability is suggested as leading to the abundance of Psocoptera (Jacob 2002). But reasons for their abundance during southwest monsoon season require detailed analysis and exploration.

Regression analysis shows that the major fauna are influenced by habitat physical factors. Correlation analysis shows that faunal abundance is positively correlated with litter depth. Faunal seasonality is due to the seasonality of litter depth (leaf falling), which is indirectly related to the climatic variables (rainfall, temperature and humidity) and its influence on their phenology of rubber plants. Present study indicates that litter depth is the major determinant of faunal abundance. These observations are substantiated by the current correlation analysis (Table 4.9a,b and Fig. 4.1b), which shows the highest incidence of fauna during pre-summer season season when litter depth is very high.

High larval abundance occurred during pre-summer season and the lowest during the summer months. High abundance in pre-summer is related to the high litter depth and the return of favourable conditions following monsoon period. Larval growth invariably requires moisture and low temperature (Lensing *et al.* 2005; Raghavendra 2001), hence the low abundance of larva recorded during the summer months could be ascribed to the high temperature and dry litter condition and the influence of fungicide applications and fertilizer additions following summer rains may be the another probable reason, but not analysed in this study.

Presence of Orthoptera, which are not strictly detritivores, attributed to the presence of grass cover and shrubs in rubber plantations especially in open spaces resulting from the uprooting of rubber trees during heavy wind in southwest monsoon season. This high abundance during northeast monsoon season is related to the presence of thick grass cover throughout the rubber plantations following the 6 month monsoon period and the total absence of litter cover following the decomposition of litter (Gunatilleke 2002).

High abundance of predatory Dermaptera during pre-summer and summer is related to the prey resource avilability (insect larva and Collembola) (Langston and Powell 1975) was substantiated by the current correlation results. Abundance of Blattaria shows a significant positive correlation with the litter depth, both of which peaked during pre-summer and summer season, indicating the influence of thickness of litter habitat on the abundance of Blattaria.

High Fisher's alpha diversity, Margalef's richness index, Pielou's evenness index, Shannon's diversity index and low simpson's dominance index were recorded during the northeast monsoon season which bear no relation with the dominance of major fauna and the presence of a good number of taxa (26/37). High Simpson's dominance index during the pre-summer is related to the high abundance of Collembola, Thysanoptera, Hymenoptera and Oribatids during this season.

Tukey test showed significant differences in the indices values recorded during northeast monsoon season (except Pielou's evenness index of southwest monsoon season since both are rainy seasons and show similar low litter depth and other litter physical factors that lead to the peculiar low abundance and even distribution of fauna during both the seasons). Significant difference in the diversity indices of the northeast monsoon season is related to the comparatively even distribution of all faunal groups compared to the other seasons.

Low Bray Curtis similarity index recorded between the southwest and pre-summer seasons is significant arising from the contrasting climatic conditions, one with wetness and the other with dryness (Fig. 4.5). So the fauna adapted to exclusively wet moist conditions are present during southwest monsoon season and those arthropods adapted to dry litter conditions are present during the comparatively drier pre-summer season.

High similarity between summer and pre-summer collections is related to the similar climatic factors with low rainfall and high litter depth.

Conclusion:

Rubber litter arthropod fauna did not exhibit seasosanal variations, whereas individual fauna showed significant seasonal variation. This disparity attributed due to the inversely proportional (mutual compensatory abundance pattern of major and minor fauna toward the total abundance of each season) abundance pattern of arthropod fauna during different seasons. Overall fauna and most of the individual faunal groups showed high abundance during the summer season. Both the evenness and diversity index was high during the northeast monsoon season. Irrespective of the seasonal disparity, detritivores feeding guild was dominanat during all seasons.

Table 4.1. Physical characteristics of litter floor in the rubber plantation at Chemperi during Dec 2002 to Nov 2003.

Parameters	**Mean [a] ± SE**
Litter temperature (^{0}C)	29.96 ± 2.75
Litter humidity (%)	65.20 ± 13.46
Litter depth (cm)	2.45 ± 1.08
Slope of the terrain	09° 00' ± 0° 20'
Rainfall (mm)	259.40 ± 383.60

[a] Mean of twelve monthly samples.

Table 4.2. Mean population density of rubber litter arthropod fauna per (¼) m^2 and standard deviation during various seasons of the year December 2002 to November 2003.

SEASON		PS	S	SW	NE
TAXA	**Guild**	**Mean ±**	**Mean**	**Mean**	**Mean**
Entomobryidae	M	4±2	4 ±2.7	2±1.9	1.3±1
Hypogastruridae	M	3.3±2.1	4±2.7	2.3±1.7	0.7±0.8
Isotomidae	M	1.3±1.1	1±1.3	0.3±0.6	0±0
Onychiuridae	M	12.3±5	13±6.1	8.3±3.5	4.3±2.1
Sminthuridae	M	1.7 ±1.4	1.7±1.5	2.3±15	1±1.2
Tenebrionidae	D	6.3±3.5	4.3±4.3	1±0.8	5±1.7
Lampyridae	D	0.3±0.5	0±0	0±0	0±0
Scarabaeidae	D	0±0	0.7±1.1	0.7±0.8	0±0
Elateridae	D	0.3±0.7	0±0	0±0	0.4±0.7
Hydrophilidae	D	0±0	0±0	0.7±0.9	0.7±0.8
Carabidae	P	0.3±0.7	0.7±0.8	1±1.4	1.5±1
Coccinellidae	P	0.3±0.7	1.7±1.4	0±0	2.1±1
Staphylinidae	P	1.3±1.5	5±3.4	4.3±2.2	4.6±3.1
Endomychidae	F	0.7±0.8	0.3±0.7	0±0	0±0
PSOCOPTERA	F	0.3±0.8	0±0	4.3±2.4	0±0
THYSANOPTERA	F	7±7.4	0.3±0.7	0±0	1.7±1
DIPTERA	D	0.3±0.7	0±0	0.7±0.8	0±0
ORTHOPTERA	D	1.6±2.7	1.3±0.9	0.3±0.7	2.3±1.3
DERMAPTERA	D	0.7±1.2	0.7±0.8	0±0	0±0
ISOPTERA	D	0±0	0.3±0.6	0±0	0±0
BLATTARIA	D	1±0.9	1±1.1	0±0	0±0
MANTODEA	P	0.3±0.8	0±0	0±0	0±0
Ants	P	18±4.5	4.7±2.6	4.3±3.3	7.3±4
Chalcidae	P	0±0	0±0	0±0	0.7±0.7
HEMIPTERA	D	1±1.3	0±0	0.7±0.7	0.7±1.1
HOMOPTERA	D	1±1.3	0.7±1.3	0±0	0±0
Larva	D	13.3±8	7.7±3.4	9±6.3	10±4.5
Millipede	D	0±0	0±0	1±1.1	0.3±0.7
ISOPODA	D	0.3±0.7	3.3±2.6	6.3±2.7	1±1.6
Oribatida	D	57.7±43	48±28	10±6.2	3.3±1.8
Astigmata	P	5.7±8.1	16±10	4.3±3.7	2±1.6

Table 4.2. continued

Prostigmata	P	6±6.4	4.3±4.3	0.7±1.1	1±1.2
Mesostigmata	P	2.3±1.7	5.3±5.3	0.7±1.1	0.7±0.8
Ticks	P	0±0	0±0	0±0	0.3±0.6
PSEUDOSCORPION	P	0±0	0±0	0±0	0.3±0.7
ARANEAE	P	1.7±2.2	4.7±4.7	1.3±1.2	2±1.3
Centipede	P	0±0	0±0	2.3±1.6	0.3±0.6

PS: Pre-summer; S: Summer; SW: SOUTHWEST MONSOON; NE: NORTHEAST MONSOON

M, Microbidetritivore; D, Detritivore; F, Fungivore; P, Predator.

