BIODIVERSITY OF ARTHROPOD FAUNA IN MAIZE ECOSYSTEM AT DIFFERENT ALTITUDES OFNAGALAND

BY

R. IMTIONEN AO

SUBMITTED

IN FULFILMENT OF THE REQUIREMENT OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

ENTOMOLOGY

NAGALAND UNIVERSITY

HEADQUARTER: LUMAMI

Dedicated

To

My Wife

&

Children

Nagaland University
School of Agricultural Sciences and Rural Development
Medziphema Campus
Medziphema – 797106, Nagaland

DECLARATION

I, R. IMTIONEN AO, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other university/institute.

This is being submitted to Nagaland University for the degree of Doctor of Philosophy in Entomology.

Date: 27/11/09

(R. IMTIONEN AO)
Candidate

(ALEMLA AO)
Joint Supervisor
Professor
Dept. of Entomology
NU, SASRD, Medziphema

(H.K.SINGH) 27-11-09
Supervisor
Reader
Dept. of Entomology
NU, SASRD, Medziphema

27.11.09

(H.K. Singh)
Reader and Head
Dept. of Entomology
NU, SASRD, Medziphema

Department of Entomology
School of Agricultural Sciences and Rural Development
Nagaland University
Medziphema Campus
Medziphema – 797106, Nagaland

Dated : 27.11.09

CERTIFICATE

This is to certify that the thesis entitled, "**Biodiversity of arthropod fauna in maize ecosystem at different altitudes of Nagaland**" submitted by **R. Imtionen Ao**, to the **School of Agricultural Sciences and Rural Development, Nagaland University** for the Degree of **Doctor of Philosophy** in **ENTOMOLOGY**. The thesis embodies the original record of investigation carried out by him under our supervision and guidance.

All help received by him have been duly acknowledged. No part of this thesis has been submitted elsewhere for any degree or diploma.

Joint-supervisor

27/11/09

(M. ALEMLA AO)
Professor
Department of Entomology

Supervisor

H.Singh
27.11.09

(H.K. SINGH)
Reader
Department of Entomology

ACKNOWLEDGEMENT

I would like to express my deep sense of gratitude to my mentor Dr. H. K. Singh Reader and Head, Department of Entomology, N.U.: S.A.S.R.D. for his able guidance and keen supervision rendered to me during the course of investigation and in the preparation of the manuscript.

I am indebted to my joint supervisor Dr. M. Alemla, Professor, Dr. D.P. Chaturvedi, Professor, , Dr. (Mrs.) Asangla, Sr. Lecturer, Mrs. Imtinaro, Lecturer, Shri. Pankaj Neog, STA; and all the staffs of the Department of Entomology for their inspiring suggestions and helps.

I sincerely thank Dr. Supong Keitzer, Director of agriculture, Govt. of Nagaland, Mrs. Banuo Z. Jamir, Principal Secretary and Mrs. Meilemla Pongener, Jt. Secretary to the government of Nagaland for granting my study leave to do Ph. D course.

I express my gratitude to The Dean and administrative staffs of S.A.S.R.D. for providing all necessary facilities during the course of my study.

My sincere gratitude is due to Mr. Mhombemo N.gullie, Assistant Librarian, Mr.Zhevito Shohe and all library staffs for their love and understanding and providing all library facilities throughout the period of study.

My deepest thanks and appreciations are due to Dr. A. Kalaisekar, Senior Scientist, and Shri. K. Saikia, Research assistant, division of Entomology, ICAR Research Complex for NEH Region, Umiam, Meghalaya for their valuable suggestion and help rendered to me in statistical analysis and also in preparation of manuscripts.

I am very much thankful to all the Dr. V.V. Ramamurthy and Dr. A. Dhandapani, Division of Entomology, ICAR Institute, New Delhi for their valuable suggestions, encouragement and help in statistical problems.

Thanks are due to Dr. Rao, Director, RRL, Jorhat, Dr. Mantu Bhuyan, Entomologist and Dr. Dipul Kalita, Physiologist, R.R.L; Jorhat, Assam for their helps and suggestions in finding out the right resource persons for my studies.

I am highly obliged to the staffs of Directorate of soil and water conservation, Kohima, Nagaland, office of the SDAO, soil and water conservation, Dimapur, Nagaland and Shri Peter Rengma, Meteorologist, ICAR Farm Jharnapani, Dimapur, for providing meteorological data.

I also acknowledge Mr. V. Akashe. Zhimomi, Ph.D. scholar for his patience and encouragement during the period of investigation and also Mr. Temjenmenba, Audio visual specialists. Deptt. of Agricultural Extension, N.U. S.A.S.R.D. for his kind help in photography.

I gratefully acknowledge Mr. Abhai Tandon, M/S Informatics, Computer Centre; Medziphema town, for his help in data analysis and other computer works.

I can not forget to express my sense of gratitude to my in-laws, Mr. Yarmong Lkr. and Mr. Imlimeren Lkr. for their understandings and possible help rendered to me in printing and arranging my papers to come into book form.

I shall be failing in my duty if I do not express my sense of gratitude to all my well wishers and friends for

their prayers and encouragement without which I could not have completed the study.

At last, but not the least, I gave Glory to our Almighty for his grace, I am indeed, very much grateful to our Lord Jesus Christ for He has been so faithful to me and gave me this great victory

Dated: 27/11/09

Place: Mulgeshana.

(R. IMTIONEN AO)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

A.M	Ante meridian
Anon.	Anonymous
cm	Centimeter
E	East
et al.	*et allia* (and others)
Fig.	Figure
ha	Hactare
i.e.	That is
IARI	Indian Agriculture Research Institute
ICAR	Indian Council of Agricultural Research
Km	kilometer
m	meter
M^2	meter square
Max.	Maximum
Min.	Minimum
Ml	Milliliter
mm	Millimeter
msl	Mean Sea Level
N	North
No	Number
N.S	non-significant
N.U.	Nagaland University
PDBC	Project Directorate of Biological Control

P.M	Prime meridian
Q	Quintal
R.H.	Relative humidity
SASRD	School of Agricultural Sciences and Rural Development
Sq.	square
Temp.	Temperature
Viz.,	*Videlicet* (namely)
%	per cent
℃	Degree centigrade

Chapter – I
Introduction

CHAPTER–I

INTRODUCTION

Biodiversity is a concept that has only recently attracted significant attention from ecologists and other researchers (Hamilton, 1991). Biodiversity is the integration of biological variability across all scales, from genetic, through species, to ecosystem and landscapes (Walker, 1992). Threats to biodiversity are global and are usually a direct result of human impact that contributes to reduction of genetic diversity through habitat loss and fragmentation (Soule, 1991). May (1991) quote that the ultimate goal in recording biological diversity is to build a factual foundation for answering basic questions about evolution and ecology.

The term Biodiversity is formed by a contraction of the term 'biological diversity'; it was coined by Walter and Rosen in 1985. There are many definitions available for biodiversity. Biological diversity means the variability among living organisms from all sources including *enter alias*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this incltides diversity within species, between species and within ecosystem

Biodiversity is defined as the variety of life, which includes the entire biological hierarchy from molecules to ecosystem, also includes the diversity of living interactions and processes at all this level of organizations. Biodiversity is what must be conserved if we do not want lo lose the biological inheritance bequeathed to us.

Arthropods are an integral part of all ecosystems and are important components of natural diversity that need to be identified (May, 1986). The phylum arthropoda includes the largest number of pests of crops and animals. The importance of arthropod fauna is being that their destructive nature on crops , animals, stored commodities and as a carrier of diseases, some of the arthropods such as, parasitoids predators, pollinators and producers of such products as honey, silk and lac and also many Arachnids that benefits man and his interest. Hence, the investigation on biodiversity of arthropod fauna in maize ecosystems, have been carried out in Nagaland

Biodiversity can be divided into three different but closely related aspects (hierarchical categories); viz. Genes, Species and ecosystem level of diversities. (Marcio *et al.* 1996; Hosetti, 2002).

Many workers expressed their views about 'Biodiversity' as synonyms to conservation biology, which is a new consensus. During the last five years, a synthetic consensus framework of conservation planning has emerged from these rather disparate developments (Sarkar, 2002). In India, biological conservation was viewed to be the so closely integrated to cultural tradition in which the conservation of biodiversity was seen as part of biocultural restoration of degraded habitat and the preservation of cultural practices that co-evolved in harmony with biodiversity (Gadgil and Berkes, 1991; Guha and Martiunez-Alier, 1998); it also mentioned that the conservation biologist have been instrumental in promoting the idea that much could be learned from the traditional ecological practices.

Speaking about biodiversity is essentially equivalent to speaking about 'Arthropods' (Platnik, 1991). Arthropods are the largest group of attimal

kingdom which is in turn divided into Phyla. They belong to a group of invertebrates, which are characterized by their jointed limbs, segmented bodies and tough chitinous exoskeleton.

Most human sees arthropods as troublesome pests. Certainly, some are destructive. It is estimated that about 20 percent of crops grown for human consumption are eaten by herbivorous insect, they also carry diseases that affect animals and human beings approximately one in every six people alive today is currently effected by insect-borne diseases (George, 2000)a. The venom of certain arthropods could be fatal, and many people have severe phobias about this group, such as spiders, scorpions and insects. Many arthropods, however, are harmless, and rather we can derive some useful products, such as honey, silk, wax, oils, dyes and medicines. It is also noticed that in many countries, including Nagaland, some insects provide nutritious food such as crickets, grasshoppers, grubs and caterpillars etc. Arthropods are used in scientific research, helping to understand genetic, physiology and animal behaviors, as pollinator and many more (George, 2000)b.

The most fundamental role that millions of arthropods play is in maintaining "Natural Balance" by acting as bio-agents in regulating the pest populations. They play an essential role in all of world's major ecosystems and are important components of natural bio-diversity (May, 1986).

About 1 million species of insects are only known out of an estimated 30 million species of the world. Of these arthropods are most dominant and constitute more than 90%. As regards India, only 60383 species are known of the 9, 83,744 known from the world that works out to only 6.13%. Among the 8, 00,000 species of insects described worldwide, coleopteran alone constitute

>40 % of the known insects and about 25 – 30 % of all animals (Ramamurthy 2009). He also stated that insect biodiversity is will known for specific variations in their distribution and range of occurrence, these essentially vary according to latitude and altitude.

As many as 130 insects have been recorded causing damage to maize crop in India (Panwar, 1995). Among these above pests, about half a dozens are of economic importance (Atwal and Dhaliwal, 1997). The important insect pests that attack the maize crop in the state of Nagaland include Cob web worm, Stem borer, Grey weevil, Aphids, Armyworm, Silk cutter, Tussel caterpillars and field crickets (Anonymous, 1997).

Nagaland, although one of the smallest states in India, it is very rich in natural flora and fauna. Geographically, the state is located in the North Eastern Region of India, with an estimated population of 19, 88,636 eovers an area of 16,579 Km^2. The climate ranges from sub tropical to sub-temperate and temperate with an altitude that varies from 200 m to 3840 m above mean sea level (human dwelling). It has rich biodiversity with beautiful mantle of nature. The state is divided into several regions having different altitudes, elimate and rainfall distributions. The socio-economic and occupation of the Nagas are entirely depended on agriculture. The farmers in the state cultivate a variety of crops (cereals, oilseeds, tubers, fruits and vegetables etc.) of which maize occupies a total of 32,000 hectare of cultivable area with a produetion of 48,000 tones during 1999-2000, which is only 6.6q per ha. (Anonymous, 2000). Realizing the importance of maize in human economy, the Direetorate of Agriculture, Govt. ofNagaland, declared 2001 as the year of MAIZE'.

With the advancement of agricultural production technology during the last twenty-five years, the maize crop is grown round the year i.e. *Kharif, Rabi* and spring seasons in one or the other region particularly in the plains. Continuous cropping of maize enhances the appearance of certain pests continuously causing major losses. The objective of the study is to find out the diverse arthropod fauna including the beneficial fauna associated with maize ecosystems and their seasonal abundance. Moreover, majority of the farmers in the state do not possess knowledge to distinguish harmful and useful insects in order to suppress as well as to conserve the different important promising species of arthropods. Besides, no such survey or study was carried out in the state Therefore, study of arthropod biodiversity is becoming the needs of the day and in order to highlight the information, the present study/investigation is to be carried out with a view on the following objectives: -

1. To study the Arthropod biodiversity in maize ecosystem in plain, semi-hill and hill conditions of Nagaland.
2. Seasonal insect pest complex population in maize at different altitudes.
3. Abiotic factors and population relationship.

Chapter – II

Review of Literature

CHAPTER– II

REVIEW OF LITERATURE

The word 'Biodiversity is a burning topic nowadays, many research works had been done so far and are still continuing. Arthropods diversity reported by various workers from different habitats depending on different environmental factors and locations. A few literatures on the topic incorporated with maize ecosystem's arthropods are listed in this study as they are considered referable to support the findings. In light of the propose research programme, the following literatures were briefly reviewed to highlight the present investigation on "Biodiversity of arthropods fauna in maize ecosystem at different altitudes of Nagaland" in this chapter under following categories:-

2.1. Arthropod diversity in maize ecosystem

The studied of insect fauna of little Cayman Island of North America and found that one of 613 insect species collected, 18 species belonged to the order Orthoptera Askew (1975). Edward *et al.* (1975) recorded about 50 species of spiders, and negligible number of millipedes and centipedes in grass land. Majer and Koch (1982) reported that a total of 39, 43 and 32 species being trapped at three habitats of maize ecosystem.

Many investigators have explored on the possibility of the soil surface dwelling arthropods as indicators of various factors (Majer, 1977 and Reddy, 1986).

In Chrysomelidae, Foster *et al.* (1982) claimed that sequential sampling plans for adult corn rootworms reduced scouting time by 36%. Matin and Yule (1984) observed population fluctuations, while Weiss and Mayo (1983)

developed a sampling technique for estimating size of larval populations of *Diabrotica longicornis* (Say). Hein *et al.* (1985) studied that sampling of eggs of *D. virgifera virgifera* LeConte. Bergman and Turpin (1986) proposed that relating phenology to calender date may provide the simplest and best estimates of seasonal occurrenee. Population dynamics studies on many species of *Diabrotica* were carried out by Risch (1980) and on *Systena basalis* Duval by Heyer *et al.* (1989).

In Bostrichidae, Bell and Watters (1982) observed the influence of environmental factors on rate of increase of *Prostephanus truncatus* (Horn) and Meikle *et al.* (1998) gave some sampling methods. Seasonal activity of carabids *Microtestes linearis* (Lec.), *Stenolophus comma* (F.), *Bembidion rapidum* (Lec.), *Chlaenius pusillus* Say and *Anisodactylus sanctaecrucis* (F.) was observed by Hsin *et al.* (1979). Lovei (1984) studied seasonality of *Pterostichus melanarius* (Ill.). Gergely and Lovei (1987) studied seasonal dynamics of *Dolichus halensis*. Desender and Alderweireldt (1988) observed seasonal fluctuations *Clivina collaris*. Seasonal flight activity and seasonal abundance of anthribid, *Araecerus fasciculatus* were studied by Throne and Cline (1991). Henckes (1992) studied its population dynamics, damage and loss in stored maize. Seasonal abundance and flight activity of *Rhyzopertha dominica* (F.) were observed by Thorne and Cline (1994).

In Coccinellidae, seasonal dynamics of larvae, pupae and adults of *Coccinella septempunctata* L. was studied by Radwan and Lovei (1983) and Hemptinne (1988) noted their ecological requirements for hibernation. Gumovskaya (1985) observed the population dynamics of *Coccinella quinqicepunctata* and Hoffmann *et al.* (1997) used yellow cards coated with adhesive to survey for the presenee, relative abundance and seasonal patterns.

Rajagopal and Channapasavanna (1975) observed the seasonal distribution of *Myllocerus*. Seasonaly abundance of curculionid, *Sitophilus zeamais* Motsch, and *S. oryzae* (L.) was studied by Throne and Cline (1991). Watson *et al.* (1980) noted that warm seasons (autumn and spring) favour the abundance, early adult emergence and flight activity of some Scarabaeids. Drinkwater (1991) studied seasonal history of some Tenebrionids. Blackmer and Phelan (1995) studied seasonal occurrence of Nitidulids.

In most habitats, the arthropod fauna of the soil is concentrated in the upper most layers and both the population densities and biodiversity declines rapidly with increasing depth. The ultimate depth to which the arthropods migrate in the soil remains an unanswered question as it is unusual for the researchers of soil arthropod ecology to sample soil layers below 15 to 20 cm from the surface (Wallwork, 1970).

Coleopteran is one of the important and abundant soil surface dwelling arthropods, many of them particularly their larval stage being pest of many economically important plants (Finlayson and Cambell, 1976, Thomas and Sleeper 1977, King *et al.* 1981).

Many workers suggested that the soil inhabiting micro arthropod usually are most abundant near the surface zone of 0 -10cm deep which is characterized by adequate living space, favourable moisture condition, aeration and rich accumulation of organic debris (Hale, 1967 and Wallwork, 1970).

Edwards *et al.* (1975) and Hutton (1978) stated that temperature is one of the most important factors in dealing with the activities of the arthropods. Arthropod activities depend upon weather conditions, especially temperature

and soil moisture and the general habitat surrounding the trap (Edward *et al*., 1975).

Studies on Collembola from various parts of the world have convincingly proved about their dominant role in soil formation, nutrient cycling and decomposition. Quite a large number of workers such as Bellinger (1954), Sheals (1957), Haarlov (1960), Dhillon and Gibson (1962), Milne (1962), Christiansen (1964), Pai and Prabhoo (1980), Takeda (1981), Loring *et al*. (1981) and Hazra and Choudhuri (1983) have studied the qualitative and quantitative ecology of Collembola population in cultivated and uncultivated fields from various parts of the world including India.

Ostbye *et al*. (1978) reported high catches of Coleoptera during June-July and noted that the group mostly as predators specially Carabidae and Staphylinidae tends to alternate in their predation activities, it was also reported by them that Carabidae showed peak activity during spring while Staphylinidae were highest in number during summer.

Maximum population size of collembotan is attained during the monsoon period or during the immediate post monsoon period (Hazra and Choudhuri, 1981). In Nagaland, the peak population of field cricket is in the fortnight of October (Vikram, 1981).

Species belonging to two families of Homoptera and one family of Heteroptera were recorded by Westerberg and Granstrom (1977). Ostbye *et al*. (1978) reported pitfall catches of sufface active Arthropod in mountain habitat at Finse, South Norway; they collected high catches of Homoptera. They also collected Plecoptera, Thysanoptera, Trichoptera, Lepidoptera and Symphyla in poor numbers. They also reported high catches of Coleoptera during June-July

and noted that the group mostly as predators specially Carabidae and Staphylinidae tends to alternate in their predation activities, it was also reported by them that Carabidae showed peak activity during spring while Staphylinidae were highest in number during summer.

Thirteen species of Carabids belonging to 14 tribes were collected using traps at UAS, Bangalore (Bhat and Rajagopal, 1992). They also reported that minimum temperature, maximum temperature, saturation upon pressure deficit (SVPD) and rainfall had correlation of +0.095 to +0.38 – 0.13 and 0.56 respectively with trap catches

Moced and Meeds (1985) recorded high number of mites particularly belonging to Cryptostigmata and Prostigmata during spring and summer froad leaf forest and found the correlation but not with the rainfall. The combined effect of abiotic factor such as soil surface, humidity, air and soil temperature, soil moisture, organic carbon, potassium and phosphorous were responsible for 71 to 82 per cent of seasonal variation of the Cryptostigmata in maize ecosystem (Reddy and Alemla, 1995)[b]. They had also reported that the total population abundance of total Acarina was significantly influenced by the combined effect of the above factors, which were responsible for 64 to 79 percent of the seasonal variation.

Ghode *et al.* (1985) reported 21 species of spiders belonging to 8 families and the species thus recorded were *Cyrtarachne* sp., *Larinia* sp., *Neoscona* sp., *Neoscona elliptica* Tikader and Pal, *Neoscona mukherjee* Tikader, *Neoscona nautica* (L. Koch), *Neoscona rumpfi* (Thorell), *Cheiracanthium* sp., *Clubiona plexippus pykulli* (Aud), *Zygoballus normadaesis* Tikader, *Sparassus* sp., *Tetragnatha* sp., *Tetragnatha*

andamenensis Tikader, *Tetragnatha mandibutata* Walck. *Philadromus* sp. and *Xyticus* sp.