Table 4.3a. Mean population density of rubber litter arthropod fauna per (¼) m^2 and standard deviation during different months of the year December 2002 to May 2003.

	DEC	JAN	FEB	MAR	APR	MAY
COLLEMBOLA	13±1.8	25±3.6	30±4.3	10±3.4	28±6.5	33±4.3
Entomobryidae	2±1.4	4±0.5	6±1.2	1±0.9	5±1.4	6±2.3
Hypogastruridae	2±1.4	3±1.3	5±2.2	2±1	6±3.3	4±1.4
Isotomidae	1±1.3	2±0.7	1±0.8	0±0	2±1.5	1±0.9
Onychiuridae	7±2.5	14±2.8	16±4.3	6±2.1	14±3.4	19±3.1
Sminthuridae	1±1.2	2±1.8	2±1	1±0.9	1±0.9	3±1.5
COLEOPTERA	15±3.5	8±3.6	6±2.2	12±4.9	15±2.9	11±2.3
Tenebrionidae	10±2.1	5±2.8	4±2.3	9±4.4	3±1.1	1±1.3
Lampyridae	0±0	1±0.5	0±0	0±0	0±0	0±0
Scarabaeidae	0±0	0±0	0±0	0±0	0±0	2±0.9
Elateridae	0±0	0±0	1±0.9	0±0	0±0	0±0
Hydrophilidae	0±0	0±0	0±0	0±0	0±0	0±0
Carabidae	1±0.8	0±0	0±0	1±0.8	1±0.8	0±0
Coccinellidae	1±0.8	0±0	0±0	1±1.1	3±1.4	1±0.8
Staphylinidae	3±1.0	1±1	0±0	1±1.3	7±1.9	7±2.4
Endomychidae	0±0	1±1	1±0.9	0±0	1±0.8	0±0
PSOCOPTERA	0±0	0±0	1±1.1	0±0	0±0	0±0
THYSANOPTERA	0±0	5±2.3	16±4.9	1±0.9	0±0	0±0
DIPTERA	0±0	0±0	1±0.9	0±0	0±0	0±0
ORTHOPTERA	5±2.5	0±0	0±0	2±0.9	1±0.7	1±0.7
DERMAPTERA	0±0	2±1.3	0±0	0±0	1±0.7	1±0.8
ISOPTERA	0±0	0±0	0±0	0±0	1±0.7	0±0
BLATTARIA	1±1	1±1.1	1±0.7	2±1.2	1±0.5	0±0
MANTODEA	0±0	1±1.2	0±0	0±0	0±0	0±0
HYMENOPTERA	19±3.9	20±5.4	15±2.7	5±2.1	3±1.9	6±3.1
Ants	19±3.9	20±5.4	15±2.7	5±1.6	3±1.9	6±3.1
Chalcidae	0±0	0±0	0±0	0±0	0±0	0±0
HEMIPTERA	0±0	1±1	2±1.4	0±0	0±0	0±0

Table 4.3a. continued

HOMOPTERA	0±0	1±1	2±1.6	0±1.6	0±0	0±0
Larva	6±2.5	11±3.6	23±4.2	10±2.5	5±1.4	8±3.9
Millipede	0±0	0±0	0±0	0±0	0±0	0±0
ISOPODA	0±0	0±0	1±0.9	2±0.5	4±2.3	5±2.7
ACARI	13±2.7	60±8.9	142±15.8	93±43.4	71±34.7	55±20.2
Oribatida	10±2.2	51±7.9	112±9	64±31.1	41±28.4	38±16.6
Astigmata	1±0.4	2±1	14±9.6	15±11.3	21±10.1	11±8.2
Prostigmata	1±0.4	4±2.5	13±6.4	5±4.4	5±2.8	3±2.8
Mesostigmata	1±0.6	3±1.9	3±1.7	9±4.4	4±2.4	3±3.0
Ticks	0±0	0±0	0±0	0±0	0±0	0±0
PSEUDOSCORPION	0±0	0±0	0±0	0±0	0±0	0±0
Spider	4±2.2	1±1.1	0±0	7±3.4	3±1.4	4±1.4
Centipede	0±0	0±0	0±0	0±0	0±0	0±0

Table 4.3b. Mean population density of rubber litter arthropod fauna per (¼) m^2 and standard deviation during different months of the year June 2003 to November 2003.

	JUN	JUL	AUG	SEP	OCT	NOV
COLLEMBOLA	16±2	19±3.1	11±3.4	9±2.7	8±2.5	5±1.9
Entomobryidae	2±1.2	3±2.6	1±1.1	2±0.8	1±0.9	1±1.1
Hypogastruridae	2±1.2	3±2.2	2±1.7	1±0.7	1±0.9	0±0
Isotomidae	1±0.7	0±0	0±0	0±0	0±0	0±0
Onychiuridae	9±2.6	10±4.4	6±1.9	4±1.3	5±2.9	4±1.8
Sminthuridae	2±1.1	3±1.7	2±1.5	2±1.3	1±0.8	0±0
COLEOPTERA	8±4.2	7±2.2	8±1.7	11±2	17±3.8	15±3.6
Tenebrionidae	1±1.1	1±0.8	1±0.5	5±1.6	6±1.3	4±1.8
Lampyridae	0±0	0±0	0±0	0±0	0±0	0±0
Scarabaeidae	1±0.9	1±0.7	0±0	0±0	0±0	0±0
Elateridae	0±0	0±0	0±0	0±0	1±0.6	0±0
Hydrophilidae	1±1.3	0±0	1±0.5	1±0.8	1±0.6	0±0
Carabidae	1±1.3	0±0	2±1.4	1±0.7	2±0.8	1±0.8
Coccinellidae	0±0	0±0	0±0	2±0.9	3±1.3	2±0.8
Staphylinidae	4±2.4	5±2	4±2.2	2±0.8	4±1.6	8±2.5
Endomychidae	0±0	0±0	0±0	0±0	0±0	0±0
PSOCOPTERA	2±1.6	5±1.8	6±1.6	0±0	0±0	0±0
THYSANOPTERA	0±0	0±0	0±0	1±0.7	2±1.2	2±0.8
DIPTERA	1±0.7	1±0.8	0±0	0±0	0±0	0±0
ORTHOPTERA	0±0	0±0	1±0.9	2±0.9	3±1.4	2±1.3
DERMAPTERA	0±0	0±0	0±0	0±0	0±0	0±0
ISOPTERA	0±0	0±0	0±0	0±0	0±0	0±0
BLATTARIA	0±0	0±0	0±0	0±0	0±0	0±0
MANTODEA	0±0	0±0	0±0	0±0	0±0	0±0
HYMENOPTERA	1±0.7	4±2.1	8±1.7	9±2	4±2	11±3.4
Ants	1±0.7	4±2.1	8±1.7	9±2	3±2.1	9±3.4
Chalcidae	0±0	0±0	0±0	0±0	1±0.7	2±0.7
HEMIPTERA	0±0	1±0.7	1±0.7	2±0.5	0±0	0±0

Table 4.3b. continued

HOMOPTERA	0±0	0±0	0±0	0±0	0±0	0±0
Larva	2±0.8	14±5.3	11±3.3	12±2.8	14±2.6	5±1.3
Millipede	0±0	2±1.1	1±0.8	1±0.8	0±0	0±0
ISOPODA	8±2.1	7±2.7	4±1.3	3±1.4	0±0	0±0
ACARI	24±6.5	18±4.3	5±2.2	9±2.1	7±3.3	6±1.4
Oribatida	16±3.5	11±4	3±1.5	2±1.2	4±2	4±1.5
Astigmata	8±4.2	3±1.5	2±0.9	3±1.7	2±1.5	1±0.7
Prostigmata	0±0	2±1.1	0±0	2±1.5	0±0	1±0.7
Mesostigmata	0±0	2±1.1	0±0	1±0.8	1±0.9	0±0
Ticks	0±0	0±0	0±0	1±0.7	0±0	0±0
PSEUDOSCORPION	0±0	0±0	0±0	0±0	0±0	1±0.8
Spider	1±0.7	1±0.8	2±1.6	1±0.5	2±0.8	3±1.6
Centipede	1±0.7	4±0.9	2±1.2	1±0.7	0±0	0±0

Table 4.4. Overall mean population density (mean and standard deviations) and relative percentage (%) of rubber litter arthropod fauna per (¼) m^2 during the study period (December 2002 to November 2003).

TAXA	**Mean**	±	**SD**	**%**
COLLEMBOLA	17.3	±	7.58	6.63
Entomobryidae	2.83	±	1.37	1.09
Hypogastruridae	2.58	±	1.45	0.99
Isotomidae	0.67	±	0.61	0.26
Onychiuridae	9.5	±	4.01	3.65
Sminthuridae	1.67	±	0.54	0.64
COLEOPTERA	11.1	±	2.99	4.26
Tenebrionidae	4.17	±	2.27	1.6
Lampyridae	0.08	±	0.17	0.03
Scarabaeidae	0.33	±	0.38	0.13
Elateridae	0.17	±	0.19	0.06
Hydrophilidae	0.33	±	0.38	0.13
Carabidae	0.83	±	0.43	0.32
Coccinellidae	1.08	±	1.1	0.64
Staphylinidae	3.38	±	1.69	1.47
Endomychidae	0.25	±	0.32	0.18
PSOCOPTERA	1.17	±	2.12	0.45
THYSANOPTERA	2.25	±	3.25	0.86
DIPTERA	0.25	±	0.32	0.1
ORTHOPTERA	1.42	±	0.83	0.54
DERMAPTERA	0.33	±	0.38	0.13
ISOPTERA	0.08	±	0.17	0.03
BLATTARIA	0.5	±	0.58	0.19
MANTODEA	0.08	±	0.17	0.03
Ants	8.5	±	6.44	3.26
Chalcidae	0.25	±	0.5	0.1
HEMIPTERA	0.58	±	0.42	0.22

Table 4.4. continued

HOMOPTERA	0.25	±	0.5	0.1
Larva	10.1	±	2.42	3.87
Millipedes	0.33	±	0.47	0.13
ISOPODA	2.83	±	2.74	1.09
Oribatida	29.7	±	27	11.4
Astigmata	6.92	±	6.03	2.66
Prostigmata	3	±	2.6	1.15
Mesostigmata	2.25	±	2.2	0.86
Ticks	0.08	±	0.17	0.03
PSEUDOSCORPION	0.08	±	0.17	0.03
Spider	2.42	±	1.52	0.93
Centipede	0.67	±	1.12	0.26

Table 4.5. List of litter arthropod fauna collected from the rubber plantation litter stand at Chemperi during Dec. 2002 to Nov. 2003 study period.

COLEOPTERA

TENEBRIOINIDAE

Spinolyprops himalayicus

Luprops tristis

Luprops gracilior

Gonocephalum sp.

CARABIDAE

Clivina extensicollis

Diplocheila polita

Tetragonoderus intermedius

Scarites sp.

Pheropsophus sp.

Caelostomus sp.

Clivina tranquebarica

Apristus sp.

Chlaenius sp.

SCARABAEINAE

Copris davisoni

Copris repertus

Sisyphus longipes

Onitis siva

Onthophagus sp3

Gymnopleurus sinuatus

OTHER BEETLE FAMILIES

Elateridae

Hydrophilidae

Lampyridae

Coccinellidae

Staphylinidae

ORTHOPTERA

Gryllus sp.

Mecopoda sp.

HYMENOPTERA

ANTS

Camponotus parius

Cardiocondyla wroughtoni

Tetramorium rothneyi

Solenopsis geminata

Solenopsis sp1

Lobopelta dentilobis

Tapinoma melanocephalum

CHALCIDAE

Braconid sp.

ISOPTERA (TERMITES)

Odontotermes anamallenssis

Odontotermes obesus

COLLEMBOLA

Entomobryidae

Hypogastruridae

Onychiuridae

Sminthuridae

Isotomidae

THYSANOPTERA

Stigmothrips limpidus

Table 4.5. continued

SPIDERS	
	Scytodes sp.
	Cheiracanthium sp.
	Gnaphosa sp.
	Lycosa sp.
	Clubiona drassodes
	Asceua sp.
	Theridion sp.
	Opopea sp.
MITES	
	Uropodella sp.
	Podothrombium sp.
	Pavlovskicheyla sp.
	Oribatella sp.
	Oribatula sp.
	Mesoplophors sp.
	Eviphis sp.
	Epicrius mollis
	Cephaeus sp.
	Cephus sp.
	Damaeus sp.
	Galumna sp.
	Histiostoma sp.
	Microtrombidium sp.
PSEUDOSCORPIONS	
	Calocheiridius sp.

Table 4.6. Seasonal variation in the diversity of litter arthropods in the rubber plantation at Chemperi during the study period (2002 - 03).

Season	**Abundance (N)**	**Fisher's diversity (α)**	**Shannon diversity (H')**	**Simpson's dominance (λ')**	**Pielou's evenness (J')**	**Margalef's richness (d)**
P-S	151	10.68	2.30	0.18	0.68	5.58
S	134	8.53	2.37	0.16	0.75	4.69
S-W	69	13.06	2.74	0.07	0.86	5.43
N-E	56	18.86	2.78	0.07	0.86	6.21

Table 4.8. Multiple regression analysis of abundance of major litter arthropod fauna, as a function of litter climatic and habitat physical factors in the rubber plantation at Chemperi during the study period (2002 – 2003).

Dependent Variable	$F_{4,11}$	R^2	P
ANTS	58.807	.672	.000
COLEOPTERA	11.204	.280	.000
LARVAE	4.692	.140	.002
ASTIGMATA	24.410	.459	.000
COLLEMBOLA	16.696	.367	.000
ACARI	60.498	.678	.000
HYMENOPTERA	57.821	.668	.000
TENEBRIONIDAE	14.651	.338	.000
ORIBATIDA	54.069	.653	.000
ONYCHUIRIDAE	12.012	.295	.000

NB: Independent variable- Litter depth, Rainfall, Temperature, Humidity
N.S- Not significant; *$P \leq 0.05$; **$P \leq 0.01$; *** $P \leq 0.001$.

Table 4.9a Pearson's correlation analysis between fauna and physical factors (bold) of rubber plantation litter stand at Chemperi during the year December 2002 to November 2003.(left side below r- correlation coefficient; right side above P – significance; N.S, Not significant; $^*P \leq 0.05$; $^{**}P \leq 0.01$; $^{***}P \leq 0.001$)