Mooed and Meads (1985) studied on Collembola and reported Poduridae, Sminthuridae and Entomobryidae from three forest communities and the former being dominant. They also found out Cryptostigmata and Prostigmata are the dominant taxa.

Dakshinamurthy *et al.* (1987) reported that predatory mites, *Pyemotes Ventricousus* (New port) were preying on the larvae of rice moth, *Corcyra* sp., Angoumois grain moth, *Sitatroga cerealella* Olive, Satin moth, *Stilpnotia salicis* L., Peach twig borer, *Anarsia linealella* Zeller, Bud moth , *Siplonota ocellata* Schiff and Coconut caterpillar, *Opisina arenosella* (Walker).

Guru *et al.* (1988) studied the species composition, vertical distribution and seasonal variations of Collembola associated with cultivated and uncultivated sites of western Orissa. Altogether, eight species of Collembola belonging to five families were recorded, out of which six species was reported from cultivated site and five species from the uncultivated site. *Cryptopygus thermophilus* was the dominant species in both sites. The population density of Collembola marked a significant decrease from upper most layers to deeper layers. Two distinct population peaks were observed in both the sites in the month of November and February in crop field site and in October and February in the uncultivated site. The lowest density was observed in the month of May in both the sites and there was no significant difference in population of Collembola in these two sites.

Yang *et al.* (1990) studied the spatial niches of spiders and observed spider's species viz., the Lycosids, *Lycosa pseudoannulata* and *Pirata subpiraticus*, the Theridiid, *Coleosoma octamaculatum*, Linyphiid, *Ummeliata insecticeps*, the Araneid, *Neoscona* sp.

Nirmala *et al.* (1991) identified a wide array of spider species and specimens recorded were *Argiope catenulata* (Dol), *Lycosa geotubalis*, Tikader and Malhotra, *Marpisa decorata* Tikader, *M. Kalapani* Tikader, *Eucta javana* Thorell, *Leucauge decorata* (Blackwall), *Neoscona elliptica* Tikader, *Pardosa sumatrana* Thorell, *Tetragnatha listeri* Graveli, *T.mandibulata* Walck, *Theridion* sp., *Lycosa pseudoannulata* (Boes at Str), *Oxyopes javanas* Thorell, *Tetragnatha javana* Thorell, *Tebellus pateli* Tikader.

Kamal *et al.* (1992) recorded 29 species of spiders belonging to 16 genera from 10 families and concluded that *Tetragnatha mandibulata*, *Oxyopes* sp. and *Neoscona theisi* were most common among them.

Reddy and Alemla (1995)a recorded a mean total number of 3469 individuals in surface dwelling arthropods belonging to 35 different taxa from maize ecosystem in Nagaland where Collembola was maximum constituting 32.68 percent of the arthropods followed by Formacidae comprising of 31.1 per cent of total arthropods.

Edwards and Thornton (1999) evaluated the arthropod community of Motmot Island for 6 days and collected 35 insect species. Lycosid spiders and ants dominated the area while Orthopterans were present in insignificant numbers.

Farr *et al.* (2002) conducted sampling of invertebrates' fauna through spring and autumn of 2001 – 2002 and indentified 35 Orthoptera species of which 16 species were recorded as indicator species.

Brantley *et al.* (2003) sampled and identified 180 species of arthropods in three years and revealed that seven species of crickets were more abundant on the shore of Colorado River than either old or new high water zone.

Upadhyay and Sharma (2004) reported that the principal component analtsis revealed that the maximum temperature, minimum temperature, rainfall and relative humidity display the largest amount of variation in the population build up of Yellow Stem Borer and Rice Gundhi Bug.

Kalaisekar and Ramamurthy (2004) reported that in rice and maize crop, Weather has a great role to play in species diversity.

Jitendra Kumar *et al.* (2007) identified the species of Scarabaeid beetles present in three regions of Kullu valley of Himachal Pradesh, by using light traps. They reported 29, 19 and 18 species of the beetles respectively. Out of these, *Anomala rufiventris* Redt., *A. lineatipennis* Blanch., *Melolontha nepalensis* Blanch., *M. furcicauda* Ancey., *Melolontha* sp., *Adoretus simplex*, *A. duvauceli*, *Brahmina flavoserica* (Bost.), *B. Crinicollis* Burm, *Xylotrupes gideon* (Linn.), *Maladera* sp., *Meriserica* sp., *Catharsius* sp., *Onthophagus* sp., *Macronota* sp., *Popillia maclellandi* Hope., *Mimela* sp. and *Leucopholis* sp. peaked period were observed during the last week of June, first or second week of July at all the three localities. Minimum temperature had significant positive correlation with the emergence of beetles.

2.2 Biodiversity index

Intuitively, we understand biodiversity or species diversity, as the number of species in a given area, habitat, or community. However, diversity, in essence, has always been defined by the indices used to measure it (Peet, 1974). Fisher *et al.* (1943), who were among the first to seek to quantify this concept, employed the parameter alpha in the logarithmic relation of numbers of species to numbers of individuals as an index of diversity.

The dual concept of diversity was introduced into the ecological literature by Simpson (1949) who considered that diversity should include both evenness and a richness component. A similar approach had already been given by Yule (1944). The indices of Simpson and Yule became a single biodiversity index as given by Southwood and Henderson (2000). Shannon and Weaver (1949) presented their index to quantify the diversity of species. Sanders (1968) differentiated the Simpson's index as an index for concentration of dominance and Shannon's formula as an index of equitability. Simpson's index is weighed towards the abundance of the commonest species rather than providing a measure of species richness (Magurran, 1988), whereas Shannon's index considers both the number of species and the distribution of individuals among species (Kikkawa, 1996). These two indices are most widely used indices of species diversity (Magurran, 1988).

Berger and Parker (1970) proposed both mathematically and conceptually a simple index as a measure of dominance. May (1975) concludes that this index seems to characterise the distribution as well as any other index, and better than most. Berger-Parker index measures the evenness or the distribution of individuals in a system among different species.

Increasing farm diversity is one method that has been known to increase ecological stability which in turn could provide positive effects, like increasing beneficial insect habitats, nutrient cycling within the system, and beneficial interference between the species, hence measuring the diversity becomes imperative to maintain the stability of agro ecosystems (Gliessman, 1998). Way *et al.* (1990) studied the insect diversity and abundance in rice fields. Hu *et al.* (1998) studied the community structure and diversity of carabids in rice fields. Ellsbury *et al.* (1998) and Varchola and Dunn (2001) calculated the diversity and species richness of carabids in different maize fields using Shannon-Weaver index. Manachini (2000) studied the diversity differences of carabids between isogenic and transgenic maize crops using Shannon-Weaver index. Wright *et al.* (2000) determined the species diversity in coccinellids using Berger-Parker dominance index and Shannon-Weaver function in different maize localities. Pesic (1999) studied the differences in diversity of weevils in different grasslands using Shannon-Weaver and Simpson biodiversity indices.

2.3. Arthropod correlation with abiotic factors.

The climatic condition such as temperature, humidity, precipitation, soil moisture effects the activities of Arthropods to a great extend and causes increase or decrease in their population size (Briggs, 1961; Duffey, 1962; Greenslade, 1964; Mitchell, 1963 a,b). Mitchell (1963) and Greenslade (1964) also reported the affect of rainfall on activity of beetles.

The effect of moisture upon soil arthropods has been emphasized and it has been shown that soil humidity influences collembolans and that the dry condition was unfavourable (Mukharji and Singh, 1970)

Tanaka (1970) and Nijima (1971) stated that micro arthropod reached two peaks of abundance and two low ebbs during the annual cycle. Many investigators are of the view that the important environmental factors influencing micro Arthropod population number are rainfall, soil moisture, soil temperature and food resources (Hagvar and Amudsen, 1981; Huhta *et al.*, 1982; Reddy, 1984). Kajak *et al.*, (1972) also reported that the activity of an ant was also correlated with the availability of food

Edwards *et al.* (1975) and Hutson (1986) reported that temperature is one of the most important factors in dealing with the activities of the Arthropods. They also reported that the Arthropod activity depends upon weather condition especially temperature and soil moisture and the general habitat surrounding the trap. Edward *et al.* (1975) also reported more catches of spiders in August and lowest in December. McColl (1975) found that rainfall was the most important factor affecting the catches of Collembola.

Ostbye (1978) reported high catches of Coleoptera during June and July, and noted that the group mostly as predators especially Carabidae and Staphylinidane tend to alternate in their predation activities. They reported that the Carabidae showed peak of its activity during spring while Staphylinidae were highest in number during summer. The Scarabaeidae beetles were absent during winter-spring and Autumn-winter season while they showed their activity from April to September.

Whitford (1978) noted increase in temperature and food served as threshold for ant population fluctuation and the increase in ant activity was correlated with the rainfall.

Pillai and Singh, (1980) established the fact that rainy condition supported greater soil fauna under Indian condition. The average amount of rainfall is critical, since litter decayed more rapidly in the high rainfall than in the low-rainfall regime (Lensing and David, 2007)

Majer (198t) reported that the ants increased in spring and summer was connected with high temperature and availability of food and low activity in winter may be the reduced availability of such food sources.

Majer and Koch (1982) and Moeed and Meads (1985) reported that increase in ant abundance was negatively correlated with rainfall. They also observed that the ntaximum activity of ants during spring and sumnter and low activity during the winter and concluded that the probable reason for the increase in ant population during this period may be the increase in the numbers of herbivores.

The insect biodiversity is will known for specific variations in their distribution and range of occurrence; these essentially vary according to latitude and altitude (Mac Arthur, 1984; Gaston, 2005). Higher altitude limits the distribution of species due to relatively cool climate (Thomas *et al*., 1998; 1999). Local temperature and moisture levels influence the distribution of arthropods and population diversity of arthropods in the entire range of a taxonomic category. That is why many a times isotherms during sumnter are always correlated with range of butterfly species (Thomas, 1993) and Hemiptera (Hill and Hodkinson, 1995; Hodkinson *et al*., 1999).

Moeed and Meads (1985) found more number of Chilopoda and Diplopoda during summer and autumn than winter and spring and stated that

both catches of Chilopoda and Diplopoda were correlated with temperature but not with rainfall. Moeed and Meads (1985) stated that the populations of Collembola were positively correlated with rainfall. They also recorded high number of mites belonging to Cryptostigmata and Prostigmata during spring and summer in a broad leaf forest and found the correlation between the abundance of mites and temperature, but not with the rainfall. Moeed and Meads (1985) did not find any positive correlation between the coleopterans abundance and rainfall. They also found number of Chilopoda and Diplopoda during summer and autumn than in winter and spring. They found that the catches of Chilopoda and Diplopoda were both correlated with temperature but notwith rainfall.

The insect species diversity per area tends to decrease with higher latitude and altitude (Gaston and Williams 1996, Andrew and Hughes 2005) Based on evidence developed by studying the fossil record some researchers (Bale *et al*, 2002) conclude that the diversity of insect species and the intensity of their feeding have increased historically with increasing temperature.

There are also possible indication of herbivore caused changes in microclimate and towards soil processes especially litter decomposition in forest ecosystems like the ones, which are rampant in the North West Himalaya. Coleopterans being important fauna playing a major role in this process will be profoundly affected by these changes. There are significant studies throwing conclusions on the magnitude and direction of herbivory impacts and their implications (Holand and Delling, 1990; van Wijnen *et al*., 1999; Hunter, 2001;Lovett *et al*., 2002). These impacts are mostly due to the effects on physical factors, mainly temperature and moisture.

Surveys conducted in the Northeastern region on the changing pest status during 1979-84 by Barwal *et al.* (1994) revealed high incidence of a large number of pests in Assam, followed by Tripura and Manipur

Reddy and Alemla (1995) reported that most of the soil surface dwelling arthropods recorded were abundant during the rainy season although there was little correlationship with the rainfall.

Coccinella septempunctata a predator of black aphid (*Aphis craccivora*) thrives well under increasing temperature at atmosphere coupled with a declining relative humidity. However, temperature beyond 30° C and below 15 °C is not suitable for its population build and predation, so also a relative humidity beyond 85 per cent. An average atmospheric temperature of 19.4 °C along with a relative humidity of 76.2 per cent was quite congenial for the population build up of the predator (Akhilesh Kumar *et al*., 1996).

Climate change resulting in increased temperature could impact insect populations, in particular the herbivores belonging to the order coleopteran in several complexes. Although some climate change (temperature) effects might tend to depress their populations, most researchers seem to agree that warmer temperatures in temperate climates as existing in the North West Himalaya will result in more types and higher populations of Coleopteras. Researchers have that increased temperatures can potentially affect insect survival, development, geographic range, and population size. It has been estimated that with a 2° C temperature increase insects might experience one to five additional life cycles per season (Yamamura and Kiritani, 1998). Other researchers have found that moisture and carbon dioxide effects on insects can be potentially important consideration in a global climate change setting (Helmiton *et al*., 2005;

Coviella and Trumble, 1999; Hunter, 2001). These predictions apply well to the Coleopterans in the North West Himalaya, whether it is a pest, predator or an innocuous biodiversity component.

Cherry and Deren (2000) reported that under the range of weather conditions encountered, which excluded rainy, stormy, very windy conditions, time of day was not a significant factor in sweep net catches of *Oebalus pugnax* or *O. ypsilongriseus* in Florida rice field

The effect of temperature on catches could not show any specific influence. Rai *et al.* (2002) reported that the peak occurrence of yellow stem borer (*Scirpophaga incertulus*) on rice was noted during the first fortnight of October. The period of peak occurrence of yellow stem borer coincide with the ranges of favourable environmental factors during the kharif season. The influence of weather factor such as maximum relative humidity and sunshine hours on yellow stem borer population catches in light trap showed positive correlation as well as co-efficient of determination was 71 per cent negative influence on the catches of yellow stem borer.

Devinder *et al.* (2007) collected and studied the nocturnal Orthoptera by means of light trap and the population fluctuations of twenty-four species of Orthopterans were correlated with temperature and relative humidity. In all six families' viz., Gryllidae, Gryllotalpidae, Tettigonidae (belonging to suborder Ensifera) and Acrididae, Tridactylidae and Tetrigidae (belonging to suborder Caelifera) were collected. Gryllidae was found dominant followed by Tetrigidae as compared to other families.

Srivastava and Raghuraman, (2009) reported that warmer temperature in temperate region will result in more diverse and larger populations of arthropods.

Thus, though a number of workers had studied on arthropods, information on arthropod biodiversity is very mearge. Also the state of Nagaland, which is considered to be one of the riches biodiversity spots, has very little information particularly on arthropods. Considering all these, the research programme with the above mentioned objectives is proposed.

Chapter – III

Materials and Methods

CHAPTER – III

MATERIALS AND METHODS

The materials used and the methods adopted in the present investigations are classified and described under the following headings.

3.1. Description of the experimental sites

The biodiversity of arthropod fauna associated with maize ecosystem in Nagaland were studies the following sites representing different altitude as well as agro-climate conditions (Table 1).

A. Plain area (Dimapur) altitude: 260m msl.

B. Foothill area (Medziphema) altitude: 310m msl

C. Uphill area (Near Kohima) altitude: 1440 m msl.

For this purpose, three maize fields were selected in each area mentioned above, and the geographical descriptions are mentioned here under:

Table 1. Silent feature of proposed site

Sl. No	Site	Geographical location	Altitude	Temperature		Rainfall (mm)	Humidity
				Max.	Min.		
1	Plainarea maizefield (Dimapur)	25° 45' 43" Latitude 93°53' 04" Longitude	260m. msl	37 °C	23 °C	2000-2600	50-105%
2	Foothillarea maize field (Medziphema)	25° 45'43"N Latitude 93°53' 04"E Longitude	310m. msl	32 °C	12 °C	2000-2700	45– 95%
3	Uphill area maize field (Kohima)	25° 40' N Latitude 94° 06'E Longitude	1440mmsl	29°C	4 °C	2500-3000	40-90%

The topography of these sites varied as shown in the table. Accordingly the data of maize showing also varied having above different crop ages throughout the year.

3.1.1. Plain area

The district of Dimapur in Nagaland is located towards south-western side of the state. The experimental field is located at a distance of 2 km from the main city (Plate I). This region is the only plain area, except few areas in other parts of the state. The climates in these places are sub-tropic and humid. The temperature rarely goes below 10°C in winter. Maize crop is usually grown during *kharif* season, but in some pockets, they are grown during winter where there are irrigation facilities.

3.1.2. Foothill area

The experimental area for foothills condition which comes under Medziphema (dist: Dimapur) is away from the district headquarter by about 34 Km. The experimental fields are located in three different places with a distance of around ½ Km apart. The topography is sloppy (10-15% slopes) and the crops are grown only during *kharif* season.

3.1.3. Uphill area maize field

The experimental area selected for the proposed investigation under hill area is located at **Jotsoma** village under Kohima district, which is away from the state capital for about 20 Km. Maize crop is generally grown during *kharif* season as rain-fed. The region experiences sub temperate to sub-tropical climatic condition. In this area, farmers do not grow the crop during the *Rabi* season.

Plate 1. General view of maize field in plain belt.

3.2. Sampling methods

The following sampling methods were employed to determined the arthropod biodiversity in maize ecosystem located at three different altitudes

3.2.1. Pitfall traps

The most commonly used and superior trapping devices available for studying the soil surface dwelling arthropod (Thiele, 1977) is employed as pitfall traps (Plate..II). Transparent bottles having 13 cm lengtli and 5 cm diameter were used to capture the ground dwelling arthropod. Five numbers of such traps were kept randomly in three different fields. whicli were buried, and the rim of such bottles remained leveled with the surface of the ground. A cover was provided at a height of about 2 cm over the mouth of the traps to exclude the rain and other unwanted particles. 5% Formaldehyde solution was used in the container (trap bottle) to avoid decomposition of trapped species. The traps were emptied at fortnightly intervals during which the solution was also changed, samples were emptied into small jars transported to the laboratory where specimens were removed and stored into vials containing 70% alcohol or dried preserved in insect boxes for identification.

The artliropod fauna prevalent at fortnightly intervals in maize fields were enumerated with the help of pitfall traps at fortnightly intervals. Fifteen pilfall traps were placed at random for counting the arthropod fauna. The mean of individual per 15 pitfalls tabulated as the mean population (family wise) per three months.

Plate II. Pitfall trap.

Plate III. Soil sampler (Auger) and Berlese Funnel

3.2.2. Soil Extraction

Soil inhabiting arthropods were estimated by taking core samples (depth 0-10 cm). The samples were collected with the help of an Auger' (Plate. III) having a dimensions of 5cm. in diameter and 10cm. long fitted with 25cm. long handle. Five numbers each of such samples were collected from three different fields at fortnightly intervals. The soil samples were brought to the laboratory and processed through a set of Berles Tullgren funnel apparatus as described by Macfadyan (1955) for 10 to 12 hours. The available arthropod were counted under stereoscopic microscope and identified.

The arthropod fauna prevalent at fortnightly intervals in maize fields were enumerated with the help of soil sampler. Fifteen soil samples were collected twice at random for counting the mean monthly population of arthropod fauna. Therefore, the data was subjected to arthropod population as trimonthly intervals.

3.2.3. Light Trap

This method was followed for trapping night-active insects (Nocturnal) for this purpose, scientifically designed light trap box were used with electric source of light (*Chinsura* light trap), and however, hurricane lamp was also used when electricity was not accessible in those selected fields for sampling (uphill). Three numbers of such light traps were installed in each field at a distance of 50m. The trap with a dimension of 83 x 24 (h x b) with a funnel of 35cm. long, 41 cm. diameters was used (Plate. IV). A 100 watts bulb was connected above the funnel and the arthropod trapped were collected in a box of 41 x 24cm. (LxB) which was placed below the funnel. The light was kept ON' from 6:00 PM to 6:00 AM daily.

Plate IV(a). Light trap (Chinsura type)

Plate IV (b). Light trap (Hurricane lamp type)

Three light traps were installed in three different fields (one each) and the samples of those trapped species were collected at weekly intervals and were brought to the laboratory for counting, recording preservation and identification.

The arthropod fauna prevalent at weekly intervals in maize fields were enumerated with the help of light traps. Three light traps were installed at random for counting the arthropod fauna. The data so generated were subjected to mean tri monthly family wise arthropod population Table.