	ANTS	ASTIGMATA	BLATTARIA	CARABIDAE	CENTIPEDES	CHALCIDAE	COCCINEILIDAE	DERMAPTERA	DIPTERA	ELATERIDAE	ENDOMICHIDAE	ENTOMOBRYIDAE	HEMIPTERA	HOMOPTERA	**HUMIDITY**	HYDROPHILIDAE	HYPOGASTRURIDAE	ISOPODA	ISOPTERA	ISOTOMIDAE	LAMPYRIDAE	LARVAE	**LITTER DEPTH**	MANTODEA	MESOSTIGMATA	MILLIPEDES	ONYCHUIRIDAE	ORIBATIDAE	ORTHOPTERA	PROSTIGMATA	PSOCOPTERA	PSEUDOSCORPION	**RAIN**	SCARABAEIDAE	SMITHURIDAE	SPIDER	STAPHYLINIDAE	**TEMPERATURE**	TENEBRIONIDAE	THYSANOPTERA	
ANTS	1	*	**	**	**	N.S	**	*	N.S	N.S	**	N.S	**	**	***	***	N.S	***	***	**	***	*	***	***	N.S	N.S	N.S	**	N.S	*	*	N.S	***	***	N.S	N.S	***	***	***	***	N
ASTIGMATA	-0.2	1	***	N.S	*	**	N.S	N.S	N.S	N.S	***	***	N.S	***	***	*	***	N.S	***	**	N.S	N.S	***	N.S	***	*	***	***	N.S	***	*	N.S	N.S	N.S	N.S	*	N.S	***	N.S	N.S	N
BLATTARIA	0.3	0.3	1	N.S	***	*	N.S	N.S	N.S	N.S	*	N.S	N.S	***	***	***	***	***	N.S	*	***	N.S	***	N.S	***	**	N.S	***	N.S	***	**	N.S	***	***	N.S	***	***	**	***	*	N.
CARABIDAE	-0.2	-0.1	-0.1	1	N.S	***	**	**	N.S	N.S	**	***	N.S	N.S	*	***	***	N.S	N.S	***	***	N.S	***	N.S	N.S	N.S	***	***	*	***	N.S	N.S	N.S	**	*	N.S	N.S	N.S	N.S	**	N
CENTIPEDES	-0.2	-0.2	-0.3	-0	1	*	***	*	***	*	*	N.S	**	*	***	N.S	N.S	***	N.S	***	N.S	N.S	N.S	N.S	*	***	N.S	***	**	*	***	N.S	***	*	***	**	N.S	***	***	**	N.
CHALCIDAE	-0.1	-0.2	-0.2	0.3	-0.2	1	***	N.S	N.S	***	N.S	**	**	N.S	N.S	*	***	***	N.S	**	N.S	N.S	***	N.S	*	N.S	***	***	**	*	*	***	N.S	N.S	***	N.S	***	N.S	N.S	N.S	N
COCCINILIDAE	-0.2	0.1	-0.1	0.3	-0.3	0.5	1	N.S	***	N.S	N.S	N.S	**	*	*	N.S	N.S	***	***	N.S	***	**	***	N.S	N.S	*	*	*	***	N.S	***	*	***	*	***	N.S	***	***	*	*	N
DERMAPTERA	0.2	0.0	0.0	-0.3	-0.2	-0.2	-0.1	1	*	N.S	***	***	N.S	N.S	**	**	***	N.S	N.S	***	***	N.S	*	***	N.S	*	***	*	*	N.S	*	N.S	***	N.S	N.S	N.S	N.S	***	N.S	N.S	N.
DIPTERA	-0.1	0.1	-0.1	-0.2	0.3	-0.2	-0.4	-0.2	1	N.S	N.S	*	N.S	N.S	**	N.S	N.S	***	N.S	N.S	N.S	*	***	N.S	N.S	N.S	N.S	*	***	**	***	N.S	***	***	N.S	***	N.S	**	**	**	N.
ELATERIDAE	-0.0	0.1	-0.0	0.1	-0.2	0.4	0.1	-0.2	0.1	1	**	N.S	N.S	N.S	N.S	**	N.S	***	N.S	N.S	N.S	***	N.S	N.S	N.S	N.S	N.S	*	N.S	***	N.S	N.S	N.S	N.S	N.S	*	*	N.S	N.S	***	N
ENDOMICHIDAE	0.3	0.3	0.2	-0.2	-0.2	-0.2	0.0	0.3	0.1	0.2	1	***	***	*	***	*	***	N.S	***	***	***	*	***	***	N.S	*	***	***	**	***	N.S	N.S	**	*	N.S	*	N.S	*	N.S	***	N
ENTOMOBRYIDAE	0.1	0.4	0.1	-0.4	-0.2	-0.3	-0.1	0.4	0.2	0.0	0.4	1	N.S	N.S	***	***	***	N.S	***	***	N.S	**	***	N.S	*	N.S	***	***	***	***	N.S	N.S	*	***	N.S	N.S	N.S	**	*	***	N.
HEMIPTERA	0.3	-0.1	-0.1	-0.1	0.2	-0.2	-0.2	-0.1	0.1	0.1	0.3	0.2	1	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	***	N.S	N.S	N.S	**	N.S	*	*	***	*	N.S	N.S	N.S	*	***	***	***	N.S	***	**
HOMOPTERA	-0.2	0.3	0.6	-0.1	-0.2	-0.2	-0.2	-0.1	0.1	0.1	0.2	0.1	0.2	1	***	*	***	***	N.S	N.S	***	***	***	N.S	***	*	N.S	***	N.S	***	N.S	N.S	***	*	N.S	N.S	***	N.S	***	***	N.
HUMIDITY	**-0.3**	**-0.5**	**-0.6**	**0.2**	**0.7**	**0.1**	**-0.2**	**-0.3**	**0.3**	**-0.1**	**-0.4**	**-0.4**	**0.1**	**-0.5**	**1**	***	***	***	***	***	N.S	N.S	***	N.S	***	***	***	***	N.S	***	***	N.S	***	N.S	*	***	N.S	***	***	***	*
HYDROPHILIDAE	-0.3	-0.2	-0.3	0.4	0.1	0.2	0.0	-0.2	0.0	0.2	-0.2	-0.4	0.1	-0.2	**0.5**	1	***	N.S	N.S	N.S	N.S	N.S	**	N.S	***	N.S	***	***	N.S	***	N.S	N.S	***	N.S	N.S	*	N.S	*	N.S	N.S	*
HYPOGASTRURIDAE	0.0	0.6	0.3	-0.2	-0.1	-0.3	-0.1	0.3	0.1	0.1	0.4	0.5	0.1	0.2	**-0.3**	-0.2	1	N.S	***	***	N.S	N.S	***	N.S	*	N.S	***	***	***	***	N.S	**	*	N.S	N.S	N.S	N.S	**	N.S	*	N.
ISOPODA	-0.5	0.1	-0.3	-0.1	0.5	-0.3	-0.2	-0.0	0.4	-0.3	-0.1	0.1	0.0	-0.2	**0.5**	0.1	0.1	1	N.S	N.S	***	**	N.S	N.S	N.S	***	N.S	*	***	N.S	***	*	***	***	**	N.S	***	N.S	***	***	N.
ISOPTERA	-0.2	0.4	0.1	0.1	-0.1	-0.1	0.4	0.1	-0.1	-0.1	0.4	0.3	-0.2	-0.1	**-0.3**	-0.1	0.3	0.1	1	***	N.S	*	N.S	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	***	N.S	N.S	N.
ISOTOMIDAE	0.3	0.3	0.2	-0.3	-0.3	-0.2	0.1	0.5	0.0	-0.0	0.5	0.4	-0.1	0.1	**-0.3**	-0.2	0.4	0	0.4	1	***	N.S	***	*	N.S	**	***	**	N.S	**	**	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.
LAMPYRIDAE	0.5	-0.2	0.2	-0.2	-0.1	-0.1	-0.2	0.6	-0.1	-0.1	0.5	0.1	0.2	0.2	**-0.1**	-0.1	0	-0.2	-0	0.4	1	N.S	***	***	N.S	N.S	*	N.S	*	N.S	N.S	N.S	*	N.S	N.S	N.S	**	N.S	N.S	*	N

Table 4.9b Pearson's correlation analysis between fauna and physical factors (bold) of rubber plantation litter stand at Chemperi during the year December 2002 to November 2003.(left side below r- correlation coefficient; right side above P – significance; N.S, Not significant; *$P \leq 0.05$; **$P \leq 0.01$; *** $P \leq 0.001$.)

	ANTS	ASTIGMATA	BLATTARIA	CARABIDAE	CENTIPEDES	CHALCIDAE	COCCINILEDAE	DERMAPTERA	DIPTERA	ELATERIDAE	ENDOMICHIDAE	ENTOMOBRYDAE	HEMIPTERA	HOMOPTERA	**HUMIDITY**	HYDROPHILIDAE	HYPOGASTRURIDAE	ISOPODA	ISOPTERA	ISOTOMIDAE	LAMPYRIDAE	LARVAE	**LITTER DEPTH**	MANTODEA	MESOSTIGMATA	MILLIPEDES	ONYCHIURIDAE	ORIBATIDAE	ORTHOPTERA	PROSTIGMATA	PSOCOPTERA	PSEUDOSCORPION	**RAIN**	SCARABAEIDAE	SMITHURIDAE	SPIDER	STAPHYLINIDAE	**TEMPERATURE**	TENEBRIONIDAE	THYSANOPTERA	TICKS
LARVAE	0.2	0.0	0.1	-0.1	0.1	-0.1	-0.3	-0.1	0.2	0.5	0.2	0.2	0.5	0.4	-0.1	0	0.2	-0.2	-0	-0.1	0	1	**	N.S	N.S	N.S	N.S	***	N.S	***	N.S	*	N.S	*	N.S	**	***	N.S	N.S	***	N.S
LITTER DEPTH	0.3	0.3	0.5	-0.4	-0.1	-0.6	-0.5	0.2	0.3	0.0	0.4	0.4	0.1	0.5	-0.4	-0.2	0.4	0	0	0.4	0.3	0.3	1	**	***	N.S	***	***	*	***	N.S	***	N.S	N.S	*	N.S	***	N.S	N.S	***	*
MANTODEA	0.3	-0.1	0.1	-0.2	-0.1	-0.1	-0.2	0.3	-0.1	-0.1	0.4	0.1	0.2	0.1	-0.1	-0.1	-0	-0.2	-0	0.2	0.7	0.1	0.2	1	N.S	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
MESOSTIGMATA	-0.1	0.4	0.5	-0.1	-0.2	-0.2	0.1	0.1	-0.1	-0.0	01	0.2	-0.0	0.5	-0.6	-0.3	0.2	-0.2	0.2	0.2	0.1	0.1	0.4	0.0	1	N.S	N.S	***	N.S	***	*	N.S	***	N.S	N.S	***	*	***	**	N.S	N.S
MILLIPEDES	-0.2	-0.2	-0.3	-0.1	0.8	-0.2	-0.2	-0.2	0.1	-0.2	-0.2	-0.1	0.3	-0.2	0.5	0.1	0	0.4	-0	-0.3	-0.1	0.2	-0.2	-0.1	-0.1	1	*	***	N.S	N.S	***	N.S	***	N.S	**	**	N.S	***	**	*	*
ONYCHIURIDAE	0.1	0.4	0.1	-0.4	-0.1	-0.3	-0.2	0.5	0.1	0.0	0.4	0.6	0.0	0.1	-0.4	-0.4	0.5	0.2	0.2	0.4	0.2	0.2	0.5	0.2	0.2	-0.2	1	***	***	***	N.S	**	N.S	***	***	N.S	N.S	**	**	***	**
ORIBATIDA	0.3	0.6	0.5	-0.3	-0.3	-0.3	-0.3	0.2	0.2	0.3	0.5	0.5	0.2	0.6	-0.7	-0.4	0.5	-0.2	0.1	0.2	0.2	0.4	0.7	0.2	0.5	-0.3	0.5	1	***	***	*	N.S	***	N.S	N.S	N.S	***	**	N.S	***	*
ORTHOPTERA	0.2	-0.2	0.0	0.2	-0.3	0.2	0.3	-0.2	-0.4	0.1	-0.3	-0.3	-0.2	-0.1	-0.1	0.1	-0	-0.4	-0	-0.1	-0.2	-0.1	-0.2	-0.2	-0.0	-0.2	-0.4	-0.3	1	*	***	N.S	***	**	***	***	N.S	N.S	***	**	N.S
PROSTIGMATA	0.2	0.4	0.3	-0.3	-0.2	-0.2	-0.1	0.1	0.3	0.3	0.5	0.5	0.4	0.4	-0.5	-0.3	0.4	-0.2	0.1	0.3	0.1	0.5	0.5	0.1	0.4	-0.1	0.4	0.7	-0.2	1	N.S	N.S	***	N.S	N.S	N.S	***	*	N.S	***	N.S
PSOCOPTERA	-0.2	-0.2	-0.3	0.1	0.7	-0.2	-0.4	-0.2	0.3	-0.1	-0.2	-0.2	0.2	-0.1	0.6	0.2	0	0.5	-0	-0.3	-0.1	0.1	-0.1	-0.1	-0.2	0.6	-0.1	-0.2	-0.3	-.2	1	N.S	***	N.S	**	*	N.S	***	***	N.S	N.S
PSEUDOSCORPION	0.0	-0.2	-0.1	0.0	-0.1	0.5	0.2	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1	-0	-0.1	-0	-0.2	-0	-0.2	-0.1	-0.2	-0.4	-0	-0.2	-0.1	-0.2	-0.2	0.1	-.1	-0.1	1	N.S	N.S	**	N.S	***	N.S	N.S	N.S	N.S
RAIN	-0.5	-0.1	-0.4	0.1	0.7	-0.1	-0.4	-0.3	0.5	-0.2	-0.3	-0.2	-0.0	-0.3	0.8	0.3	-0	0.7	-0	-0.2	-0.2	-0.2	-0.0	-0.1	-0.3	0.5	-0.1	-0.4	-0.4	-.3	0.7	-0.1	1	***	**	***	N.S	***	***	***	N.S
SCARABAEIDAE	-0.3	0.1	-0.3	-0.2	0.2	-0	-0.2	0.1	0.3	-0.2	-0.2	0.3	-0.1	-0.2	0.2	-0.1	0.1	0.5	-0	0.0	-0.1	-0.2	0.1	-0.1	-0.0	0.1	0.4	-0.0	-0.2	-.1	0.1	-0.1	0.3	1	***	N.S	***	N.S	***	*	N.S
SMINTHURIDAE	0	-0.0	-0.1	-0.2	0.3	-0.3	-0.3	0.1	0.2	-0.1	-0.1	0.2	0.2	0.0	0.2	0.1	0.2	0.3	-0	0.1	0.1	0.1	0.2	-0	-0	0.3	0.3	0.1	-0.3	-0	0.3	-0.3	0.3	0.4	1	N.S	N.S	N.S	***	N.S	N.S
SPIDERS	-0.1	0.2	0.3	0.1	-0.3	-0.0	0.2	-0	-0.3	-0.2	-0.2	-0.2	-0.4	0.0	-0.4	-0.2	-0	-0.1	0.1	0.0	-0.2	-0.2	0.0	-0.2	0.4	-0.3	-0.1	0.0	0.4	-0.1	-0.2	0.1	-0.3	0.0	-0.2	1	N.S	***	***	***	N.S
STAPHYLINIDAE	-0.4	0.0	-0.3	0.1	0.1	0.4	0.3	0.0	-0.1	-0.2	-0.1	0.1	-0.4	-0.4	0.2	-0.1	0	0.3	0.2	-0.1	-0.2	-0.4	-0.5	-0.2	-0.2	0.0	0.1	-0.4	0.0	-0.3	0.1	0.4	0.1	0.3	-0.1	0.1	1	***	***	***	N.S
TEMPERATURE	-0.3	0.5	0.2	-0	-0.4	0.1	0.4	0.3	-0.3	-0.0	0.2	0.3	-0.3	0.1	-0.6	-0.2	0.3	-0.1	0.5	0.2	-0.1	-0.1	-0.0	-0.1	0.4	-0.4	0.3	0.3	-0.0	0.2	-0.4	0.1	-0.4	0.1	-0.1	0.4	0.3	1	N.S	N.S	N.S
TENEBRIONIDAE	0.4	0.0	0.5	0.1	-0.4	0.1	0.2	-0.1	-0.3	0.1	-0.1	-0.2	-0.2	0.3	-0.4	-0.1	-0	-0.6	-0	-0.0	0	0.0	0.1	0.1	0.2	-0.3	-0.3	0.1	0.5	0.0	-0.5	-0.0	-0.5	-0.4	-0.4	0.3	-0.3	0.0	1	N.S	N.S
THYSANOPTERA	0.4	0.1	0.2	-0.3	-0.2	-0	-0.2	0.0	0.3	0.5	0.4	0.4	0.4	0.5	-0.4	-0.1	0.2	-0.3	-0	0.1	0.2	0.6	0.4	0.1	0.1	-0.2	0.3	0.7	-0.3	0.6	-0.1	-0.0	-0.3	-0.2	0.0	-0.3	-0.4	-0.1	0.1	1	N.S
TICKS	-0.0	-0.1	-0.2	0.1	0.0	-0.1	0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.5	-0.1	0.2	0.3	-0	0	-0	-0.2	-0.1	0.1	-0.2	-0	-0.1	0.2	-0.2	-0.2	0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.1	-0.2	-0.1	-0.1	0.1	-0.1	1

Table 4.10. Partial correlation analysis of the relation between climatic and habitat physical factors (Humidity, Litter depth, Rain and Temperature) and major arthropod fauna in the rubber plantation litter stand at Chemperi during the study period (2002 – 2003).