3.2.4. Sweep Net

This method was adopted specially to sample the arthropod that is closely associated with crop canopy. An insect- net (Plate. V) with aluminum handle of 70cm. long, 30cm. rim and a netted cloth bag of 72cm. long with 1.5m. mesh size was used for collection. Five sweeps were made randomly from each field at fortnightly interval. The population collected at fortnightly intervals was subjected to tri monthly family wise population and are presented in table.

3.3. Meteorological records

During the period of investigation, information on the meteorological data were obtained from the Office of the Soil and Water Conservation, Dimapur for Plain area, ICAR Research Complex for foothill area and meteorological observatory station at **Sechu**, Kohima for uphill area. (Fig.1-3). The meteorological data for three different locations are tabulated and presented in Appendix I, II and III.

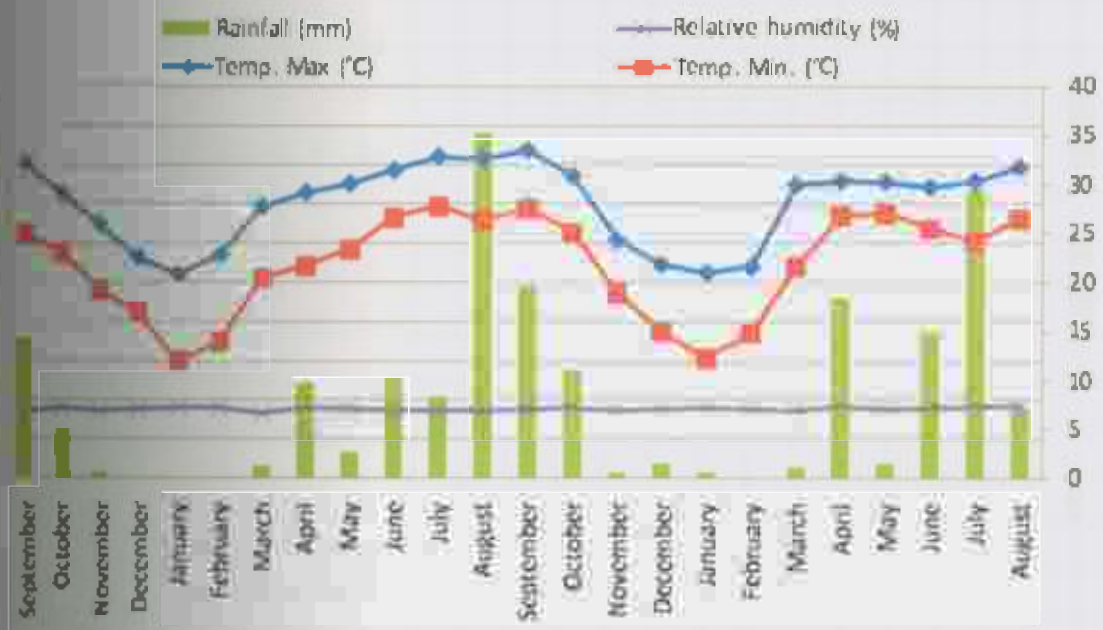

Fig1. Meteorological observation during the period of investigationat lowland (September 2002–August 2004)

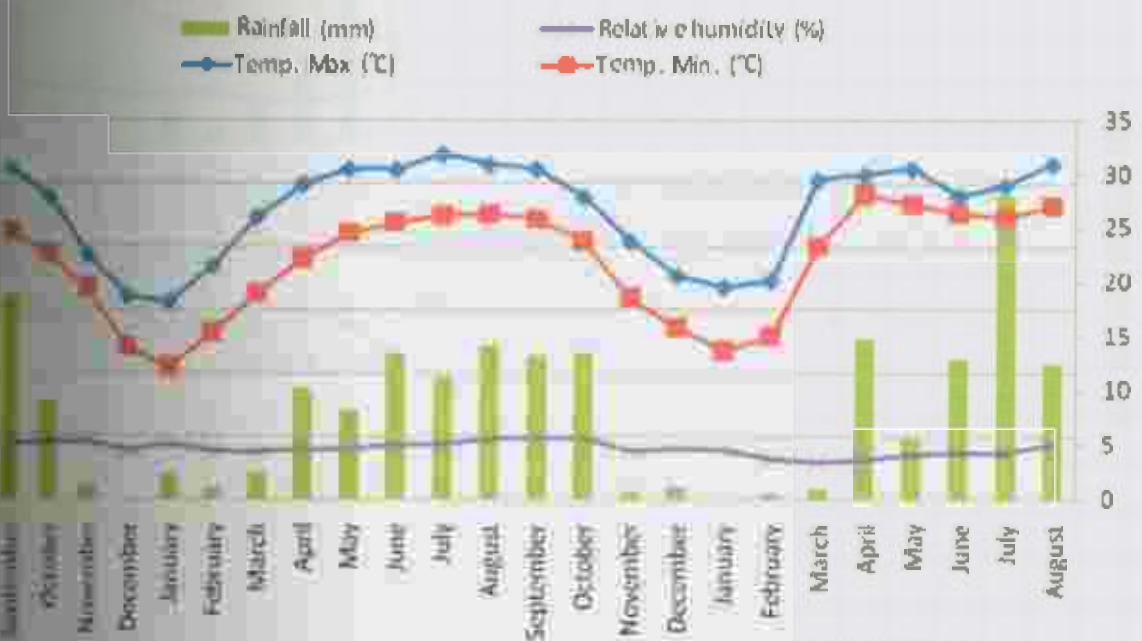

Fig2. Meteorological observation during the period of investigation at foothill (September 2002–August 2004)

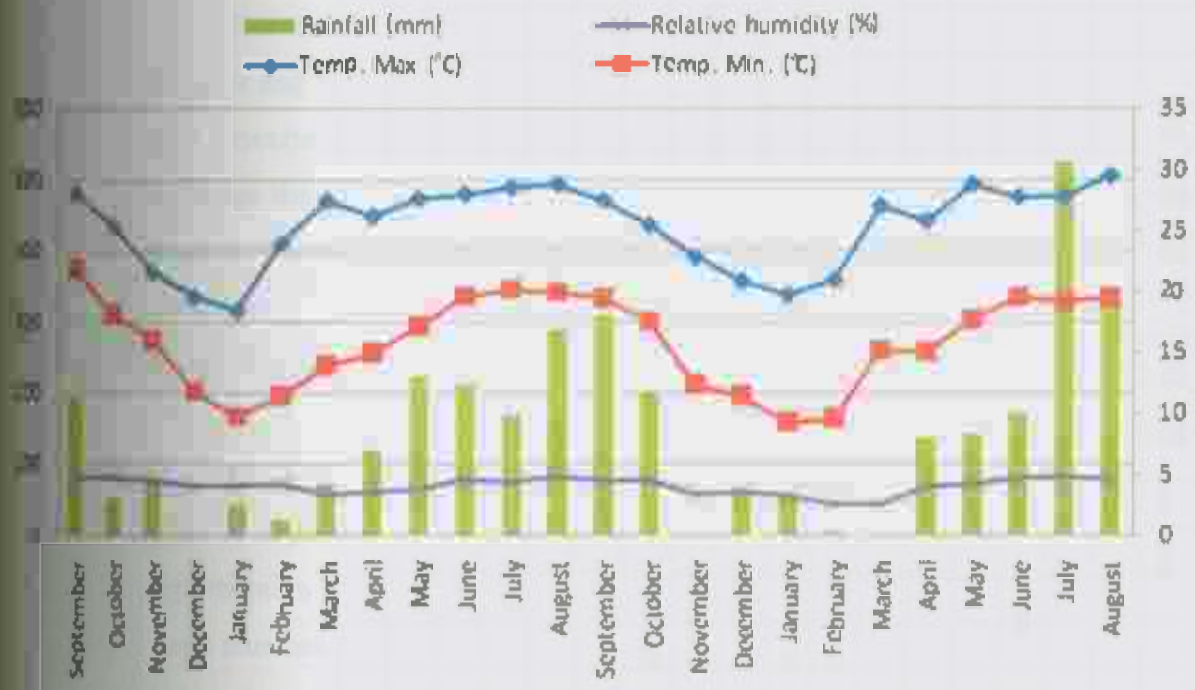

Fig3. Meteorological observation during the period of investigation at upland (September 2002– August 2004)

3.4. Observations and preservation of specimens

Minutes and soft bodied insects such as Collembola, Mites, Spiders, Wire worms etc were examined under stereo Binocular Microscope with magnification 10x to 30x or 20x to40x and wide-field eye piece WF 10x and a build in incident light with 6v-20w halogen bulb.

3.4.1. Wet preservation

The collected specimens were preserved in glass vials (1.2cm. diameter and 5cm. length) containing Oudeman's fluid (87 parts alcohol, 5 parts glycerin and 8 parts glacial acetic acid. Precautions were taken to submerge the specimen completely in the fluid. (Plate VI). The glass vials were refilled from time to time with the liquid preservatives.

3.4.2. Dry preservation

Collected and killed insects specimens were pinned properly and dried by exposing them to sunlight in order to remove excess moisture and kept them in insect boxes for further identification and to keep them in insect museum. (Plate VII).

3.5. Identification

Macro arthropod specimens were identified visually while the micro arthropods were identified with the help of stereo-binocular microscope following the keys and microphotographs as per George, 2000,; Neil *et al*., 2003,; Van and Abdul, 1986,; Anonymous, 1997 and Anonymous, 2006.

Plate V. Insects net.

Plate VI. Wet preservation

Plate VII. Dry preservations

Un-identified specimens were identified by providing preserved specimens to the taxonomist/s working at IARI, New Delhi, PDBC (ICAR), Bangalore and Zoological Survey of India (ZSI), Kolkata.

Statistical analysis

The mean family/order and insect species wise tri monthly population of arthropods prevalent in maize ecosystem of Nagaland collected through four sampling methods were subjected to seasonal incidence and diversity abundance, relative abundance and relationship with abiotic factors. Therefore, the common/ uncommon arthropod information's are presented in tables, graphs separately.

i) Shannon-**Wiener diversity index**: This index considers both the number of species and the distribution of individuals among species (Kikkawa, 1996). The formula for this index is:-

$$H = -\sum p_i \log_e p_i$$

Where,

H = the Shannon-Wiener biodiversity index

p_i = the proportion of individuals in the i^{th} samples (relative abundance)

$\log_e$ = The natural of log of pr.

ii) Simpson-**Yule diversity index**: This index is weighed towards the abundance of the commonest species rather than providing a measure of species richness (Magurran, 1988). The formula for this index is

D = 1/C, where C = probability statistic, which is calculated as,

$C = \sum pi^2$, where pi = the proportion of the individuals in the i^{th} species.

iii) The relative abundance of different arthropod present in three maize ecosystems were statistically worked out by following the method as suggested by Singh and Rai (2005).

$$R = \frac{a}{n} \times 100$$

Where,

R = Relative abundance %

a = No. of individuals present on date of sampling

n = Total population of all species

And,

iv) Correlations between the arthropod and abiotic factors (Maximum & Minimum temperature, Rainfall and Relative Humidity) were calculated by using the formula from Microsoft Office Excel and SPSS (1997).

Chapter - IV
Experimental Findings

CHAPTER–IV
EXPERIMENTAL FINDINGS

The findings of the present study on Bio diversity of arthropod fauna in maize ecosystem at different altitudes of Nagaland which was carried out during September 2002 to August 2004 are discussed and illustrated in this chapter

4.1. Seasonal insect pest complex population at three different maize ecosystem

The arthropod populations which are obtained from maize ecosystem from three locations during September 2002 to August 2004 are listed and tabulated in Table 2. All the Pests, Natural enemies and Non pests are listed in thetable.

Inventory of arthropod fauna in maize ecosystem

The inventory of arthropod fauna from three different locations revealed that (Table 2) 13 arthropod orders under 40 families and species were recorded. Order Coleoptera recorded the maximum arthropod families 11 no. viz: Carabidae, Coccinellidae, Cicindellidae, Cerambycidae, Scarabaeidae, Melononthidae, Hydrophyllidae, Buprestidae, Elaterid, Meloidae and Curculiniodae. Family Carabidae was recorded highly abundant from all the locations and the remaining families recorded moderately or their presence. The family Hydrophyllidae was recorded only from plain area so as Curculiniodae from foothill maize field.

Table 2. Inventory of arthropod fauna in maize ecosystem at three locations.

Sno	Order	Family	Common Name	Scientific name	Location		
					Plain	Foothill	Uphill
1	Coleoptera	Carabidae	Ground beetle	Unidentified	* *	* *	* *
		Coccinellidae	Ladybirdbeetle	*Coccinella spp.*	+	*	*
		Cicindellidae	Tigre beetle	*Cicindella spp.*	*	*	*
		Cerambycidae	Trunk borer	unidentified	*	* *	*
		Scarabaeidae	Dung beetle	*Heliocopris spp*	* *	* *	*
		Melonontidae	White grub	Unidentified	*	*	*
		Hydrophyllidae	Water beetle	Unidentified	* *	-	-
		Buprestidae	Metalic borer	Unidentified	*	+	-
		Elateridae	Click beetle	Unidentified	+	*	-
		Meloidae	Blister beetle	Unidentified	-	+	+
		Curculiniodae	Pumpkin beetle	Unidentified	-	+	-
2	Hemiptera	Coreidae	Gundhi bug	*Leptocorisa spp*	+	*	-
		Falgoridae		Unidentified	+	+	+
		Pentatomidae	Sting bug	*Dolycoris spp*	* *	* *	*
		Cicadidae	Cicada	*Cofana spectra*	*	* *	*
		Delphacidae	Brown Leafhopper	*Sogatella spp.*	*	*	-
		Cicadellidae	Green leafhopper	*Cofanaspecta*	*	*	+
3	Orthoptera	Gryllidae	Field cricket	*Acheta spp*	* *	* *	*
		Acrididae	Shorthorned grass hopper	*Hieroglyphus spp*	* *	* *	* *
		Tettigonidae	Long horned grass hopper	Unidentified	+	*	+
		Gryllotalpidae	Molecricket	*Gryllotalpa africana*	+	*	+
4	Hymenoptera	Formicidae	Ant	*Dorylus orientalis*	* *	* *	*
		Vespidae	Wasp	Unidentified	+	+	-
2	Diptera	Muscidae	Fly	Unidentified	*	*	*
		Agromyzidae	Miner	Unidentified	*	*	*
6	Odonata	Coenagrionidae	Dragonfly	*Agriocnemis spp*	*	*	*
		Agrionidae	Damselfly	Unknown	*	+	+
7	Dictyoptera	Blattidae	Cockroach	*Periplaneta americana*	*	*	* *
		Mantidae	Praying Mantis	Unidentified	*	*	*
8	Dermaptera	Forficulidae	Ear wig	Unidentified	*	*	*
9	Isoptera	Termitidae	Termites	*Macrotermes spp*	* *	* *	* *
10	Lepidoptera	Noctuidae	Maize borer	*Chilo spp*	* *	* *	*
		Pyralidae	Caterpillar	*Cnaphalocrocis spp*	*	+	-
		Pieridae	Caterpillar	Unidentified	+	-	-
11	Araneida	Lycosidae	Spider	*Lycosa spp*	* *	* *	* *
		Oxyopidae	Spider	*Oxyopes spp*	*	*	*
		Araneidae	Spider	*Argiope spp*	*	*	* *
12	Collembola	Entomobyridae	Collembola	*Anurida spp*	*	*	* *
		Poduridae	Collembola	unidentified	* *	* *	* *
13	Acarina	Temipalpidae	Mites	Unidentified	*	*	-
		Tetranychidae	Mites	unidentified	*	*	*

- Absent + Present

* Moderately abundant * * Highly abundant

Family Coreidae, Falgoridae, Pentatomidae, Cicadidae, Delphacidae and Cicadellidae under orded Hemiptera were recorded with their genus *Leptocorisa spp, Dolycoris spp, Cofana spectra, Sogatella spp* and *Cofana specta* except for Falgoridae which genus was unidentified. It was evident from the table that the degree of their presence is reflected except for *Leptocorisa spp* and Sogatella *spp* which were not recorded from uphills.

Field cricket *Acheta spp*, Short horned grasshopper *Hieroglyphus spp*, Long horned grasshopper (unidentified), and Mole cricket *Gryllotalpa Africana* were found recorded as highly abundant for the first two genus and the remaining genus shows their presence from all the fields.

Formicidae and Vespidae, O: Hymenoptera represented by ants *Dorylus orientalis* and wasps (unidentified) were found recorded highly abundant at plain and foothill and moderately abundant at uphill (for formicidae), where as wasp presence was recorded from plain and foothill but was absent at uphill. Likewise Dipteran flies Muscidae and leafminer Agromyzidae (unidentified) were recorded moderately present from all the fields. Also Dragonfly *Agriocnemis spp*, family Coenagrionidae O: Odonata was moderately abundant and Agrionidae (Damselfly) records its presence from all the fields.

Dictyoptera; family Blattidae and Mantidae; cockroach *Periplaneta Americana* and praying mantis (unidentified) were found recorded moderately abundant from all the three maize fields, so as the O: Dermaptera; family Forficulidae, Ear wig (unidentified).

Termites *Macrotermes spp.* under family Termitidae O: Isoptera was found highly abundant from all the fields. Lepidopteran moths and caterpillars of family Noctuidae *Chilo spp*, Pyralidae *Cnaphalocrocis spp* and Pieridae

(unidentified) were recorded highly to moderately abundant, except for Pieridae, it was found recorded from plain area of their presence but was nil at foothill and uphill.

Spiders O: Araneida; families Lycosidae *Lycosa spp*, Oxyopidae *Oxyopes spp* and Araneidae *Argiope spp* recorded their highly to moderately presence from all the three maize fields. Apart from the above arthropod fauna a few species of Collembola family Entomobyridae *Anurida spp* was recorded moderately abundant from plain and foothill maize fields and highly abundant from uphill area. Family Poduridae was recorded highly abundant from all the fields. Likewise mites of family Tenuipalpidae and Tetranychidae were recorded moderately present from all the fields except for Tenuipalpidae which was recorded nil from uphill area maize field.

The details of the findings are discussed in the next chapter under suitable headings.

4.2. Biodiversity of Soil Surface Arthropod Fauna

4.2.1. Plain Area (Dimapur)

Abundance of soil surface inhabiting arthropod fauna in maize field ecosystem from plain area (Dimapur) during September 2002 to August 2004 from pitfall traps is tabulated in Table3, Fig. 4. Their seasonal occurrence and density shows that the Coleopteran recorded the maximum number of families. Among the coleopteran, family Carabidae (10.18) recorded maximum population during June to August 2004 and the minimum (2.05) during December to February 2003-04. The other families; viz; Cicindillidae, Scarabaeidae and Elateridae was also recorded during the time of investigation. Cicindellidae was found maximum (3.38) during Jun.–Aug. in 2004, and less

Table 3. Arthropod diversity in maize ecosystem of plain area (Dimapur) through pitfall traps.

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-weiner diversity index (H)	Simpson-Yule Diversity Index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Carabidae	*3.18	2.31	6.11	9.64	4.65	2.05	5.19	10.18	0.08	2.38
Cicindellidae	0.00	0.00	1.58	3.38	1.44	0.46	2.85	2.45	0.03	3.48
Scarabaeidae	0.00	0.00	11.16	6.45	0.72	1.52	1.90	1.50	0.05	2.92
Elateridae	0.00	0.00	0.00	4.93	0.19	0.00	0.00	0.59	0.02	4.14
Gryllidae	7.85	8.51	27.64	22.93	11.05	8.72	7.48	7.25	0.12	1.64
Gryllotalpidae	0.00	0.72	0.52	0.18	0.00	0.26	0.92	0.20	0.01	4.76
Lycosidae	6.32	6.31	11.38	18.58	7.05	5.25	6.57	8.38	0.10	1.96
Formicidae	20.69	22.17	34.62	50.29	14.04	10.25	33.44	17.46	0.16	1.04
Forficulidae	0.00	0.00	0.33	0.31	0.06	0.00	0.52	0.32	0.01	5.28
Blattidae	0.12	0.06	0.59	1.64	0.19	0.00	0.31	0.25	0.01	4.65
Poduridae	0.99	0.00	103.38	35.58	3.32	0.00	13.71	21.33	0.15	1.15
Entomobyridae	0.00	0.00	2.31	1.12	0.38	0.20	1.25	2.18	0.02	3.91
Tenupalpidae	0.00	0.00	0.00	9.31	0.20	0.00	0.85	4.79	0.04	3.29
Tetranychidae	0.00	0.00	0.00	0.44	0.19	0.00	0.52	0.99	0.01	4.99
Total	**39.15**	**40.08**	**199.60**	**164.80**	**43.48**	**28.71**	**75.51**	**77.87**	**0.81**	**45.58**

* The values are the tri-monthly mean arthropod population recorded through pitfall traps.

or nil during Sept.-Nov. and Dec.-Feb. Scarabaeidae was found maximum (11.16) during March to May 2003 and nil (0.00) in between Sept. 2002 and Feb. 2003. The family Elateridae was at its maximum during Jun.-Aug. in 2003 (4.93) and was nil during Sept. - Feb. months.

Among Orthoptera, family Gryllidae was recorded maximum (27.64) during Mar.-May 2003 and the minimum (7.25) Jun.-Aug. in 2004. The family Gryllotalpidae was recorded maximum (0.92) during Mar.-May in 2004 and nil (0.00) during September to November.

Arachnida, family Lycosidae was found maximum (18.58) during June to August in 2003 and the minimum (5.25) during December to February in 2003-04.

Among Hymenoptera, family Formicidae was recorded maximum (50.29) during Sept.-Nov. months in 2003, while they were less (10.25) during Dec.-Feb. in 2003-04. This family was found to the most dominant arthropod recorded during the time of investigation.

Family Forficulidae; order: Dermaptera was recorded maximum (0.52) during March t0 May in 2004 and are nil (0.00) during September to November.

Blattidae, order Dictyoptera; was found recorded its maximum (1.64) during Sept.-Nov. season in 2003 but was less during Dec.-Feb. season.

Under Collembola, family Poduridae dominates the arthropod population which was recorded the second largest diversity (103.38) during Mar.-May season in 2003 but were completely nil (0.00) duritg Dec.-Feb.

season. The other family under this order includes Entomobyridae with its maximum catches during Mar.-May and Sept.-Nov. season, and was minimum or nil during Sept.-Nov. and Dec.-Feb. season.

Mites comprises of family Tenuipalpidae and Tetranychidae which were found maximum during Sept.-Nov. season (9.31 and 0.99 respectively) but were nil (0.00) in Dec.-Feb. season.

The diversity indices; (H, and D); ranged between 0.01 - 0.16; and 1.04 - 5.28 respectively which differs significantly in both the cases. From table 3, it shows that family Formicidae was more diversified as compared to other families (H = 0.16) followed by Poduridae of Collembolan order (H = 0.15). Among these, the most abundant family remained Formicidae (D = 1.04).

4.2.2. Foothill Area (Mediphema)

The means of soil surface inhabiting arthropod fauna at foothill areas (Medziphema) in maize ecosystem was collected seasonally during September 2002 to August 2004 (fortnightly collection) are tabulated and presented in Table 4 and Fig. 5. From the table it is evident that Coleopteran recorded the most diverse family. The most abundant and regular arthropod family was the Formicidae under order Hymenoptera and the lowest was family Acrididae under order Orthoptera.

Among the coleopteran, family Carabidae (2.3) is recorded maximum during June to August 2003 and the minimum (0.33) numbers is recorded during December to February (2002-03). Families; Scarabaeidae was found maximum (3.69) during March to May 2003 and less (0.3) in between December and Feb. (2002-03). Ciccindillidae and Elateridae were also recorded during the time of investigation. Cicindellidae was found maximum

Table 4. Arthropod diversity in maize ecosystem of foothill area (medziphema) through pitfall traps.

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-wanier diversity index (H)	Simpson-Yule Diversity Index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Carabidae	*0.68	0.33	1 03	2.30	0.84	0.70	0.20	1.98	0.08	2.24
Scarabaeidae	1.99	0.30	3.69	1.32	1 49	0.6	2 55	2.02	0.11	1.83
Ciccindelidae	0 00	0 00	0 00	0.17	0.03	0 00	0.01	0.01	0 01	5.36
Elateridae	0 00	0 00	0 00	0.08	0 00	0 00	0.15	0 06	0.01	5.29
Gryllidae	1 20	0.92	2 70	3.65	1.96	0.95	2.94	0.84	0 12	1.76
Gryllotalpidae	0.06	0.16	0 10	0 01	0 04	0.16	0 15	0.05	0 01	4.39
Acrididae	0 00	0 00	0.05	0 01	0 00	0 00	0.09	0 07	0 01	5.43
Lycosidae	1 07	0.90	1.32	1.97	1.25	1.31	2.45	2.50	0 11	1.90
Formicidae	4.20	3.21	4 84	14.79	5.19	4.47	0.01	5.78	0.16	0.75
Forficulidae	0.00	0 00	0 12	0.09	0 00	0 00	0.09	0.11	0.01	4.89
Blattidae	0 02	0 00	0.17	0.27	0 00	0 00	0.06	0 16	0 01	4.45
Termitidae	0 00	0.07	0.22	0 17	0 00	0.68	0.70	0.00	0.03	3.59
Entomobyridae	0 00	0 00	1.46	0 14	0 00	0.04	1.84	0.84	0 05	2.89
Poduridae	0 00	0 00	0 18	0.95	0 00	0 00	0.54	0.55	0 03	3.42
Tenuipalpidae	0.24	0 00	0 00	2 13	0.25	0 00	0.37	0.03	0 05	2.95
Tetranychidae	0.06	0 00	0 00	0.12	0.20	0 00	0 06	0.23	0 01	4.46
Total	20 11	3.69	20 16	20.31	20 14	8 91	20.23	20.20	0.81	55.59

* The values are the tri-monthly mean arthropod population recorded through pitfall traps.

(0.17) during Sept.-Nov. in 2003, and was nil (0.00) during Dec.-Feb. season. The family Elaterid was at its maximum during Mar.-May season in 2004 (0.15) and was nil (0.00) during September to February months.

Gryllidae; Order: Orthoptera was recorded maximum (3.65) during Sept.-Nov. season in 2003. The family Gryllotalpidae was recorded maximum (0.16) during Dec. to Feb., they were found minimum during Sept.-Nov. and Sept.-Nov. season. A few species of family Acrididae was recorded during. March to August months.

Arachnida. family Lycosidae was found maximum (2.5) during June to August in 2004 and the minimum (0.9) during December to February in 2002-03.

Among Hymenopterans; family Formicidae was recorded maximum (14.79) during Sept.-Nov. months in 2003, while they were less (3.21) during Dec.-Feb. in 2002-03. This family was the most dominate arthropod diversity aswell as the prominent recorded during the period of investigation.

Family Forficulidae; order: Dermaptera was recorded maximum (0.12) during March to May in 2003 and are nil (0.00) during September to November.

Blattidae, Order: Dictyoptera; was found recorded its maximum (0.27) during Sept.-Nov. season in 2003 but was nil (0.00) during Dec.-Feb. season. The worker termites; family Termitidae was also found recorded during Dec.-Feb. months but were nil during Sept.-Nov..

Collembola; family: Entomobyridae was recorded its maximum (1.64) during Mar.-May season in 2004 but were completely nil (0.00) during Sept.-Nov. season. The other family under this order includes Poduridae with its maximum catches during Mar.-May and Sept.-Nov. season, and was nil during Sept.-Nov. and Dec.-Feb. season.

Mites; family: Tenuipalpidae and Tetranychidae were found maximum during Sept.-Nov. season but were nil (0.00) during Dec.-Feb. season

The diversity indices; (H, and D): ranged between 0.01 - 0.16; and 0.75 - 5.43 respectively which differs greatly in both the cases. From table 3, it is evident that family Formicidae was more diversified as compared to other families (H = 0.16) followed by Gryllidae (H = 0.12) and the dominance arthropod family was represented by Formicidae (D = 0.75).

4.2.3. Uphill Area (Kohima)

Diversity of soil surface inhabiting arthropod fauna in maize field ecosystem from uphill area (Kohima) during September 2002 to August 2004 from pitfall traps is tabulated in Table 5, Fig. 6. Their seasonal occurrence and abundance shows that the Coleopteran recorded the maximum number of families. Among the coleopteran, family Carabidae (1.9) is recorded maximum during June to August 2004 and the minimum (0.04) numbers is recorded during December to February 2002-03. The other families; viz: Meloidae, Scarabaeidae and Ciccindillidae were also recorded during the period of investigation. Meloidae was found maximum (0.18) during Mar.-May in 2004 and was nil (0.00) duringSept.-Nov.and Dec.-Feb. Scarabaeidae was found in equal numbers (0.13) during Sept.- Nov and Sept.-Nov. season in 2002 and 2004 respectively. The family Ciccindillidae was at its maximum during Mar.-May in 2004 (0.11)and was nil during Dec.-Feb. season.

Table 5. **Arthropod diversity in maize ecosystem of uphill area (Kohima) through pitfall traps.**

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-wenier diversity index	
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Shannon-wenier diversity index (H)	Simpson-Yule Diversity index (D)
Carabidae	*1.12	0.04	0.80	1.47	1.12	0.09	0.67	1.90	0.05	2.95
Meloidae	0.00	0.00	0.11	0.13	0.00	0.00	0.18	0.10	0.01	5.23
Scarabaeidae	0.13	0.00	0.00	0.10	0.06	0.00	0.00	0.13	0.01	5.41
Cicindellidae	0.01	0.00	0.08	0.08	0.07	0.00	0.11	0.10	0.01	5.36
Gryllidae	0.61	0.23	0.86	0.67	0.72	0.17	0.64	1.10	0.04	3.26
Gryllotalpidae	0.00	0.02	0.06	0.00	0.00	0.02	0.12	0.00	0.01	5.95
Lycosidae	0.91	0.14	0.79	1.21	0.72	0.21	0.60	1.04	0.04	3.16
Formicidae	6.63	1.06	11.59	11.39	7.17	1.12	4.92	15.28	0.16	1.13
Muscidae	0.13	0.04	0.18	0.28	0.10	0.02	0.13	0.28	0.01	4.53
Forficulidae	0.01	0.01	0.08	0.08	0.09	0.05	0.22	0.01	0.01	5.18
Blattidae	0.18	0.09	0.21	0.03	0.17	0.19	0.16	0.2	0.02	4.31
Ensomobyridae	6.26	0.34	37.24	43.70	7.10	0.27	21.29	15.72	0.12	0.41
Termitidae	0.00	0.00	0.21	0.00	0.00	0.00	0.21	0.00	0.01	5.41
Total	**13.87**	**1.93**	**51.30**	**57.81**	**17.20**	**2.05**	**28.40**	**33.86**	**0.41**	**52.33**

* The values are the tri-monthly mean arthropod population recorded through pitfall traps.

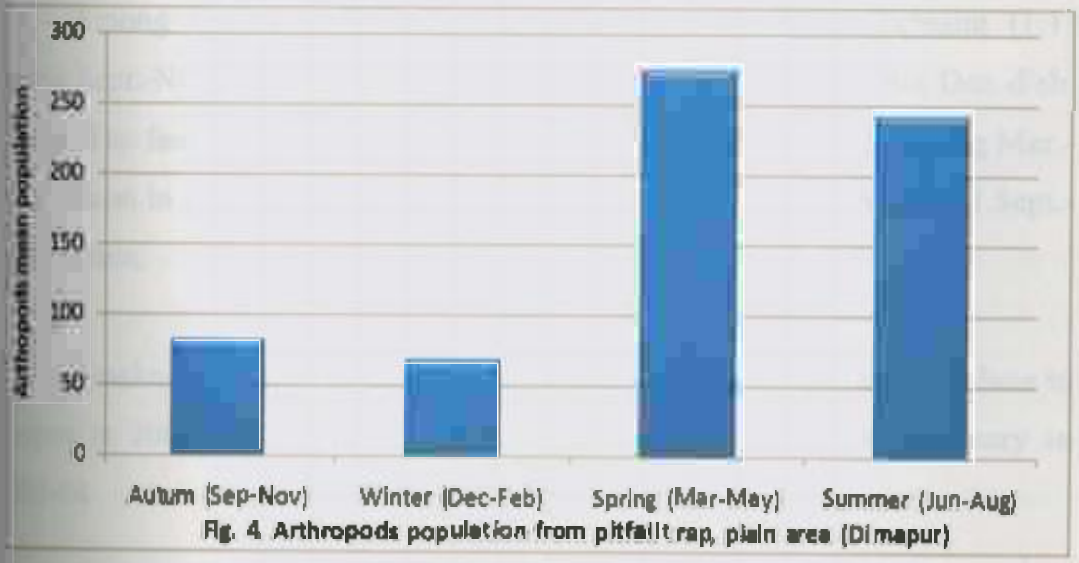

Fig. 4 Arthropods population from pitfall trap, plain area (Dimapur)

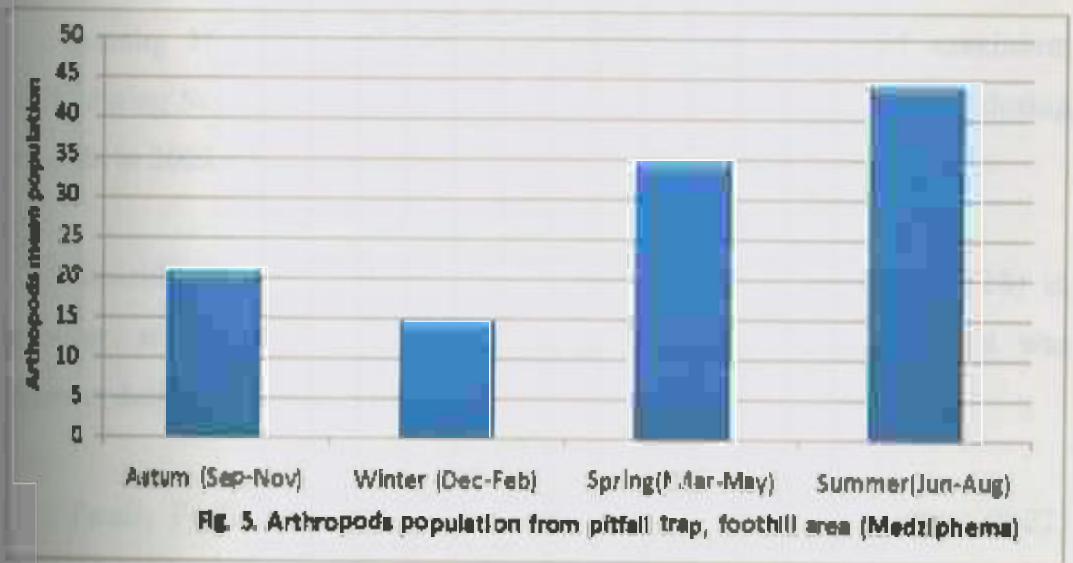

Fig. 5. Arthropods population from pitfall trap, foothill area (Medziphema)

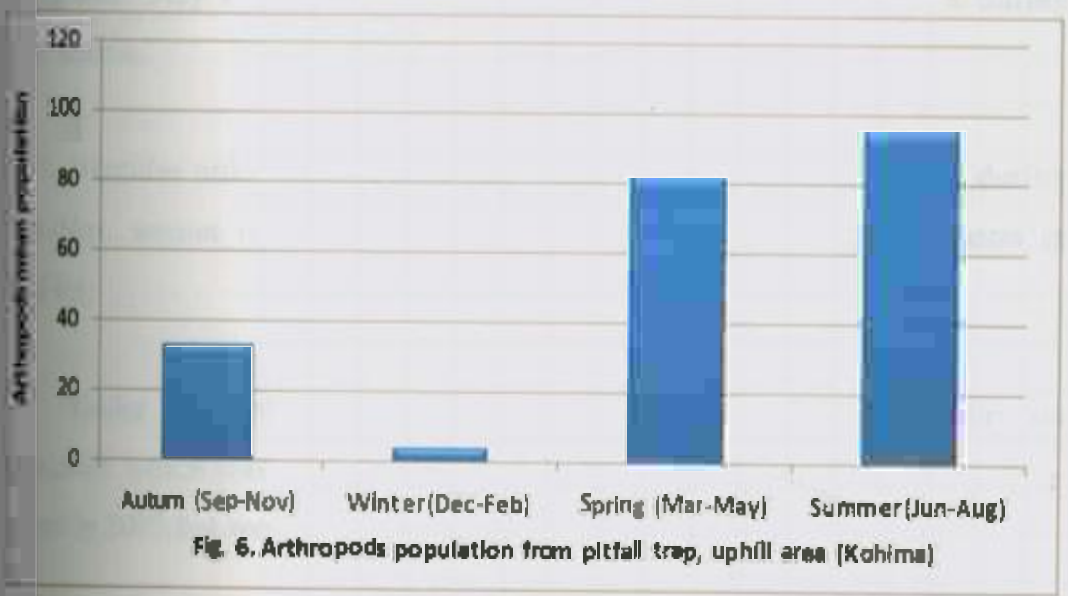

Fig. 6. Arthropods population from pitfall trap, uphill area (Kohima)

Among Orthoptera, family Gryllidae was recorded maximum (1.1) during Sept.-Nov. season in 2004 and the minimum (0.17) in 2004 Dec.-Feb. season. The family Gryllotalpidae was recorded maximum (0.12) during Mar.-May season in 2004. They were found nil (0.00) during Sept.-Nov. and Sept.-Nov. season.

Arachnida, family Lycosidae was found maximum (1.21) during June to August in 2003 and the minimum (0.21) during December to February in 2003-04.

Among Hymenoptera, family Formicidae was recorded maximum (15.28) during Sept.-Nov. months in 2003, while they were less (1.06) during Dec.-Feb. in 2002-03.

Muscidae, Order: Diptera was recorded equat in numbers (0.28) in Sept.-Nov. season on both the years i.e. during 2003 and 2004 but was minimum during Dec.-Feb. swasons.

Family Forficulidae; order: Dermaptera was recorded maximum (0.22) during Mar.-May season (March to May) in 2004 and was negligible during other season.

Blattidae order Dictyoptera; was found recorded maximum (0.3) during Sept.-Nov. season in 2003 but was less (0.09) during Dec.-Feb. season in 2002-03.

Under Collembola, family Entomobyridae dominates the arthropod population which was recorded the largest diversity (37.24) during Mar.-May season in 2003 but were less during Dec.-Feb. season.

A few numbers of termites was found recorded during Mar.-May season (0.21) in 2003 and 2004 but were nil (0.00) in rest of the season.

The diversity indices and the dominance arthropod as represented by H and D ranges between 0.01 - 0.16; and 0.41 – 5.98 respectively. Table 5 shows that family Formicidae was more diversified as compared to other families (H = 0.16) and the dominance arthropod family was represented by Entomobyridae (D = 0.41). The diversity indices and dominance differs greatly in both the cases.

4.3. Soil inhabiting arthropod fauna collected from 0-10cm layer of soil

4.3.1. Plain area (Dimapur)

The diversity of soil inhabiting arthropod fauna from 0.10-cm. layer of soil profile at plain area (Dimapur) per samples in maize ecosystem and was collected seasonally during September 2002 to August 2004 are recorded and presented in Table 6, Fig. 7

The table shows that the arthropod populations include mostly the mites and collembola. The most dominant and prominent group of arthropod under this group was the family Tetranychidae, which was found recorded its maximum (1.35) during Sept.-Nov. season in 2003 and less during Dec.-Feb. (0.08) in 2003-04. Family Tenuipalpidae was recorded maximum during Sept.-Nov. season in 2003 (0.57) and less during Sept.-Nov. season (0.07) which was in contrast to pitfall traps.

Table 6. Arthropod diversity in maize ecosystem of plain area (Dimapur) through soil core samples.

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-wenier diversity index (H)	Simpson-Yule Diversity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Tetranychidae	*0.36	0.46	0.73	1.35	0.10	0.08	0.14	0.11	0.16	1.09
Tenuipalpidae	0.18	0.21	0.24	0.07	0.57	0.50	0.13	0.41	0.14	1.41
Poduridae	0.08	0.22	0.65	0.34	0.54	0.57	0.40	0.43	0.15	1.12
Formicidae	0.15	0.17	0.10	0.09	0.28	0.21	0.19	0.12	0.11	1.90
Muscidae	0.10	0.07	0.10	0.08	0.12	0.18	0.19	0.18	0.01	2.12
Termitidae	0.11	0.07	0.06	0.01	0.08	0.03	0.05	0.08	0.06	2.76
Total	0.98	1.20	0.88	1.94	1.59	1.57	1.10	1.33	0.70	10.39

*The values are mean of fifteen samples (0-10cm. deep) recorded seasonally at three months interval.