VARIABLES	D.F.	R	*P*
Collembola - Humidity	115	-.0787	N.S
Collembola - Litter Depth	115	.3493	***
Collembola - Rain	115	.1004	N.S
Collembola - Temperature	115	.2113	*
Onychiuridae- Humidity	115	-.1211	N.S
Onychiuridae- Litter Depth	115	.2523	**
Onychiuridae- Rain	115	.1255	N.S
Onychiuridae- Temperature	115	.1535	N.S
Coleoptera - Humidity	115	-.0198	N.S
Coleoptera - Litter Depth	115	-.2732	**
Coleoptera - Rain	115	-.1256	N.S
Coleoptera - Temperature	115	.1263	N.S
Ants - Humidity	115	0.214	*
Ants - Litter Depth	115	0.414	***
Ants - Rain	115	-0.605	***
Ants – Temperature	115	-0.518	***
Hymenoptera- Humidity	115	0.197	*
Hymenoptera - Litter Depth	115	0.37	***
Hymenoptera- Rain	115	0.602	***
Hymenoptera– Temperature	115	-0.527	***
Larvae - Humidity	115	.0751	N.S
Larvae - Litter Depth	115	.2136	*
Larvae - Rain	115	-.1816	*
Larvae - Temperature	115	-.1304	N.S
Acari- Humidity	115	-0.473	***
Acari- Litter Depth	115	0.308	***
Acari- Rain	115	0.30	***
Acari- Temperature	115	-0.038	N.S
Oribatida- Humidity.	115	-0.451	***
Oribatida- Litter Depth	115	0.312	***
Oribatida- Rain	115	0.252	**
Oribatida- Temperature	115	-0.146	N.S
Astigmata- Humidity	115	-.2973	***
Astigmata- Litter Depth	115	-.0790	N.S
Astigmata- Rain	115	.3297	***
Astigmata- Temperature	115	.3063	***

N.S., Not significant; $*P \leq 0.05$; $**P \leq 0.01$; $***\ P \leq 0.001$
(Independent variables: Litter depth, Rain, Temperature, Humidity)

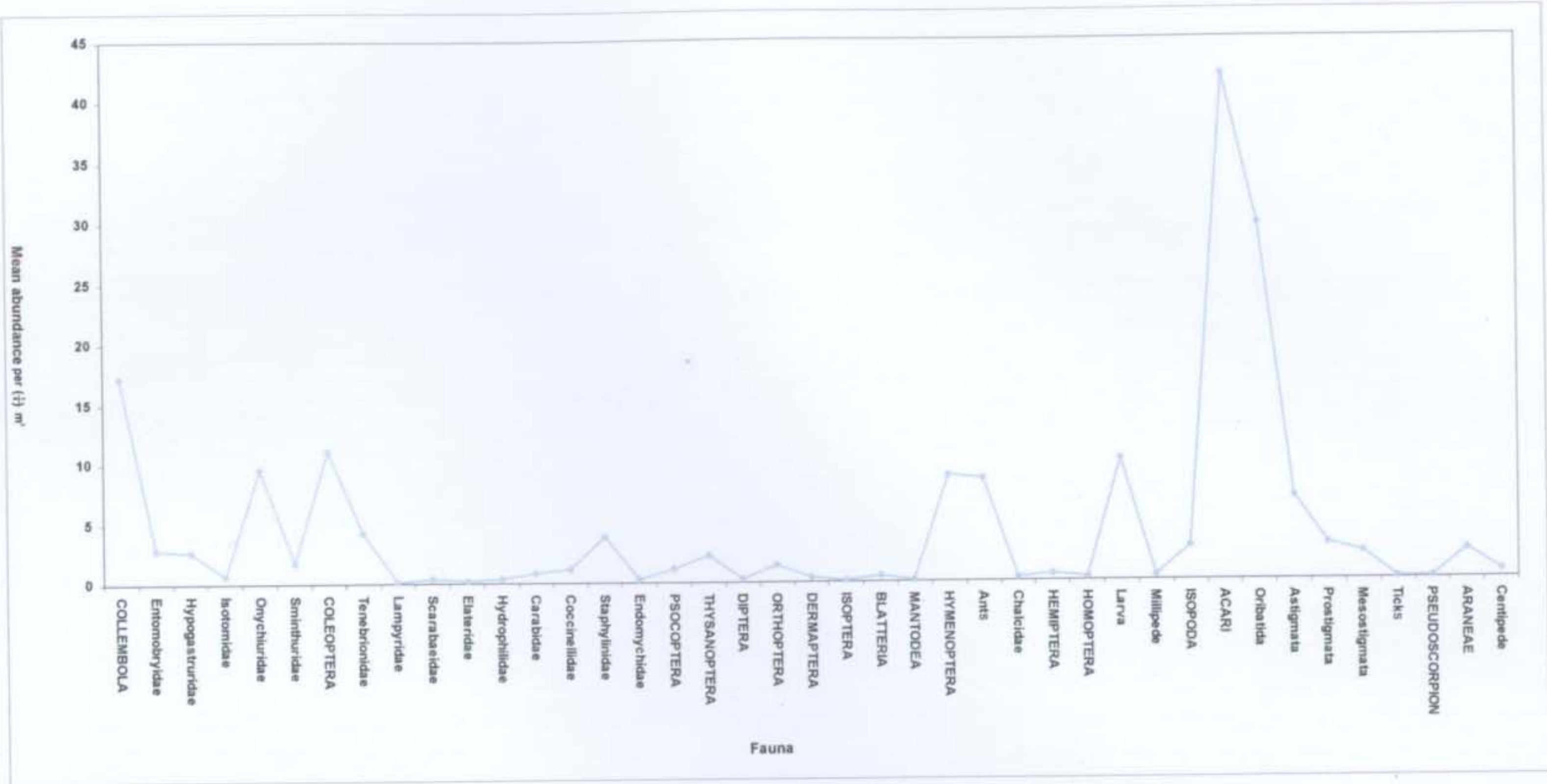


Figure 4.2. Abundance of litter arthropod fauna in the rubber plantation during the study period of Dec 2002 to Nov 2003.