Collembolan family includes Poduridae, which was recorded maximum (0.65) during Sept.-Nov. in 2003 and least during Sept.-Nov. in 2002 (0.08). Other group includes Formicidae Order: Hymenoptera recorded maximum (0.28) during Sept.-Nov. season in 2003. A few numbers of the Dipteran maggots was recorded (0.19) in 2004 Mar.-May season, and least during Dec.-Feb. in 2002-03. Worker termites under family Termitidae was also found recorded its maximum (0.11) during Sept.-Nov. season in 2002 and least (0.01) during Sept.-Nov. in 2003.

The diversity indices; (H, and D); ranged between 0.01 - 0.16; and 1.09 - 2.76 respectively which differs greatly in both the cases. From table 6, it is clear that the family Tetranychidae was more diversified as compared to other families (H = 0.16) followed by Poduridae of Collembolan order (H = 0.15) and the dominance arthropod family was represented by Tetranychidae (D = 1.04) and the least was represented by Termitidae (D = 2.76).

4.3.2. Foothill Area (Medziphema)

The mean of soil inhabiting arthropod fauna collected from 0-10 cm. layer of soil at foothill area in maize ecosystem during September 2002 August 2004 are recorded and presented in Table 7 Fig. 8. The diversity of different arthropod recorded was dominated by Mites and Collembola and were found throughout the season.

Soil inhabiting arthropod fauna in foothill area maize ecosystem mainly consists of five orders, six families and three classes of arthropod. Collembolans, Mites and Hymenopterans were the dominant. The family Poduridae, Order: Collembola recorded (2-69) maximum during Dec.-Feb. season of 2003-04 and was least during Sept.-Nov. season in 2002 where as

Table 7. Arthropod diversity in maize ecosystem of foothill area (Medziphema) through soil core samples.

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-weiner diversity index (H)	Simpson-Yule Divinity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Poduridae	*0.10	1.60	2.30	1.98	1.52	2.68	2.31	1.68	0.16	0.82
Entomobyridae	0.01	.0.04	3.31	0.99	.0.20	0.09	0.31	1.0.42	.0.08	2.37
Tentipalpidae	0.45	1.04	1.76	4.10	.0.66	1.49	1.76	2.33	0.16	0.85
Tetranychidae	0.28	0.08	0.17	.0.13	0.21	0.33	0.32	0.45	0.07	2.54
Formicidae	.0.08	0.28	0.28	0.43	0.49	0.34	0.54	0.32	0.08	2.25
Muscidae	0.02	0.02	0.04	0.07	0.01	0.07	.0.08	.0.08	0.02	3.94
Termitidae	0.02	0.19	0.17	0.22	.0.08	0.46	0.06	0.01	.0.05	3.02
Total	**20.03**	**3.23**	**20.08**	**20.11**	20.08	**5.46**	**20.09**	**20.09**	**0.62**	**15.79**

*The values are mean of fifteen samples (0-10cm. deep) recorded seasonally at three months interval.

family Entomobyridae was maximum during Sept.-Nov. season in 2003 (0.99) but least during Sept.-Nov. in 2002.

Family Tenuipalpidae (mites) recorded its maximum during Sept.-Nov. season in 2004 (2.33) but least during Sept.-Nov. season in 2002. A few numbers of family Tetranychidae was recorded its maximum during Sept.-Nov. season in 2004 (0.45) and minimum during Dec.-Feb. season of 2002-03 (0.06).

Apart from the above arthropod; family Formicidae (ants) under Order: Hymenoptera recorded its maximum presence during Mar.-May season in 2004 (054) and least during Sept.-Nov. season in 2—2 (0.06). However, a few numbers of Dipteran maggots are recorded during the period of study especially during Mar.-May and Sept.-Nov. season (0.08) between March and August 2004.

Some worker termites under order: Isoptera, family Termitidae was recorded maximum during Sept.-Nov. of 2003 (0.22) but was nil (0.00) during September to November 2003.

The diversity indices and the dominance arthropod as represented by H and D ranges between 0.02 - 0.16; and 0.82 – 3.94 respectively (Table 7) family Poduridae and Tenuipalpidae represent both the diversity and the dominance characters. (H = 0.16; D = 0.82).

4.3.3. Uphill area (Near Kohima)

The mean of soil inhabiting arthropod fauna collected from 0-10cm. layer of soil at uphill area in maize ecosystem during September 2002 August 2004 are tabulated and presented in Table 8, Fig. 9

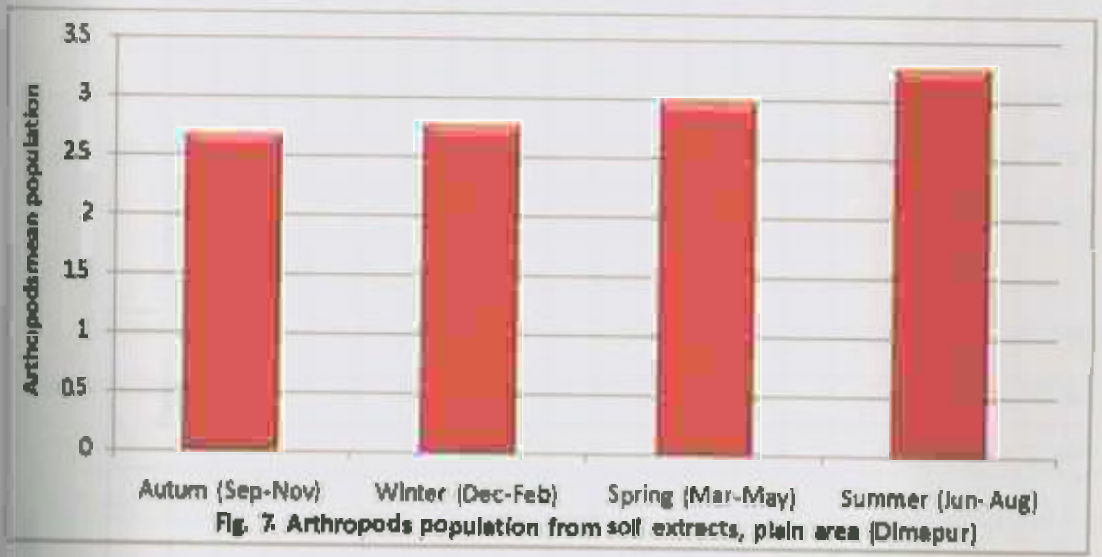

Fig. 7. Arthropods population from soil extracts, plain area (Dimapur)

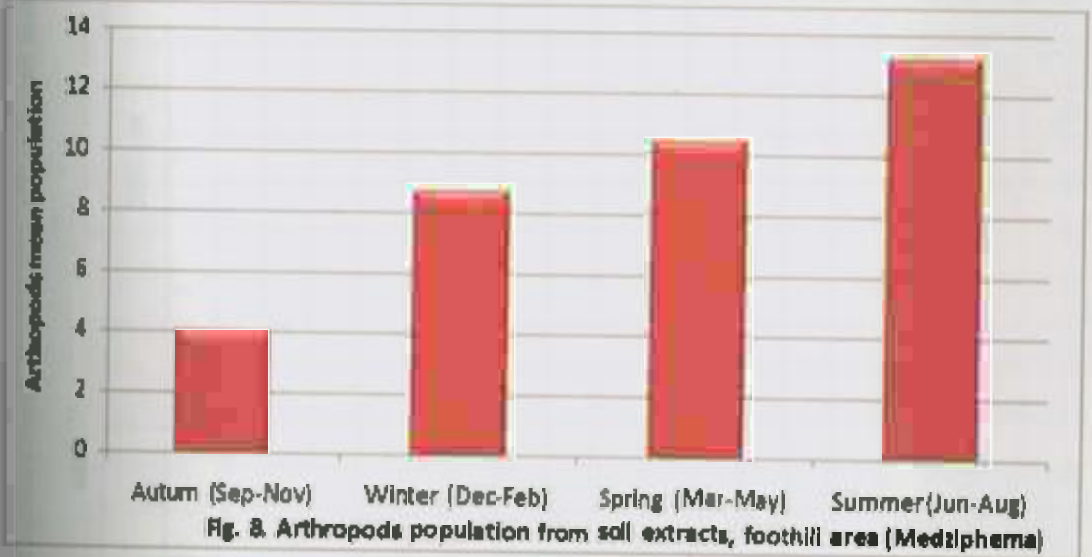

Fig. 8. Arthropods population from soil extracts, foothill area (Medziphema)

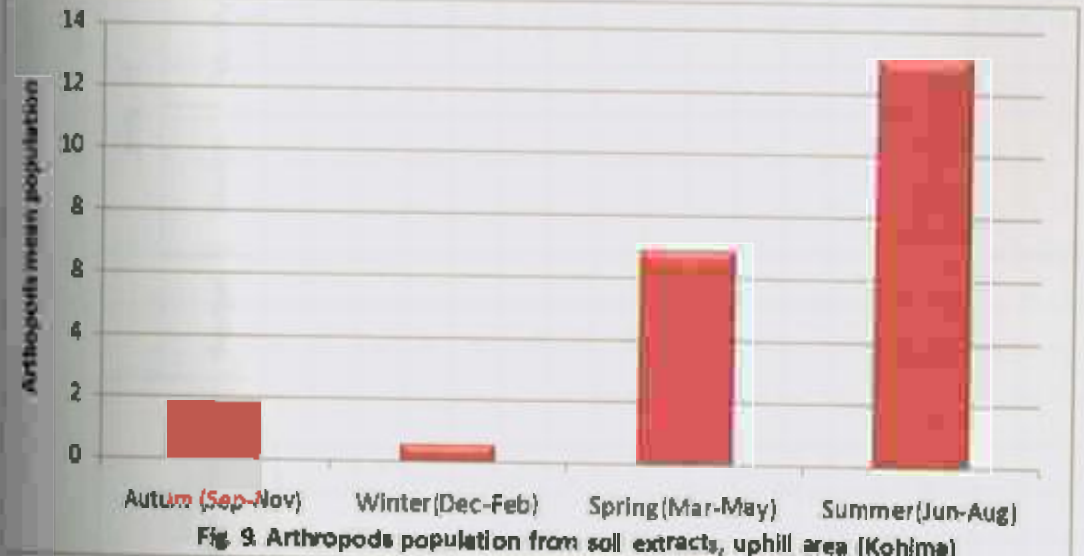

Fig. 9. Arthropods population from soil extracts, uphill area (Kohima)

Table 8. Arthropod diversity in maize ecosystem of uphill area (Kohima) through soil core samples.

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-wener diversity index (H)	Simpson-yule Divirsity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Tetranychidae	*0.57	0.25	0 80	1.21	0 45	0.18	1.25	1.45	0.15	1.12
Scarabaeidae	0.00	0.00	0.09	0 15	0.00	0.00	0.22	0.12	0.04	3.17
Poduridae	0.10	0 04	2 32	5.80	0.71	0.10	2 19	4.36	0.11	0.31
Total	0.67	0.29	3.21	7.16	1.16	0.28	3.66	5.93	0.30	4.60

*The values are mean of fifteen samples (0-10cm. deep) recorded seasonally at three months interval.

The soil inhabiting arthropod fauna in upland area maize ecosystem mainly consists of Mites, and Collembolans. Mites' family, Tetranychidae was maximum (1.45) during Sept.-Nov. season in 2004 and was least (0.18) during Dec.-Feb. season in 2003-04.

Collembola dominated the arthropod catches in upland area of maize ecosystem during the period of investigations, under which, family Poduridae was recorded maximum (5.8) during Sept.-Nov. season in 2003 and was least during Dec.-Feb. season (0.01) in both the years.

A few numbers of Coleopteran order under family Scarabaeidae was also found recorded during Mar.-May and Sept.-Nov. months but was nil (0.00) during Sept.-Nov. and Dec.-Feb. season in both the years of investigations.

The diversity indices H and D represented by 0.15, 0.11, 0.04 (for Tetranychidae, Poduridae, Scarabaeidae) and 0.31, 1.12, 3.17; (Poduridae, Tetranychidae, Scarabaeidae) and their totals of 0.30 and 4.60 respectively (Table 8).

4.4. Night active arthropod Fauna

4.4.1. Plain Area (Dimapur)

Diverse group of night active arthropod fauna (light trap) recorded seasonally from plain area (Dimapur) in maize ecosystem during September 2002to August 2004 is presented in Table 9, Fig.10. The table shows that a total of 12 arthropod orders and 33 families are recorded during the period of investigation.

Table 5. Arthropod diversity in some ecosystem of plain area (Dibrugarh through light traps.

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-weiner diversity index (H)	Simpson-Yule Divisity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Hydrophillidae	*0.07	10.19	27.77	6.34	0.12	22.27	9.10	0.3	0.14	1.43
Chrysomelidae	0.00	0.00	0.00	1.46	0.00	0.00	0.80	0.23	0.01	4.40
Scarabaeidae	2.35	1.04	14.65	10.88	3.21	1.29	2.42	2.81	0.10	2.01
Cicindelidae	0.15	0.07	0.40	1.42	0.03	0.15	1.27	0.18	0.02	4.05
Cerambycidae	0.38	0.00	0.00	0.30	0.00	0.00	0.10	0.11	0.01	5.29
Buprestidae	0.08	0.00	0.00	0.15	0.00	0.00	0.00	0.18	0.01	6.01
Elateridae	0.11	0.00	0.07	0.30	0.11	0.00	0.20	0.11	0.01	5.28
Carabidae	0.50	1.65	4.88	5.11	0.94	1.25	1.43	0.33	0.06	2.78
Pentatomidae	0.65	0.00	2.23	4.15	0.61	0.00	1.02	0.26	0.04	3.29
Coreidae	0.00	0.00	0.11	0.27	0.23	0.00	0.28	0.37	0.01	4.99
Belastomidae	0.07	0.00	0.00	4.34	0.03	0.00	0.40	0.81	0.03	3.72
Cicadidae	0.07	0.00	0.00	0.19	0.00	0.00	0.17	0.35	0.01	5.40
Fulgoridae	0.15	0.00	0.00	1.53	0.00	0.00	0.10	0.28	0.01	4.56
Delphacidae	1.42	0.38	4.18	3.57	3.13	1.04	5.11	5.27	0.07	2.42
Gryllidae	0.00	0.61	2.03	0.93	0.12	1.09	0.53	0.33	0.03	3.69
Gryllotalpidae	0.03	0.00	0.03	0.54	0.00	0.12	0.33	0.11	0.01	5.06
Acrididae	0.80	0.15	1.42	2.88	0.88	0.02	0.74	0.71	0.03	3.43

Contd.....

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-weiner diversity index (H)	Simpson-Yule Divisity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Tettigonidae	0.50	0.07	0.00	0.42	0.71	0.12	0.33	0.30	0.01	4.41
Vaspidae	0.70	0.77	5.65	1.23	0.52	1.02	1.39	0.30	0.05	3.06
Formicidae	1.15	1.00	5.73	14.5	0.48	1.10	0.07	0.87	0.08	2.40
Culicidae	0.00	10.19	32.88	0.00	0.10	10.71	2.94	0.00	0.12	1.68
Muscidae	0.34	0.80	0.00	0.46	0.69	0.17	0.35	0.33	0.02	4.20
Agromyzidae	0.00	0.00	1.61	1.65	0.32	6.38	0.71	0.28	0.04	3.11
Coenagrionidae	0.80	0.38	1.84	0.08	0.83	0.10	0.25	0.35	0.03	3.74
Agrionidae	0.34	0.00	0.07	0.11	0.39	0.22	0.3	0.11	0.01	4.81
Pyralidae	0.53	0.53	6.68	13.64	0.81	5.14	3.02	1.85	0.10	1.94
Noctuidae	0.84	0.11	3.69	1.77	1.03	0.53	0.94	0.26	0.04	3.26
Pieidae	0.07	0.07	0.19	1.54	0.00	0.00	1.23	0.42	0.02	4.10
Termitdae	0.00	0.57	5.56	10.23	0.00	2.45	1.38	0.00	0.07	2.53
Blatide	0.15	0.18	0.19	0.81	0.31	0.10	0.12	0.23	0.01	4.85
Maruidae	0.00	0.03	0.03	0.15	0.02	0.00	0.15	0.07	0.01	5.83
Forficulidae	0.00	0.00	0.07	0.38	0.03	0.00	0.22	0.23	0.01	5.25
Therlidae	0.00	0.00	0.00	0.15	0.10	0.00	0.17	0.45	0.01	5.31
Total	12.14	26.74	133.10	92.08	15.56	55.27	32.57	18.57	1.18	128.07

* The values are mean of three light traps.

Coleopteran order recorded the highest number of arthropod family; of which hydrohillidae dominated the group of arthropod family with 27.77 numbers during Mar.-May season in 2003 and was as low as 0.07 was recorded during Sept.-Nov. in 2002. Family Chrysomelidae was recorded maximum (1.46) during Sept.-Nov. season in 2003 but were completely nil (0.00) during Sept.-Nov. and Dec.-Feb. months. Searabaeidae was recorded highest number during Mar.-May season in 2003 (14.65) and was least (1.04) during Dec.-Feb. in 2003. The family Ciccindelidae was at its highest (1.42) during Sept.-Nov. and as low as 0.03 during Sept.-Nov. in 2003. A few individuals from families Cerambycidae, Bubrestidae and Elateridae were recorded their maximum presence during Sept.-Nov. season but were nil in Dec.-Feb.s. Carabidae which was a dominant figure was found present through out the investigation periods with their maximum in 2003 Sept.-Nov. season (5.11) but was least (0.33) during the same season in 2004.

Pentatomidae, Order; Hemiptera recorded maximum during Sept.-Nov. season in 2003 (4.15) but was nil during Dec.-Feb. season (0.00). Similarly, family Coreidae, Belastomidae, Cicadidae, Falgoridae and Delphacidae were recorded the maximum during Sept.-Nov. season of 2003/04 but were nil during Dec.-Feb.s except for Delphacidae which was recorded through out the season.

Orthopteran ineludes family Gryllidae, Grytotalpidae, Acrididae and Tettigonidae which were found recorded through out the season except for the first two families which were nil or less during Sept.-Nov. and Dec.-Feb. season. Vaspidae and Formicidae were the two Hymenopteran recorded during the time of investigation and were recorded maximum of 5.65 and 14.5 during Mar.-May and Sept.-Nov. respectively.

Dipteran fly Culicidae was recorded maximum during Mar.-May season (32.88) in 2003 and suddenly disappeared in Sept.-Nov. season. Muscidae and Agromyzidae recorded the maximum of 0.8 and (6.28) during Dec.-Feb. in 2002-03 and 2003-04 respectively. Coenagrionidae (dragonfly) and Agrionidae (damselfly) belongs to Order Odonata were also recorded almost through out the season except Agrionidae which was found nil (0.00) during Dec.-Feb. in 2003. Lepidopteran moth and butterfly belonging to family Pyralidae and Noctuidae were recorded maximum during Mar.-May season; 16.68 and 3.69 and Pieridae (1.54) in Sept.-Nov. season in 2003 respectively.

Winged termite belonging to family Termitidae, Order; Isoptera was recorded maximum during Sept.-Nov. in 2003 (10.23) but were nil (0.00) during Sept.-Nov. season.

Blatidae and Mantidae, Order; Dictyoptera was recorded maximum number during Sept.-Nov. season i.e. 0.61 and 0.15 respectively in 2003 and less during Dec.-Feb. season. Forficulidae, Order; Dermaptera was recorded its maximum during Sept.-Nov. of 2003 (0.38) and was nil (0.00) in Dec.-Feb. season, so as Theriidae of Order Arachneda recorded maximum of 0.45 during Sept.-Nov. of 2004 and nil (0.00) during Dec.-Feb. season.

The diversity indices of arthropod as represented by H ranges between 0.01 - 0.14; and the dominanee between 1.43 and 6.01 (Table 9). Family Hydrophillidae represent the diversity and the dominance characters. (H = 0.14); (D =1.43), followed by Culicidae (H = 0.12; D = 1.68) respectively.

4.4.2. Foothill Area (Medziphema)

Diverse group of night active arthropod fauna collected at foothill area per trap in maize ecosystem during September 2002 to August 2004 is

presented in Table 10, Fig. 11. An overall observation of arthropod fauna in foothill area maize ecosystem consists of 10 orders, 31 families.

Coleoptera comprises of nine families in which Scarabaiedae dominate the group of catches. Family Carabidae recorded (6.51) maximum during Mar.-May season in 2004 and the least during Sept.-Nov. season in 2003. Chrysomelidae was maximum during Sept.-Nov. in 2004 (0.3) but was nil (0.00) during Dec.-Feb. season. Scarabaiedae was abundant through out the season with its maximum during Sept.-Nov. in 2003 (13.48) but Cicindelidae was maximum during Dec.-Feb. season in 2003-04 (1.05). Family Curculionidae was maximum during Sept.-Nov. season (1.05) in 2002 but was nil (0.00) during Sept.-Nov. season. Family Elateridae was found maximum during Sept.-Nov. in 2002 (1.02) but was nil (0.00) during Dec.-Feb. season. Cerambycidae was maximum during Dec.-Feb. season (1.40) in 2002-03 so as Coccinehdae (1.05 in 2003-04) but were less the remaining season.

Hemiptera comprises of seven families, Coreidae, Pentatomidae, Belustomatidae, Fulgoridae, Cecadidae and Delphaeidae in which Delphacidae dominated the group of catches in number. Coreidae and Pentatomidae were maximum during Sept.-Nov. in 2004 (1.87 and 1.71) but were nil (0.00) during Dec.-Feb. months. Belustomatidae was maximum during Sept.-Nov. season in 2002 (101.) so as Cecadidae (1012). Fulgoridae recorded maximum during Dec.-Feb. season in 2003-04 (1.05) and were nil (0.00) between September 2002 and May 2003. Delphacidae was at its highest during Sept.-Nov. (10.73) in2004.

Order Orthoptera includes Gryllidae which was maximum during Mar.-May in 2003 (3.10) dominate the catches and were found through out the season so as Gryllotalpidae (0.28) during Mar.-May season in 2004. Acrididae,

Table 10. Arthropod diversity in maize ecosystem of foothill area (Medziphema) through light traps.

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-weaver diversity index (H)	Simpson-Yule Divirsity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Carabidae	*1.61	2.68	2.17	3.54	0.66	0.53	6.51	0.80	0.09	2.11
Chrysomelidae	0.00	0.00	0.20	0.07	0.23	0.00	0.23	0.30	0.01	4.62
Scarabaeidae	0.71	5.22	9.60	13.48	2.79	4.39	12.48	10.66	0.16	1.10
Cicindelidae	1.02	0.12	0.28	0.06	0.12	1.05	0.48	0.19	0.03	3.60
Curculionidae	1.05	0.00	0.64	0.00	0.20	0.00	0.10	0.00	0.02	4.05
Elateridae	1.02	0.00	0.48	0.10	0.25	0.00	0.17	0.13	0.02	3.98
Cerambycidae	0.00	1.40	0.15	0.25	0.25	1.12	0.23	0.30	0.03	3.51
Buprestidae	0.00	0.05	0.17	0.00	0.05	0.00	0.12	0.02	0.01	5.42
Coccinellidae	0.00	0.07	0.00	0.07	0.07	1.05	0.10	0.23	0.02	4.24
Coreidae	0.00	0.00	0.00	0.35	1.07	0.00	0.15	1.87	0.03	3.57
Pentatomidae	1.05	0.25	0.00	1.30	0.84	0.00	0.33	1.71	0.04	3.17
Belustomatidae	1.17	0.25	0.00	0.00	0.10	0.10	0.20	0.11	0.02	4.07
Fulgoridae	0.00	0.00	0.00	0.02	0.23	1.05	0.10	0.19	0.02	4.25
Cecadidae	1.12	0.00	0.00	0.79	0.43	0.00	0.33	0.35	0.03	3.68
Delphacidae	0.08	0.00	0.00	3.22	2.48	0.58	3.87	10.73	0.10	2.00

Contd.....

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-weiss diversity index (H)	Simpson-Yule Divisity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Gryllidae	0.10	0.05	3.10	0.58	0.33	1.15	2.45	0.78	0.06	2.78
Gryllotalpidae	0.00	0.00	0.22	0.05	0.05	0.05	0.28	0.13	0.01	4.86
Acrididae	0.20	0.12	1.40	1.61	0.86	1.51	1.02	1.11	0.05	2.86
Tettigonidae	1.05	0.02	0.10	0.25	0.76	0.56	0.38	0.42	0.03	3.55
Vaspidae	0.10	6.43	2.40	1.97	0.84	1.17	1.94	1.11	0.06	2.65
Formicidae	0.30	1.04	1.92	2.17	1.66	1.58	1.38	0.42	0.06	2.60
Coenagrionidae	1.63	9.40	0.38	1.48	1.04	1.76	0.59	0.52	0.05	2.86
Agrionidae	1.02	0.07	0.00	0.02	0.05	0.20	0.00	0.00	0.01	4.38
Culicidae	0.00	0.02	0.20	0.00	0.79	1.07	0.43	0.00	0.02	3.84
Muscidae	0.00	0.00	0.02	0.00	0.30	0.00	0.61	0.21	0.01	4.53
Blattidae	1.07	0.05	0.02	0.73	0.89	0.30	0.33	0.28	0.03	3.51
Mantidae	0.00	0.00	0.02	0.30	0.30	0.20	0.05	0.47	0.01	4.39
Pyralidae	1.28	0.33	0.38	1.71	0.10	1.25	0.12	0.07	0.04	3.21
Nymphelidae	1.12	0.02	0.00	0.07	0.00	0.00	0.15	0.07	0.01	4.33
Noctuidae	1.05	0.00	0.00	0.00	0.97	0.23	1.15	1.02	0.04	3.35
Termitidae	1.03	0.00	2.63	1.89	1.53	0.00	4.30	0.09	0.07	2.52
Total	18.78	12.59	26.48	36.07	20.24	20.09	40.57	34.28	1.20	109.60

* The values are mean of three light traps..

second larges group was recorded through out the season with its maximum during Sept.-Nov. in 2003 (1.61) followed by Tettigonidae (1.05) during Sept.-Nov. in 2002.

Vaspidae and Formicidae Order; Hymenoptera were recorded through out the season with their maximum during Mar.-May and Sept.-Nov. season in 2003 (2.40 and 2.17) respectively. Coenagrionidae (dragonfly) and Agrionidae (damselfly) belongs to Order Odonata were also recorded almost through out the season except Agrionidae which was found nil (0.00) during Mar.-May season. Dipteran fly Culicidae was recorded maximum during Dec.-Feb. season (1.07) in 2003-04 and were nil (0.00) during Sept.-Nov. season. Muscidae recorded the maximum of 0.61 during Mar.-May in 2004.

Blatidae and Mantidae, Order; Dictyoptera was recorded maximum number during Sept.-Nov. season i.e. 1.07 and 0.30 respectively in 2002 and 2003. Lepidopteran moth and butterfly belonging to family Pyralidae Nymphelidae and Noctuidae were recorded maximum during Mar.-May season except for Nymphelidae which was recorded maximum during Sept.-Nov. season (1.12) in 2002.

Winged termite belonging to family Termitidae, Order; Isoptera was recorded maximum during Mar.-May in 2004 (4.30) but were nil (0.00) during Dec.-Feb. season.

The diversity indices; (H. and D) ranged between 0.01 - 0.16; and 1.10 - 5.42 respectively which differ significantly in both the cases. From table 10, it is clear that the family Scarabaeidae was more diversified as compared to other families (H = 0.16) and the abundance arthropod family was also

represented by the same family (D = 1.10) and the least was represented by Buprestidae (D = 5.42).

4.4.3. Uphill Area (Near Kohima)

Diverse group of night active arthropod fauna (light trap) recorded seasonally from uphill area (Kohima) in maize ecosystem during September 2002 to August 2004 is presented in Table 11, Fig. 12. The table shows that a total of 20 families belonging to different orders were recorded during the period of investigation.

Araneida with two different groups were recorded, through out the season in which, Theridid spider was the dominant group with its maximum (0.28) numbers of mean catches during Sept.-Nov. in 2004 followed by Salticid (0.11) in the same season.

Order; Coleoptera comprises of family Cerambycidae, Meloidae, Chrysomelidae, and Coccinelidae were found recorded during the period of investigation in which Chrysomelidae dominate the group with its maximum of 0.35 during Mar.-May in 2003 followed by Meloidae and Cerambycidae .023 and 0.12 respectively. Coccinelidae was maximum during Sept.-Nov. season (0.10 in 2003) but were nil (0.00) during Sept.-Nov. and Dec.-Feb. season.

Among Orthoptera; family Acrididae, Tettigonidae and Gryllidae were recorded with their maximum records of 0.49, 0.18 and 0.18 during Sept.-Nov. in 2004 respectively. Also Dipterans flies of family Muscidae was recorded maximum (0.25-06) during Sept.-Nov. season

Table 11. Arthropod diversity in maize ecosystem of uphill area (Kohima) through light traps

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-weaver diversity index (H)	Simpson-Yule Diversity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Therlidae	*0.10	0.07	0.10	0.07	0.22	0.02	0.10	0.28	0.06	2.74
Salticid	0.07	0.02	0.05	0.10	0.10	0.05	0.02	0.11	0.04	3.28
Cerambycidae	0.07	0.00	0.12	0.10	0.12	0.00	0.10	0.07	0.04	3.18
Meloidae	0.00	0.00	0.23	0.17	0.00	0.00	0.17	0.09	0.04	3.07
Chrysomelidae	0.10	0.00	0.35	0.20	0.15	0.00	0.15	0.14	0.06	2.63
Coccinelidae	0.00	0.00	0.00	0.10	0.00	0.00	0.02	0.07	0.02	4.15
Acrididae	0.02	0.02	0.05	0.61	0.07	0.02	0.12	0.49	0.07	2.42
Tettigonidae	0.12	0.02	0.05	0.12	0.15	0.00	0.05	0.18	0.05	3.03
Gryllidae	0.20	0.00	0.12	0.15	0.10	0.05	0.15	0.18	0.06	2.75
Muscidae	0.05	0.17	0.40	0.25	0.15	0.05	0.40	0.28	0.09	2.23
Pentatomidae	0.15	0.07	0.10	0.10	0.15	0.05	0.18	0.11	0.06	2.79
Cicadellidae	0.15	0.02	0.05	0.20	0.10	0.02	0.05	0.11	0.05	3.02
Coenagrionidae	0.20	0.10	0.15	0.28	0.22	0.07	0.12	0.09	0.07	2.42
Blattidae	0.10	2.63	0.10	0.27	0.20	0.12	0.20	0.42	0.13	1.50
Mantidae	0.05	0.00	0.12	0.07	0.07	0.00	0.07	0.04	0.03	3.46
Noctuidae	0.12	0.10	0.58	0.15	0.33	0.12	0.38	0.23	0.09	2.10
Forficulidae	0.23	0.02	0.15	0.12	0.28	0.12	0.25	0.14	0.07	2.47
Termittidae	0.00	0.00	0.20	0.51	0.00	0.00	0.38	0.21	0.07	2.48
Ichneumonidae	0.18	0.00	0.37	0.07	0.22	0.02	0.07	0.11	0.06	2.67
Formicidae	0.13	0.00	0.10	0.12	0.20	0.00	0.07	0.07	0.05	3.03
Total	2.04	3.24	3.39	3.76	2.83	0.71	3.05	3.57	1.22	65.42

* The values are mean of three light traps.

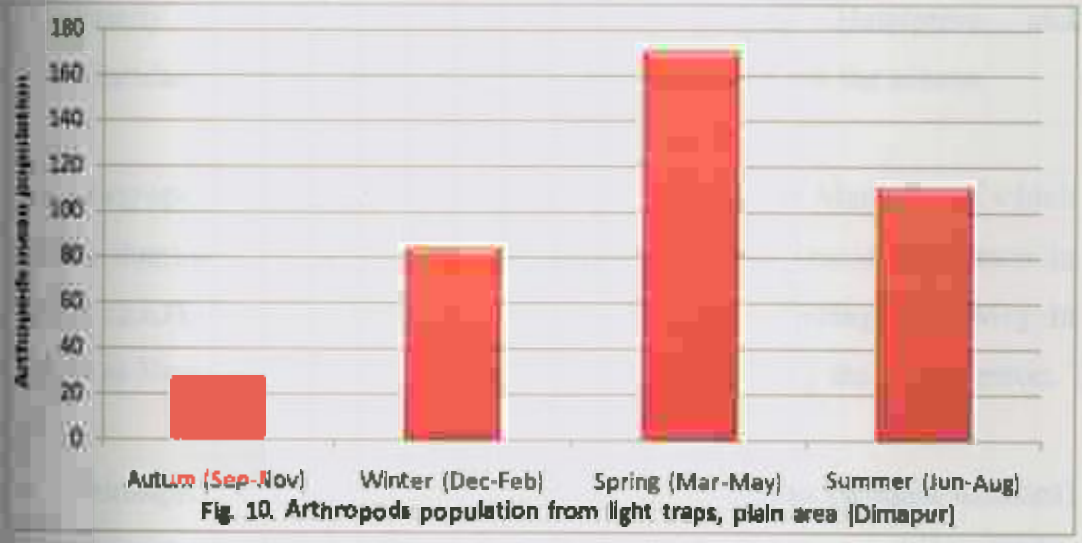

Fig. 10. Arthropods population from light traps, plain area (Dimapur)

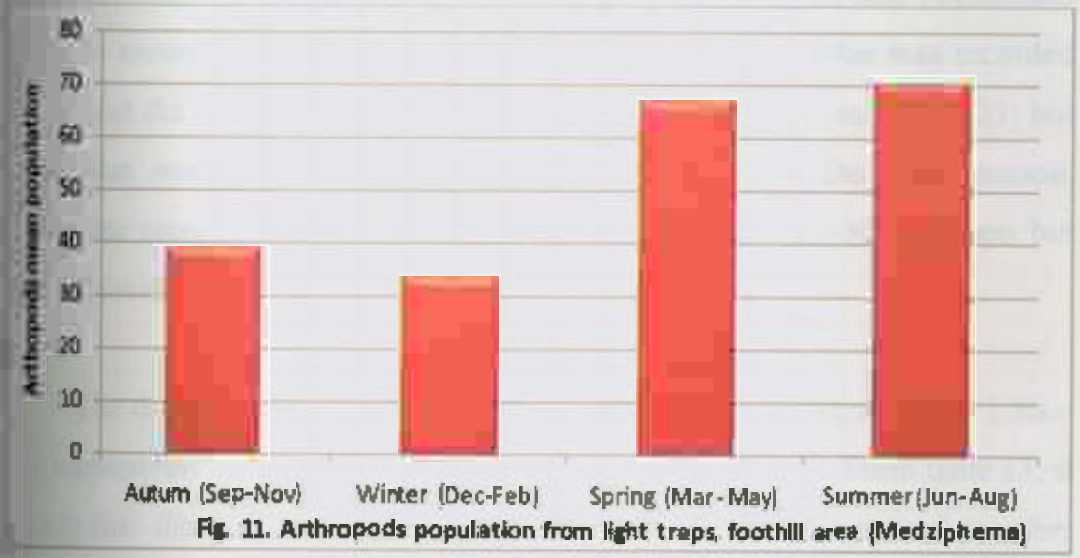

Fig. 11. Arthropods population from light traps, foothill area (Medziphema)

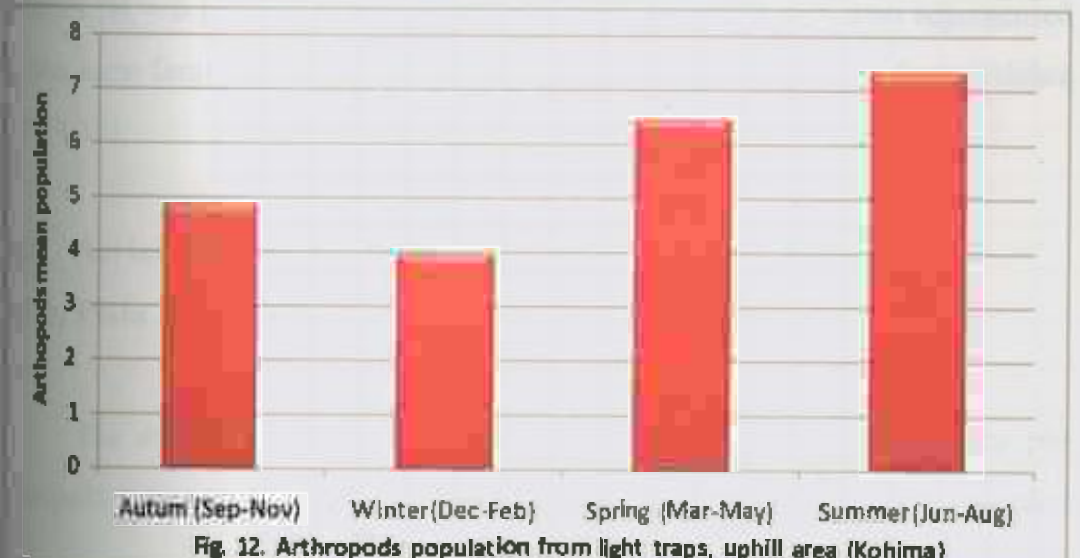

Fig. 12. Arthropods population from light traps, uphill area (Kohima)

Family Pentatomidae and Cicadellidae of Hemiptera and Coenagrionidae of Order; Odonata were recorded through out the season

Dictyoptera was represented by family Blattidae and Mantidae of which Blattidae dominate the group with its maximum during Dec.-Feb. season in 2002-03 (2.63), but Mantidae with only 0.12 numbers during Mar.-May in 2003, so as Noctuidae, Order; Lepidoptera with 0.58 durinng the same season.

Dermapteran (earwig) family Forficulidae, Isopteran (winged termites) family Termittidae and Hymenopteran family Ichneumonidae and Formicidae were also recorded during the investigation period. Forficulidae was recorded through out the season with its maximum during Sept.-Nov. season (0.23) but Termittidae was found nil (0.00) during Sept.-Nov. and Dec.-Feb. season. Formicidae recorded maximum during Sept.-Nov. and Sept.-Nov. season but were nil during Dec.-Feb.s.

The diversity indices ranged between (H= 0.02 - 0.13); and (D= 1.50 – 4.15 respectively which differs significantly in both the cases. From table 11, it is clear that the family Blattidae was more diversified as compared to other families (H = 0.13) and the abundance arthropod family was also represented by the same family (D= 1.50) and the least was represented by Coccinelidae (D=4.15).

4.5. Aerial arthropod fauna

4.5.1. Plain Area (Dimapur)

The diversity of aerial arthropod fauna collected at plain area per sweeps in maize ecosystem during September 2002 to August 2004 is recorded

and presented in Table 12, Fig. 13. The aerial arthropod fauna in plain area maize ecosystem consists of 10 orders, 19 families.

Coleoptera recorded two families, Carabidae and Scarabaeidae in which the former one was found maximum during Mar.-May and Dec.-Feb. months of 2003 and 2003-04. on the other side, the later group of family was found recorded maximum during Sept.-Nov. month in 2003 (0.13).

Diptera; was represented by family Culicidae which was recorded through out the season with a maximum during Mar.-May season in 2004 (0.39) followed by Agromyzidae (0.17) during Sept.-Nov. season in 2003. Muscidae was with only (0.08) during Dec.-Feb. season in 2003-04.

Odonata (dragonfly) represented by family Coenagrionidae recorded maximum during Sept.-Nov. season in 2003 (0.12).

Orthoptera comprises of Acrididae, with their maximum during Sept.-Nov. season in 2004 (0.29) and were recorded through out the period of investigation and Tettigonidae with their maximum during Mar.-May season in 2004 (0.12) but were recorded nil (0.00) during September 2002 to February 2003.

Hymenoptera with three different families, Formicidae, Vespidae and Apidae were recorded with their maximum during Mar.-May season in 2004, 0.16, 0.08 and 0.05, during December to February 2002-03 respectively.