15413

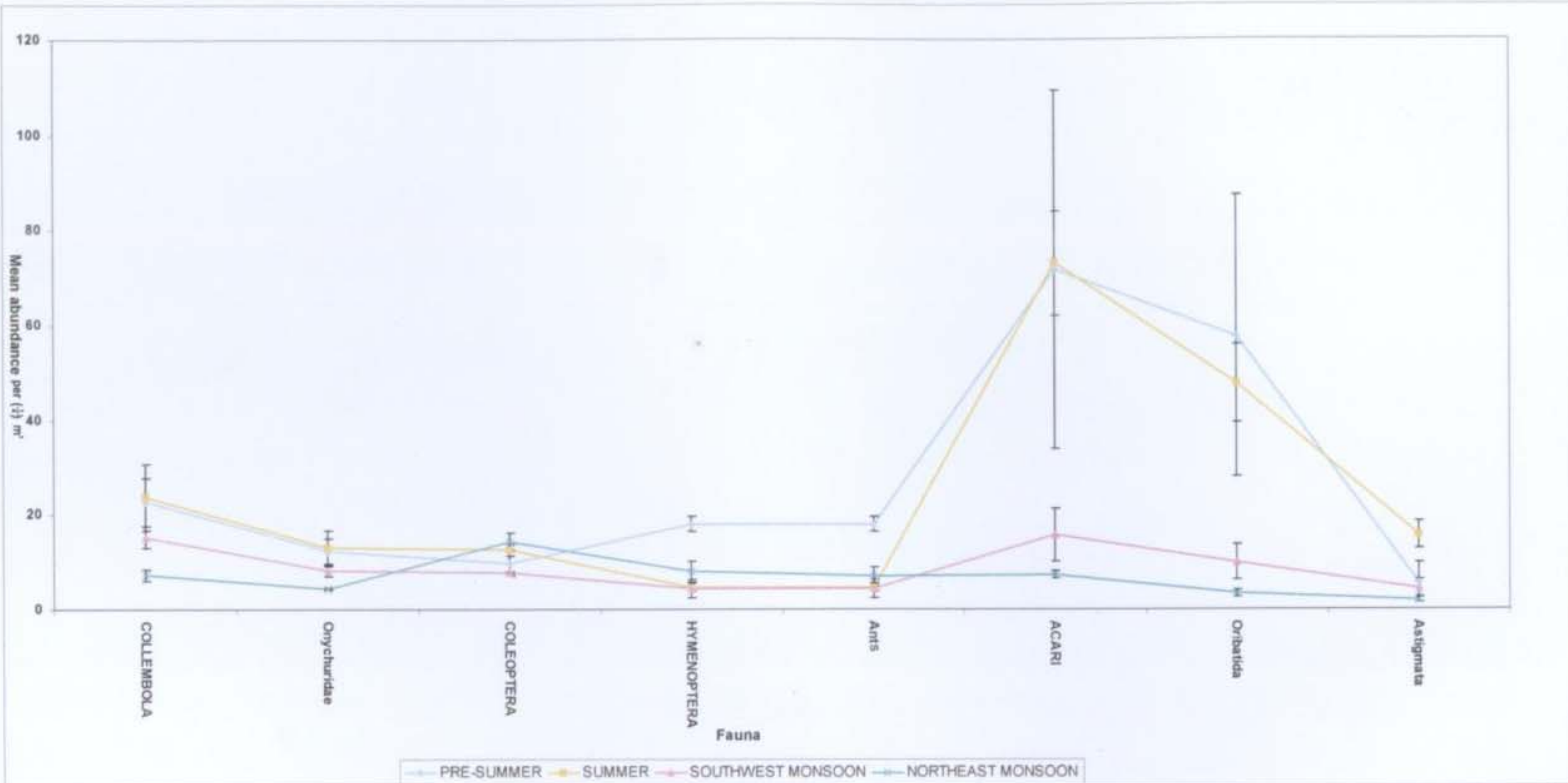


Figure 4.3. Seasonal distribution of major litter arthropod fauna in the rubber plantation during the study period (2002-03).

15A C

24

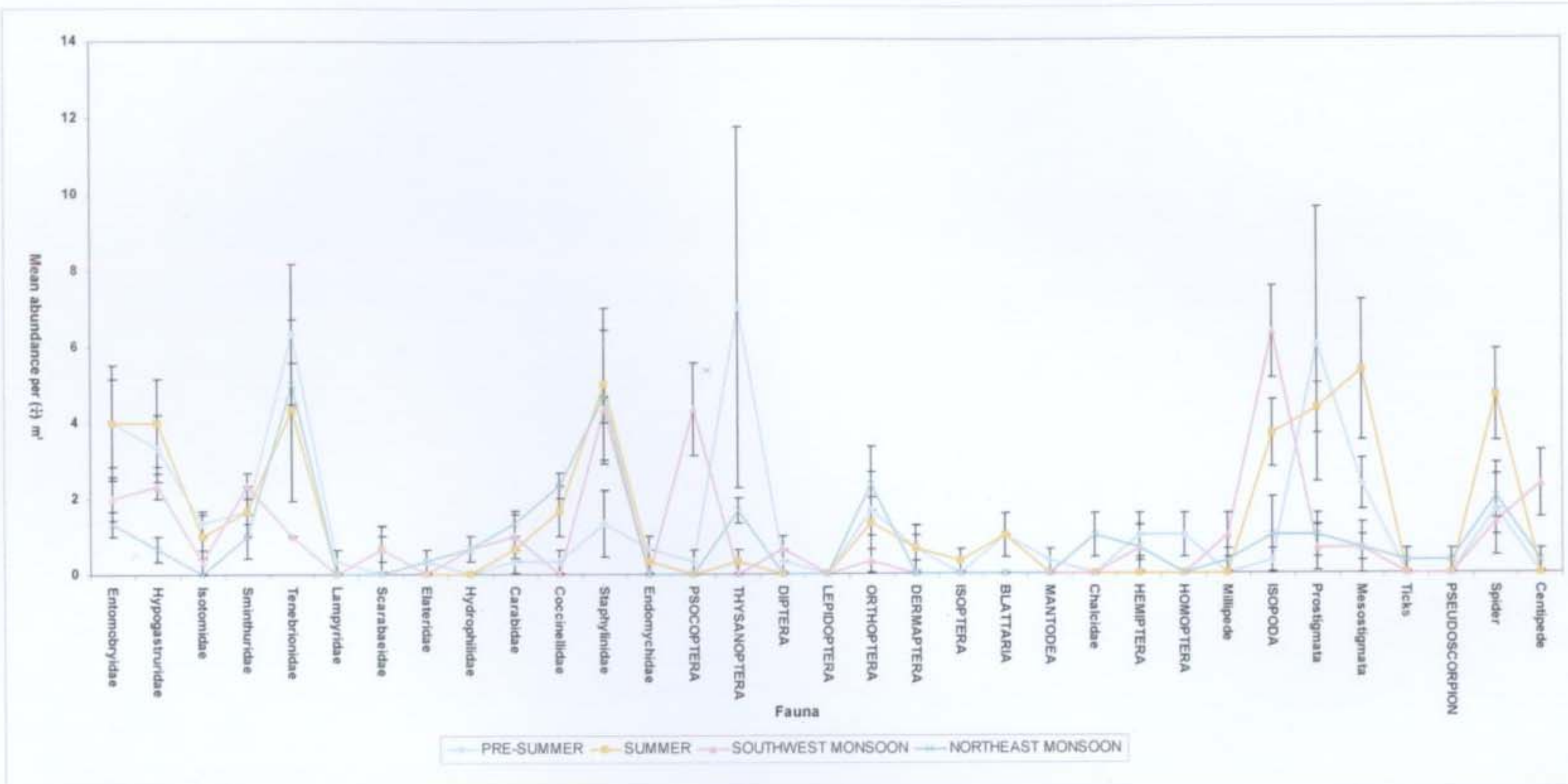


Figure 4. 4. Seasonal distribution of minor litter arthropod fauna in the rubber plantation during study period (2002-03).