Family Coreidae and Pentatomidae of Hemiptera were recorded maximum during Mar.-May in 2003 (0.08) and Sept.-Nov. (0.33) respectively.

Table 12. Arthropod diversity in maize ecosystem of plain area (Dimapur) through sweep net.

Arthropod family/Season (Period)	2002 – 03				2003 - 04				Shannon-weiner diversity index (H)	Simpson-Yule Divisity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Carabidae	0.04	0.04	0.06	0.04	0.02	0.06	0.04	0.05	0.05	3.02
Scarabaeidae	0.00	0.00	0.03	0.13	0.06	0.01	0.08	0.08	0.05	2.92
Culicidae	0.13	0.14	0.23	0.15	0.24	0.15	0.39	0.11	0.12	1.73
Muscidae	0.03	0.04	0.06	0.02	0.02	0.08	0.03	0.01	0.04	3.18
Coenagrionidae	0.06	0.03	0.04	0.12	0.03	0.07	0.10	0.10	0.06	2.62
Agromyzidae	0.00	0.03	0.01	0.11	0.17	0.14	0.11	0.05	0.07	2.48
Acrididae	0.04	0.07	0.14	0.25	0.13	0.15	0.24	0.29	0.11	1.87
Tettigonidae	0.00	0.00	0.05	0.04	0.06	0.05	0.12	0.11	0.05	2.84
Formicidae	0.00	0.00	0.01	0.02	0.02	0.01	0.18	0.03	0.04	3.31
Vaspidae	0.02	0.01	0.01	0.01	0.02	0.05	0.08	0.04	0.04	3.34
Apidae	0.00	0.02	0.01	0.01	0.00	0.00	0.05	0.01	0.02	4.10
Coreidae	0.05	0.04	0.18	0.14	0.07	0.03	0.06	0.17	0.08	2.37
Pentatomidae	0.00	0.00	0.13	0.23	0.33	0.04	0.03	0.17	0.09	2.17
Delphacidae	0.04	0.01	0.15	0.50	0.55	0.07	0.15	0.47	0.13	1.53
Pyralidae	0.00	0.00	0.02	0.02	0.01	0.01	0.02	0.04	0.02	3.95
Oxyopidae	0.15	0.10	0.06	0.13	0.00	0.00	0.01	0.01	0.06	2.72
Araneidae	0.03	0.01	0.01	0.01	0.22	0.20	0.05	0.01	0.06	2.64
Termittidae	0.00	0.01	0.01	0.01	0.00	0.03	0.06	0.03	0.02	3.75
Mantidae	0.00	0.00	0.01	0.05	0.00	0.07	0.06	0.06	0.04	3.24
Total	0.59	0.55	1.25	1.99	1.95	1.22	1.84	1.89	1.15	53.78

* The values are mean of five sweeps at random.

Homoptera; family Delphacidae (leaf-hoppers) was recorded maximum during Sept.-Nov. in 2003 with mean total of 0.55, and was found recorded through out the season of investigation.

Lepidoptera (Moth), Family; Pyralidae was recorded maximum during Sept.-Nov. in 2004 (0.04) also Araneida (spiders) of *Oxyopes* and *Argiope spp.* recorded their maximum (0.15 and 0.22) during Sept.-Nov. season in 2002 and 2003 respectively.

Family Termitidae of Order Isoptera was recorded during Mar.-May season in 2004 (0.06) and Mantidae of Dictyoptera with 0.08 numbers during Sept.-Nov. season in 2004.

The diversity indices; (H, and D); ranged between 0.02 - 0.13; and 1.53 - 4.10 respectively which differs significantly in both the cases. From table 12, it is clear that the family Delphacidae was more diversified as compared to other families (H= 0.13) followed by Culicidae (H =0.12) and the abundance arthropod family was represented by Delphacidae (D = 1.53) and the least was represented by Apidae (D =4.10).

4.5.2. Foothill Area (Medziphema)

The Diversity of aerial arthropod fauna collected at foothill area per sweeps in maize ecosystem during September 2002 to August 2004 is shown in Table B fig.14. The aerial arthropod fauna in foothill area maize ecosystem consists of 10 orders and 22 families.

Among Orthoptera, family Gryllidae, Acrididae and Tettigonidae were recorded through out the period of investigation with their maximum catches

Table 13: Arthropod diversity in maize ecosystem of foothill area (Medziphema) through sweep net.

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-weaver diversity index (H)	Simpson-Yule Divirsity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Gryllidae	*0.01	0.06	3.16	0.13	0.02	0.13	0.13	0.12	0.09	2.24
Acrididae	0.08	0.05	0.15	0.28	0.21	0.09	0.06	0.20	0.11	1.90
Tettigonidae	0.02	0.01	0.06	0.11	0.11	0.05	0.06	0.12	0.07	2.53
Coreidae	0.00	0.00	0.00	0.03	0.02	0.01	0.01	0.04	0.02	3.92
Pentatomidae	0.00	0.00	0.00	0.14	0.04	0.02	0.01	0.13	0.05	2.94
Pyrrocoridae	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.03	0.02	4.19
Fulgoride	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.08	0.02	3.84
Delphacidae	0.35	0.27	0.18	0.17	0.27	0.28	0.19	0.15	0.14	1.46
Cicadidae	0.00	0.00	0.00	0.10	0.03	0.01	0.01	0.07	0.04	3.31
Muscidae	0.00	0.00	0.05	0.06	0.08	0.00	0.01	0.08	0.03	3.40
Culicidae	0.00	0.03	0.02	0.01	0.00	0.03	0.03	0.06	0.03	3.49
Oxyopidae	0.15	0.14	0.43	0.40	0.22	0.20	0.16	0.13	0.14	1.47
Araneidae	0.00	0.00	0.01	0.01	0.00	0.00	0.04	0.06	0.02	3.84
Pyralidae	0.00	0.00	0.02	0.03	0.11	0.07	0.01	0.04	0.04	3.10
Carabidae	0.00	0.02	0.02	0.01	0.00	0.01	0.12	0.02	0.03	3.40
Elateridae	0.00	0.01	0.01	0.01	0.01	0.02	0.05	0.01	0.02	3.84
Coenagrionidae	0.05	0.06	0.14	0.16	0.15	0.11	0.08	0.05	0.09	2.19
Agromyzidae	0.00	0.0	0.05	0.01	0.03	0.01	0.09	0.04	0.04	3.28
Blattidae	0.00	0.00	0.01	0.02	0.00	0.01	0.01	0.01	0.01	4.44
Mantidae	0.02	0.04	0.01	0.03	0.05	0.07	0.01	0.03	0.04	3.17
Vespidae	0.04	0.08	0.04	0.04	0.04	0.07	0.05	0.04	0.06	2.80
Apidae	0.00	0.00	0.03	0.01	0.00	0.00	0.08	0.04	0.03	3.59
Total	0.72	0.77	1.39	1.81	1.33	1.20	1.22	0.55	1.13	68.35

* The values are mean of five sweeps at random.

during Mar.-May season in 2003 (0.16), Sept.-Nov. season in 2003, 2004 (0.28 and 0.12) respectively.

Coreidae, Pentatomidae and Pyrrhocoridae of Order; Hemiptera were recorded their maximum during Sept.-Nov. season in 2003 and 2004 with 0.04, 0.14 and 0.03 respectively, also Order; Homoptera, with family Fulgoridae, Delphacidae and Cicadidae were recorded with maximum catches during Sept.-Nov. season in 2004 (0.08, 0.07) in case of Fulgoridae and Cicadidae and during Dec.-Feb. in 2003-04 (0.28) for Delphacidae.

Dipteran flies of family Muscidae and Culicidae were recorded with a maximum of 0.08 and 0.06 during Sept.-Nov. season in 2004 respectively. Muscidae recorded nil (0.00) during Sept.-Nov. and Dec.-Feb. season and Colicidae recorded nil (0.00) during Sept.-Nov.

Arachnida (spiders), comprised of Oxyopidae & Arancidae which were active during Mar.-May and Sept.-Nov. season were recorded maximum (0.22) during Sept.-Nov. in 2003 in case of the former family and during Sept.-Nov. (0.06) for the latter family.

Lepitopteran (moth), Family Pyralidae was recorded during Sept.-Nov. in 2003 (0.11). Carabidae and Elateridae of Orded Coleoptera were recorded with a maximum of 0.12 and 0.05 during Mar.-May season in 2004 respectively.

Odonata, family Coenagrionidae (Dragonfly) was recorded maximum during Sept.-Nov. season in 2003 (0.16) while Order; Dictyoptera was represented by Family Blattidae and Mantidae recorded in small numbers.

Vespidae and Apidae of Order; Hymenoptera was recorded during Dec.-Feb. in 2002-03 (0.08) and during Mar.-May season (0.08) in 2004.

The diversity indices; (H, and D): ranged between 0.01 - 0.14; and 1.46 - 4.44 respectively which differs signifieantly in both the cases. From table 13, it is dear that the families Delphacidae and Oxyopidae were more diverse as compared to other families (H = 0.14) and the abundance arthropod family was represented by Delphacidae (D = 1.46) and the least was represented by Blattidae (D = 4.44).

4.5.3. Uphill Area (Near Kohima)

Diversity of aerial arthropod fauna eollected at uphills area per sweeps in maize ecosystem during September 2002 to August 2004 was recorded in Table 14, fig.15. The aerial arthropod fauna in uphill area maize ecosystem consists of 8 orders and 20 families.

Coleoptera with family Chrysomellidae, Ciceinellidae, Meloidae and Coccinellidae were recorded during the period of investigation. The first two families recorded maximum during Sept.-Nov. season 0.73 and 0.37 in 2003 and 2004 respectively. Family Meloidae recorded maximum during Mar.-May season (0.42) in 2004 and Coccinellidae during Sept.-Nov. (0.23) in 2003.

Orthoptera comprises of family Acrididae, Gryllidae and Tettigonidae of which Acrididae dominate the group and maximum record of 0.65 during Sept.-Nov. season in 2004. Gryllidae recorded maximum during Sept.-Nov. season in 2003 (0.36) so as family Tettigonidae was recorded maximum during Sept.-Nov. in 2004 (0.12).

Table 14. Arthropod diversity in maize ecosystem of uphill area (Kohima) through sweep net.

Arthropod family/Season (Period)	2002 - 03				2003 - 04				Shannon-weaver diversity index (H)	Simpson-Yule diversity index (D)
	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug		
Chrysomellidae	*0.17	0.11	0.55	0.73	0.16	0.10	0.64	0.35	0.10	2.02
Cicindellidae	0.07	0.01	0.08	0.12	0.16	0.02	0.01	0.37	0.04	3.07
Meloidae	0.00	0.00	0.20	0.37	0.00	0.00	0.42	0.23	0.06	2.74
Coccinellidae	0.17	0.02	0.03	0.14	0.23	0.03	0.01	0.17	0.04	3.11
Acrididae	0.30	0.12	0.18	0.80	0.90	0.21	0.40	0.65	0.11	1.81
Gryllidae	0.40	0.06	0.09	0.27	0.36	0.19	0.17	0.28	0.08	2.40
Tettigonidae	0.07	0.01	0.08	0.30	0.03	0.01	0.05	0.12	0.04	3.27
Pentatomidae	0.33	0.01	0.04	0.20	0.20	0.02	0.06	0.18	0.05	2.88
Cecadellidae	0.13	0.02	0.03	0.20	0.00	0.00	0.08	0.21	0.04	3.27
Fulgoridae	0.03	0.01	0.05	0.12	0.06	0.01	0.05	0.12	0.03	3.61
Blatidae	0.27	0.15	0.25	0.12	0.16	0.08	0.12	0.24	0.06	2.63
Mantidae	0.23	0.03	0.01	0.08	0.16	0.02	0.01	0.05	0.03	3.38
Muscidae	0.27	0.12	0.67	0.43	0.16	0.02	0.63	0.51	0.10	2.02
Agromyzidae	0.17	0.02	0.08	0.35	0.26	0.03	0.03	0.19	0.06	2.03
Coenagrionidae	0.33	0.16	0.19	0.51	0.73	0.16	0.25	0.46	010	2.81
Forficulidae	0.13	0.07	0.15	0.07	0.20	0.05	0.09	0.21	0.05	2.94
Therlidae	0.40	0.08	0.18	0.22	0.20	0.11	0.27	0.21	0.07	2.47
Salticidae	0.20	0.03	0.14	0.24	0.20	0.02	0.14	0.07	0.05	2.88
Oxyopidae	0.10	0.01	0.08	0.27	0.33	0.04	0.09	0.32	0.06	2.73
Araneidae	0.20	0.37	0.05	0.01	0.10	0.44	0.06	0.01	0.06	2.73
Total	3.97	1.41	3.13	5.55	4.60	1.56	3.58	4.95	1.23	54.80

* The values are mean of five sweeps per sq.m. recorded seasonally at three months interval.

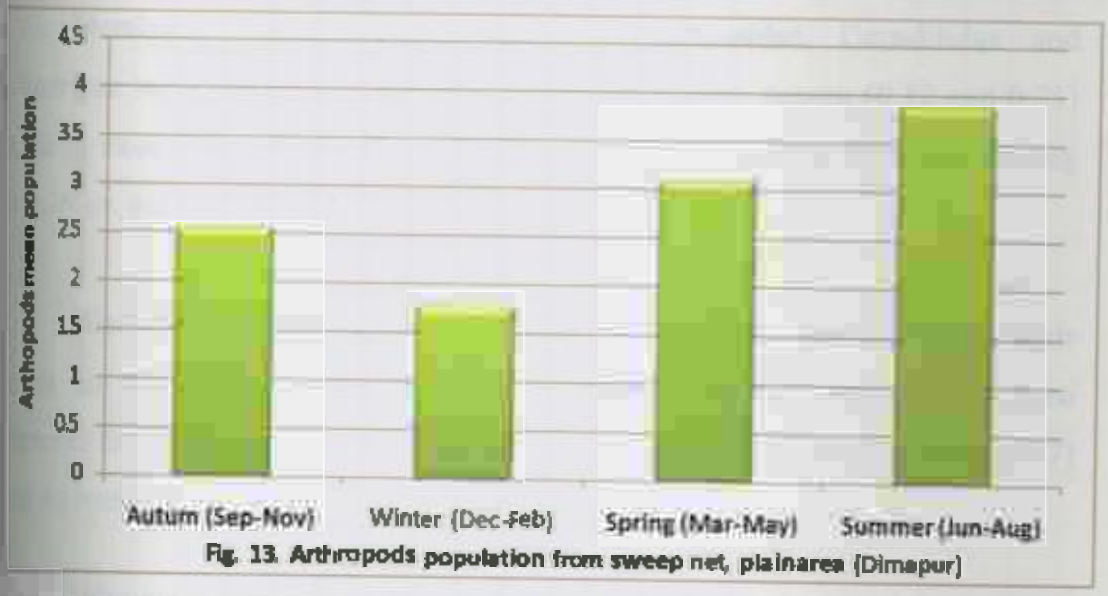

Fig. 13. Arthropods population from sweep net, plainarea (Dimapur)

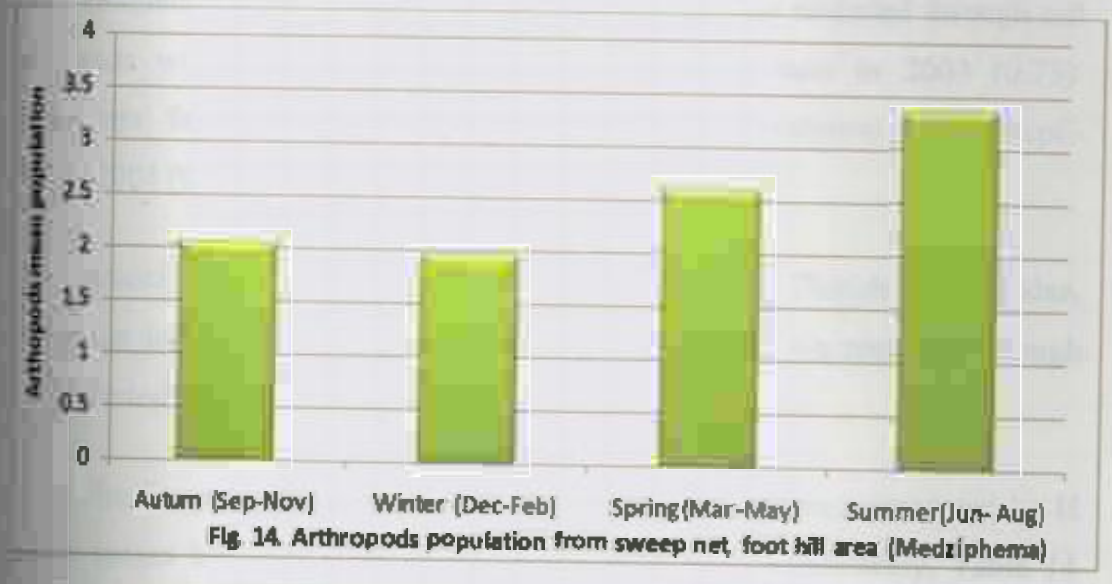

Fig. 14. Arthropods population from sweep net, foot hill area (Medziphema)

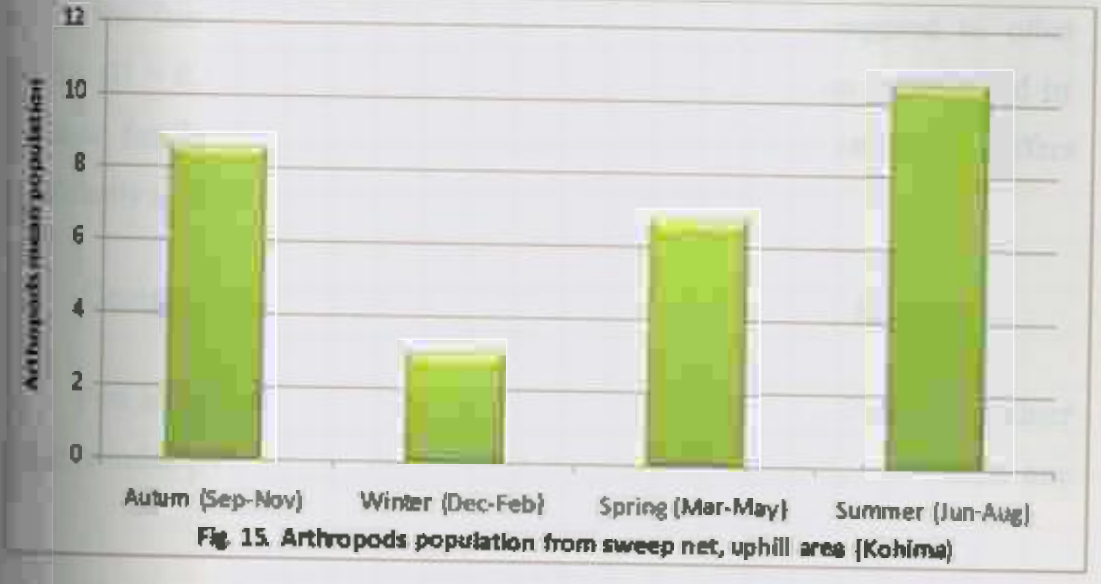

Fig. 15. Arthropods population from sweep net, uphill area (Kohima)

Hemiptera represented by family Pentatomidae, Cecadilidae and Fulgoridae were recorded maximum during Sept.-Nov. season (0.12 and 0.21) in 2004 except for family Pentatomidae which was found dominant during Sept.-Nov. season in 2002 respectively.

Blattidae and Mantidae of Order Dictyoptera was recorded their maximum during Sept.-Nov. season in 2002, 0.27 and 0.23 respectively. Also Diptera; family Muscidae recorded dominant during Mar.-May season (0.67) and Agromyzidae during Sept.-Nov. in 2003 (0.34).

Odonata, family Coenagrionidae (Dragonfly) was recorded through out the season with its maximum during Sept.-Nov. season in 2003 (0.73). Dermaptera; family; Forficulidae (earwig) recorded maximum during Sept.-Nov. in 2004 (0.21).

Araneida (spiders) of different families Viz:- Theridae, Salticidae, Oxyopidae and Araneidae represented the group which were recorded through out the period of investigation.