154D

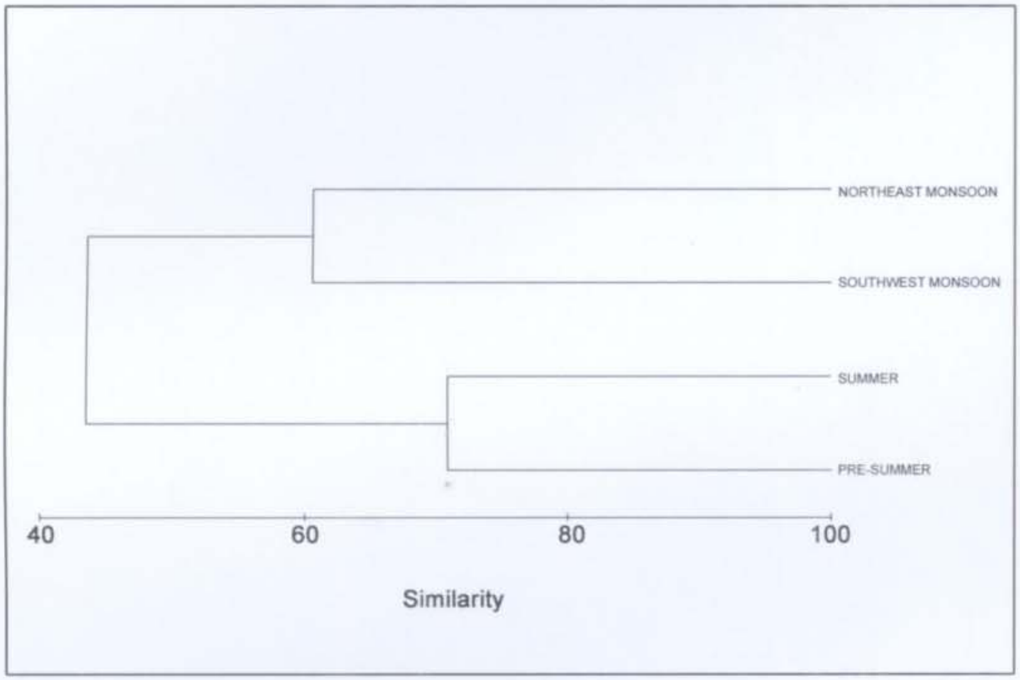


Figure 4.5. Dendrogram of litter arthropod faunal assemblage during different seasons of the study period based on hierarchical agglomerative clustering (group-linking).

Table 4.7. Significance levels (Tukey pair wise significance test) of seasonal variation in Margalef's richness, Pielou's evenness, Shannon diversity, Fisher's alpha and Simpson's dominance indices of litter arthropods in the rubber plantation at Chemperi during the 2002 – 03 study period.

Seasons	PRESUMMER	SUMMER	SOUTHWEST
Margalef's Richness			
SUMMER	N.S		
SOUTHWEST	***	***	
NORTHEAST	***	***	***
Pielou's Evenness			
SUMMER	N.S		
SOUTHWEST	***	***	
NORTHEAST	***	***	N.S
Shannon Diversity			
SUMMER	N.S		
SOUTHWEST	N.S	*	
NORTHEAST	***	***	***
Fisher's Alpha			
SUMMER	N.S		
SOUTHWEST	N.S	N.S	
NORTHEAST	***	***	***
Simpson's Dominance			
SUMMER	N.S		
SOUTHWEST	N.S	N.S	
NORTHEAST	***	***	***

N.S- Not significant; *$P \leq 0.05$; **$P \leq 0.01$; *** $P \leq 0.001$

CONCLUSION

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CONCLUSIONS

Seasonal variations in the abundance, diversity and guild composition influence of habitat physical factors (temperature, rain, humidity, litter depth) in determining litter faunal abundance and reciprocal relationships among the faunal groups, in an evergreen and a deciduous forest and monoculture rubber plantation in the north region of south Western Ghats were analysed.

Distinct seasonal variation in the abundance of litter fauna was recorded from the evergreen forest. No seasonality is noticed in deciduous forest and rubber plantation. Deciduous forest recorded higher faunal abundance per unit area (253 per (¼) m^2). Lowest abundance was recorded from rubber plantations (102 per (¼) m^2).

Overall arthropod abundance showed no significant difference ($F_{2, 147} = 2.6$, $P = 0.08$) between the three litter habitats. Highest faunal abundance is recorded during the northeast monsoon season in evergreen and deciduous forests and during the pre-summer season in rubber plantation. Season wise comparison of litter fauna in three habitats showed that significant variation during northeast monsoon season ($F_{2, 147} = 6.223$, $P = 0.0025$). No significant variation in faunal abundance between the habitats were recorded during any other season (pre-summer, $F_{2, 147} = 0.605$, $P = 0.55$; Summer, $F_{2, 147} = 1.36$, $P = 0.26$; and Southwest monsoon, $F_{2, 147} = 2.74$, $P = 0.07$).

Detritivores dominated during summer and southwest monsoon seasons in evergreen forest and predators during pre-summer and northeast monsoon season. Fungivores were not recorded during southwest monsoon season. All four feeding guilds were present throughout the seasons in deciduous forest. Except during southwest monsoon season predatory guild dominated during all seasons in deciduous forest. During southwest monsoon, microbidetritivore dominated. Members of all four guilds were present in rubber litter stands round the year. Relative abundance of feeding guilds showed distinct seasonal variation. Irrespective of this seasonal disparity in abundance, detritivore feeding guild dominated during all seasons.

Collembola, mites, ants and larva were the major taxa in the litter stands of deciduous and evergreen forests and rubber plantation. The order of dominance varied between the sites. Dominance order was Collembola > Acari > Hymenoptera > Larva > Araneae in evergreen forest, and that of deciduous forest was Acari > Hymenoptera > Collembola > Coleoptera > Thysanoptera and in rubber was Acari > Collembola > Coleoptera> larva> Hymenoptera.

Collembola, Coleoptera, Orthoptera, Hymenoptera, Acaridae, Araneae and Larva were present during all seasons in all the three litter habitats. Hymenoptera and larva were present during all four seasons in deciduous and evergreen forests and Isopoda in rubber plantations and evergreen forest litter habitats. Mantids were specific to pre-monsoon in all three habitats. Pseudoscorpions were recorded only during northeast monsoon season in deciduous forest and rubber plantation. Meloidae, Cerambycidae, Histeridae, Ptiliidae, Rhyncophoridae and Lepidoptera were recorded only in evergreen forest, Nitidulidae in deciduous forest and Coccinellidae and Homoptera only from rubber litter stands.

High abundance and species richness of tenebrionids in rubber litter stands (4.17 per (¼) m^2), spiders in evergreen forests (15.42 per (¼) m^2) and mites (63.1 per (¼) m^2), ants (50.6 per (¼) m^2) and thrips (18.8 per (¼) m^2) in deciduous forest litter stands are recorded.

High diversity (Shannon diversity H' = 3.04), evenness (Pielou's evenness J'= 0.79), richness (Margalef's richness d = 9.11) and lowest dominance (Simpson's index, λ = 0.06) were recorded in evergreen litter stands and the lowest diversity (Shannon diversity H' = 2.66), evenness (Pielou's evenness J' = 0.74) and highest dominance (Simpson's index, λ = 0.11) in rubber plantation litter.

Highest Shannon diversity was recorded during the northeast monsoon season in all three litter stands (evergreen, deciduous forest and rubber plantation). Highest evenness index was recorded during the southwest monsoon season in evergreen and deciduous forests and during northeast season in rubber plantation. Highest Margalef's richness index was recorded during northeast monsoon season in litter stands.

Highest faunal similarity (Bray Curtis) is recorded in between evergreen and deciduous forests (65.9) and the lowest similarity is recorded between deciduous forest and rubber (49.1). Rubber litter fauna showed more similarity with evergreen forest litter fauna (53.3). It is arising from the similarity in the abundance of Coleoptera, Psocoptera, Dermaptera, Hymenoptera, Hemiptera, larva, Isopoda, mites and Pseudoscorpion in rubber plantation and evergreen forest litter than with deciduous forest.

Regression analysis revealed significant influence of physical factors on faunal abundance in all litter stands. Correlation analysis of relationship between physical factors (rainfall, temperature, humidity and litter depth) and abundance of litter fauna showed significant relationships in between more groups in rubber and deciduous litter habitat than in evergreen forest.

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