The diversity indices and the dominanee arthropod as represented by H and D; ranges between 0.03 - 0.11; and 1.81 – 3.61 respectively. Table 14 shows that family Aeridiidae was more diversified as compared to other families (H = 0.11) and the abundanee arthropod' family was represented by the same family (D = 1.81). The diversity indices and dominance differs significantly in both the eases.

4.6. Comperative studies of total arthropod diversity indices

Two indices were used to determine the diversity 1). Shannon-Weiner Diversily index (H) and (2). Simpson-Yule diversity index (D). The former one

Table 15. Shannon-Weiner (H) and Simpson-Yule (D) diversity indices of arthropod at three different maize ecosystems in accordance to the methods of collection during September 2002 – August 2004.

Diversity Index	Pitfall			Soil extract			Light trap			Net-sweep		
	Plain area	Foothill	Uphill	Plain area	Foothill	Uphill	Plainrarea	Foothill	Uphill	Plain area	Foothill	Uphill
(H) =	0.808	0.807	0.471	0.706	0.617	0.304	1.178	1.194	1.215	1.150	1.133	1.232
(D) =	45.575	55.586	52.331	10.390	15.791	4.603	128.068	109.596	55.420	53.783	68.347	54.805

considers both the number of species and the distribution of individuals among species (Kikkawa, 1996); where as the latef index weighed towards the abundance of the commonest species rather than providing a measure of species richness (Magurran, 1988). In order to make the arthropod communities uniform, the taxonomic groups are booked in family wise to find out the diversity index (Table 15).

4.6.1. Diversity indices of soil surface dwelling arthropod from Pitfall traps at three maize ecosystems

Diversity indices from the table shows that the arthropod diversity is higher at plain areas followed by foothill and uphill (H = 0.808, 0.807 and 0.471 respectively). Where as the abundance of commonest species from pitfall trapping method shows more in plain area followed by uphill and least in foothills (D = 45.575, 52 331 and 55.586 respectively) (Table 15).

4.6.2. Diversity indices of soil inhabiting arthropod from soil extraction at three maize ecosystems

Basing on the diversity indices, the arthropod populations are more diverse in plain area (H = 0.706) followed by foothill and uphill (H = 0.617 and 0.304) respectively. While on the other hand the species abundance D' is more in uphill (4.603) followed by plains 10.390) and the least abundance species at foothills (15.791) (Table 15).

4.6.3. Diversity indices of night active arthropod from light traps at three maize ecosystems

Based on the information figure from the table it is evident that the uphill area is more diverse as compared to foothill and plain area maize

ecosystems (H = 1.215, 1.194 and 1.176) respectively. Similarly, species abundance is also more in uphill then foothills and plains in descending order. (D= 55.420, 109.596 and 128.068) respectively (Table 15).

4.6.4. Diversity indices of aerial arthropod from net-sweeping method at three maize ecosystems

Diversity indices from the table, by net sweepings, shows that the arthropod diversity is higher at foothill areas followed by plains and uphill (H = 1.133, 1.150 and 1.232 respectively). Where as the abundance of commonest species shows more in plain area, uphill and least in foothill (D = 53.783, 54.805 and 68.347 respectively) (Table 15).

4.7. Biodiversity of common arthropod populations from three different maize ecosystems

The common arthropod populations from three different maize ecosystems are described and tabulated in Table 16 – 18. Family wise according to their orders and season during September 2002 to August 2004 are as described below:

4.7.1. Biodiversity of common seasonal arthropod populations from plain area maize ecosystem (Dimapur)

Pooled data on the mean population of dominant Arthropod groups recorded at plain area maize ecosystem and their seasonal abundance (Table 16) revealed that a mean total number of 838.35 arthropod belonging to twenty seven families under thirteen dominant orders i.e. Coleoptera, Hemiptera,

Table 16. Common mean arthropod diversity prevalent in plain area irrespective of collection method during Sept. 2002 –Aug. 2004.

Arthropod family/Season (Period)	Sep-Nov	Dec.-Feb.	Mar.-May	Jun-Aug	Total	Shannon (H)	Simpson (D)
Coleoptera							
Chrysomelidae	0.00	0.00	*0.80	1.69	2.49	0.01	5.05
Carabidae	9.37	7.36	17.71	25.35	59.79	0.08	2.29
Cerambycidae	0.38	0	0.1	0.41	0.89	0.01	5.95
Cicindelidae	1.82	0.68	6.14	7.43	15.87	0.03	3.45
Scarabaeidae	6.34	3.86	30.24	21.85	62.29	0.08	2.26
Total	17.71	11.9	54.99	56.73	141.33	0.21	19.00
Hemiptera							
Pentatomidae	1.26	0.04	3.41	4.81	9.52	0.02	3.89
Fulgoridae	0.15	0.00	0.10	1.81	2.06	0.01	5.22
Cicadidae	0.07	0.00	0.17	0.54	0.78	0.01	6.06
Total	1.48	0.04	3.68	7.16	12.36	0.03	15.17
Orthoptera							
Gryllidae	19.02	18.93	37.68	31.44	107.07	0.11	1.79
Acrididae	1.76	0.39	2.54	4.13	8.82	0.02	3.96
Tettigonidae	1.21	0.24	0.5	0.8	2.55	0.01	5.03
Gryllotalpidae	0.03	1.10	1.80	0.83	3.76	0.01	4.70
Total	22.02	20.66	42.52	37.00	122.2	0.15	15.47
Hymenoptera							
Formicidae	36.80	34.93	74.32	83.4	229.45	0.15	1.13
Diptera							
Muscidae	1.18	1.34	0.73	1.08	4.33)	0.01	4.57
Agromyzidae	0.52	6.55	2.44	2.12	11.63	0.03	3.72
Total	1.7	7.89	3.17)	3.2	15.96	0.04	8.29
Odonata							
Coenagrionidae	3.54	1.22	6.86	3.48	15.10)	0.03	3.49
Lepedoptera							
Noctuidae	1.87	0.64	4.63	2.03	9.17	0.02	3.92
Isoptera							
Termitidae	0.11	3.15	8.21	10.36	21.83	0.04	3.17
Dictyoptera							
Blatidae	0.77	0.32	1.21	2.73	5.03	0.01	4.44
Mantidae	0.0	0.07	0.25	0.35	0.69	0.00	6.17
Total	0.79	0.39	1.46	3.08	.72	0.02	10.61
Dermaptera							
Forficulidae	0.03	0.00	1.14	1.24	2.41	0.01	5.08
Arachneda							
Lycosidae	13.37	11.56	17.95	26.96	69.84	0.09	2.18
Oxyopidae	0.15	0.10	0.10	0.14	0.49	0.00	6.47
Araneidae	0.03	0.21	0.06	0.02	0.32	0.00	6.84
Total	13.55	11.87	18.11	27.12	70.65	0.09	15.46

Contd...

Arthropod family/Season (Period)	Sep-Nov	Dec.-Feb.	Mar.-May	Jun-Aug	Total	Shannon (H)	Simpson (D)
Collembola							
Entomobyridae	0.38	0.20	3.56	1.12	5.26	0.01	4.40
Poduridae	4.93	0.79	118.14	57.68	181.54	0.14	1.33
Total	5.31	0.99	121.7	58.8	186.8	0.16	5.73
Acarina							
Tetranychidae	0.65	0.54	1.39	2.79	5.37	0.01	4.39
Grand Total	**105.56**	**94.22**	**362.18**	**296.39**	**838.35**	**0.97**	**110.90**

*Mean value of two years pooled data (Sept.2002–Aug. 2004).

Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachneda, Collembola and Acarina.

Coleoptera the most dominant order comprises of Families; Chrysomelidae, Carabidae, Cerambycidae, Ciccindelidae and Searabaeidae with their mean totals of 2.49, 59.79, 0.89, 15.87 and 62.29 respectively. Overall mean population under this order was recorded 141.33 and season wise comparison records maximum 56.73 during Sept.-Nov. (Jun-Aug).

Hemiptera comprises of Families; Pentatomidae, Falgoridae and Cicadidae in which Pentatomidae was the maximum 9.52 Seasonal distribution records maximum during Sept.-Nov. 7.16. The mean totals under this order records 12.36.

Orthoptera was the next dominant group comprising four families Viz:- Gryllidae, Acrididae, Tettigonidae and Grylotalpidae. Among the families, Gryllidae was the most dominant which recorded mean total of 107.07 and the seasonal abundance records maximum during Mar.-May 42.52.

Order Hymenoptera with a single family Formicidae was the most abundant arthropod (total mean of 229.45). Seasonal distribution recorded the maximum during Sept.-Nov. 83.40.

Diptera includes family Muscidae and Agromyzidae; and are recorded a mean totals 15.96. Maximum population was recorded during Dec.-Feb. season (789). Other arthropod taxa under family Coenagrionidae, (O; Odonata); Noctuidae (O; Lepedoptera) nd Termitidae (O; Isoptera) recorded mean totals of 15.10, 9.17 and 21.83 respectively.

Order Dictyoptera comprises of two families viz: Blatidae and Mantidae which was recorded mean totals of 5.03 and 0.69 and the maximum populations was during Sept.-Nov. season

Dermaptera; Family Forficulidae records mean totals of 2.41 and Acarina; Family Tetranychidae mean totals of 5.37 maximum during Sept.-Nov. season. Arachneda comprise of families Lycosidae, Oxyopidae and Araneidae records a mean totals of 70.65, maximum during Sept.-Nov. season (mean of total of 27.12). Collembola recorded two families viz: Entomobyridae and Poduridae with mean totals of 186.80, maximum poputations during Mar.-May season (mean total 121.70).

The diversity indices and the dominance arthropod as represented by H and D ranges between 0.01 - 0.15; and 1.13 – 6.06 respectively. Table 16 shows that family Formicidae was more diversified as compared to other families (H = 0.15) and the abundance arthropod family was also represented by the same family (D = 1.13). The diversity indices and dominance differs significantly in both the cases.

4.7.2. Biodiversity of common seasonal arthropod populations from foothill maize ecosystem (Medziphema)

The pooled data of the mean population of common dominant Arthropod groups recorded from foothill maize ecosystem and their seasonal abundance (Table 17) revealed that a mean total number of 297.85 arthropod belonging to twenty seven families under thirteen dominant orders i.e. Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachneda, Collembola and Acarina.

Table 17. Common mean arthropod diversity prevalent in foothill area irrespective of collection method during Sept. 2002 – Aug. 2004.

Arthropod family/Season (Period)	Sep-Nov	Dec.-Feb.	Mar.-May	Sept.-Nov.	Total	Shannon (H)	Simpson (D)
Coleoptera							
Carabidae	3.75	4.27	10.74	8.65	27.41	0.10	2.07
Chrysomelidae	0.23	000	0.43	0.37	1.03	0.01	4.92
Scarabaeidae	6.98	10.51	27.78	27.48	72.75	0.15	1.22
Cicindelidae	1.19	1.17	0.77	0.42	3.55	0.02	3.85
Cerambyidae	0.25	2.52	0.38	0.55	3.7	0.30	5.88
Total	12.4	18.47	40.1	37.47	108.44	0.16	0.88
Hemiptera							
Pentatomidae	1.93	0.27	0.34	3.28	5.82	0.03	3.42
Fulgoridae	0.23	1.05	0.10	0.32	1.70	0.01	4.49
Cicadidae	1.58	0.01	0.34)	1.31	3.24	0.02	3.99
Total	3.74	1.33	0.78	4.91	10.76	0.07	11.83
Orthoptera							
Gryllidae	3.62	3.26	11.48	6.1	24.46	0.09	2.17
Gryllotalpidae	0.15	0.37	0.75	0.24	1.51	0.01	4.59
Acrididae	1.35	1.77	2.63	3.28	9.03	0.05	3.04
Tettigondae	1.95	0.64	0.60	0.90	4.09	0.03	3.72
Total	7.07	6.04	15.46	10.52	39.09	0.17	13.52
Hymenoptera							
Formicidae	11.9	10.58	14.97	23.91	61.36	0.14	1.37
Diptera							
Muscidae	0.33	009	0.73	0.50	1.65	0.01	4.51
Agromyzidae	1.10	0.28	0.23	0.07	1.68	0.01	4.50
Total	1.43	0.37	0.96	0.57	3.33	0.03	9.01
Odonata							
Coenagrionidae	2.87	2.33	1.27	2.21	8.68	0.04	3.07
Lepidoptera							
Noctuidae	2.02	0.23	1.15	1.02	4.42	0.03	3.66
Isoptera							
Termittidae	2.58	1.40	8.08	2.38	14.44	0.06	2.63
Dictyoptera							
Blattidae	1.98	0.36	0.60	1.47	4.41	0.03	3.66
Mantidae	0.37	0.31	0.09	0.80	1.57	0.01	4.56
Total	2.35	0.67	0.69	2.27	5.98	0.04	8.22
Dermaptera							
Forficulidae	0.00	0.00	0.21	0.20	0.41	0.01	5.72
Arachneda							
Lycosidae	2.32	2.21	6.29	4.47	15.29	0.07	2.58
Oxyopidae	0.37	0.34	0.59	0.53	1.83	0.01	4.42
Araneidae	0	0	0.04	0.07	0.11	0.00	6.87
Total	2.69	2.55	6.92	5.07	17.23	0.08	13.87

Contd ...

Arthropod family/Season (Period)	Sep-Nov	Dec.-Feb.	Mar.-May	Sept.-Nov.	Total	Shannon (H)	Simpson (D)
Collembola							
Poduridae	1.62	4.28	5.33	5.16	16.39	0.07	2.52
Entomobyridae	0.21	0.17	2.26	2.39	5.03	0.03	3.54
Total	1.83	4.45	7.59	7.55	21.42	0.10	6.06
Acarina							
Tetranychidae	0.75	0.39	0.55	0.6	2.29	0.02	4.23
Grand Total	**51.63**	**48.81**	**98.73**	**98.68**	**297.85**	**1.08**	**99.07**

*Mean value of two years pooled data (Sept. 2002–Aug. 2004).

Coleoptera the most dominant order comprises of Families; Chrysomelidae, Carabidae, Cerambycidae, Ciccindelidae and Scarabaeidae with their mean totals of 27.41, 1.03, 72.75, 3.55, and 3.70 respectively. Overall mean population under this order was recorded 108.44, seasonal wise comparison records maximum 40.10 during Mar.-May (March-May).

Hemiptera comprises of Families; Pentatomidae, Falgoridae and Cicadidae ia which Pentatomidae was the maximum 5.82; Seasonal population records maximum during Sept.-Nov. 4.90. The mean totals under this order recorded 10.76.

Orthoptera was the next dominant group comprising four families Viz:- Gryllidae, Acrididae, Tettigonidae and Grylotalpidae. Among the families, Gryllidae was the most dominant which recorded mean total of 24. and the seasonal abundance records maximum population during Mar.-May season as mean totals of 15.46.

Order Hymenoptera with a single family Formicidae was the most abundant arthropod (total mean of 61.36).

Diptera ineludes family Muscidae and Agromyzidae; and are recorded a mean totals 3.33, maximum population was recorded during Sept.-Nov. season 1.43;. Other arthropod taxa under family Coenagrionidae, (O; Odonata); Noctuidae (O; Lepedoptera) nd Termitidae (O; Isoptera) recorded mean totals of 8.68. 4.42 and 14.44 respectively. The seasonal abundance of those families recorded during Sept.-Nov. season for the former two families and the later ones' during Mar.-May season as 2.87, 2.02 and 8.08 respectively.

Order Dictyoptera comprises of two families viz: Blatidae and Mantidae which was recorded mean totals of 4.41 and 1.57 and the maximum populations during Sept.-Nov. season and over all mean total of 5.98.

Dermaptera; Family Forficulidae records mean totals of 0.41 and Acarina; Family Tetranychidae mean totals of 2.29, maximum during Mar.-May and Sept.-Nov. season.

Arachneda comprise of families Lycosidae, Oxyopidae and Arancidae records a mean total of 17., maximum during Mar.-May season (mean total of 4.92. Collembola records two families viz: Entomobyridae and Poduridae with mean totals of 21.42 maximum populations during Mar.-May season (mean total 7.59).

The diversity indices; (H, and D): ranged between 0.02 - 0.30; and 1.22 - 6.87 respectively which differs significantly in both the cases. From table 17, it is clear that the family Cerambycidae was more diversified as compared to other families (H = 0.30) followed by Scarabaeidae (H = 0.15) and the abundance was represented by the same family (D = 1.22) and the least abundance was represented by Araneidae (D = 6.87).

4.7.3. Biodiversity of common seasonal afthropod populations from uphill maize eeosystem (Kohima)

Pooled data on the mean population of common and dominant Arthropod groups recorded from uphill maize ecosystem and their seasonal abundance (Table 18) shows that a total number of 297.35 different arthropod belonging to twenty seven families under thirteen dominant orders i.e. Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata,

Table 18. Common mean arthropod diversity prevalent in uphill area irrespective of collection method during Sept. 2002 – Aug. 2004.

Arthropod family/Season (Period)	Sept.-Nov.	Dec.-Feb.	Mar.-May	Sept.-Nov.	Total	Shannon (H)	Simpson (D)
Coleoptera							
Carabidae	2.24	1.16	1.47	3.37	8.24	0.04	3.11
Scarabaeidae	0.19	0.06	0.31	0.50	1.06	0.01	4.90
Cerambycidae	0.19	0.00	0.22	0.17	0.58	0.01	5.42
Cicindellidae	0.31	0.09	0.28	0.67	1.35	0.01	4.69
Chrysomelidae	0.58	0.21	1.69	1.42	3.9	0.02	3.78
Total	3.51	1.52	3.97	6.13	15.13	0.09	21.88
Hemiptera							
Pentatomidae	0.83	0.15	0.38	0.59	1.95	0.01	4.37
Fulgoridae	0.09	0.02	0.1	0.24	0.45	0.00	5.64
Cicadidae	0.38	0.06	0.21	0.73	1.38	0.01	4.67
Total	1.3	0.23	0.69	1.56	3.78	0.03	14.67
Orthoptera							
Acrididae	1.29	0.37	0.75	2.55	4.96	0.03	3.56
Tettigoniidae	0.37	0.04	0.15	0.72	1.28	0.01	4.73
Gryllidae	1.66	0.41	0.9	3.27	6.24	0.04	3.36
Gryllotalpidae	0.00	0.02	0.18	0.00	0.2	0.00	6.34
Total	3.32	0.84	1.98	6.54	12.68	0.08	17.99
Hymenoptera							
Formicidae	13.13	8.23	16.68	26.86	64.9	0.14	1.32
Diptera							
Muscidae	0.86	0.5	2.41	2.01	5.78	0.03	3.42
Agromyzidae	0.42	0.05	0.11	0.54	1.12	0.01	4.85
Total	1.28	0.55	2.52	2.55	6.9	0.04	8.27
Odonata							
Coenagrionidae	1.48	0.49	0.71	1.51	4.19	0.03	3.70
Lepidoptera							
Noctuidae	0.45	0.22	0.96	0.38	2.01	0.01	4.34
Isoptera							
Termitidae	0.00	0.00	1.00	0.72	1.72	0.01	4.48
Dictyoptera							
Blattidae	1.08	3.24	0.85	1.55	6.72	0.04	3.29
Mantidae	0.51	0.05	0.21	0.24	1.01	0.01	4.94
Total	1.59	3.29	1.06	1.79	7.73	0.05	8.23
Dermaptera							
Forficulidae	0.93	0.36	0.94	0.63	2.86	0.02	4.03
Arachneda							
Lycosidae	0.72	0.86	1.39	2.25	5.22	0.03	3.51
Oxyopidae	0.43	0.05	0.17	0.59	1.24	0.01	4.76
Araneidae	1.15	0.91	1.56	2.84	6.46	0.04	3.33
Total	2.3	1.82	3.12	5.68	12.92	0.08	11.60

Contd...

Arthropod family/Season (Period)	Sept.-Nov.	Dec.-Feb.	Mar.-May	Sept.-Nov.	Total	Shannon (H)	Simpson (D)
Collembola							
Poduridae	0.81	0.14	4.51	10.16	15.62	0.07	2.56
Entomobyridae	14.36	8.44	58.53	59.42	140.75	0.15	0.65
Total	15.17	8.58	63.04	69.58	156.37	0.22	3.21
Acarina							
Tetranychidae	1.02	0.43	2.05	2.66	6.16	0.03	3.37
Grand Total	**45.48**	**26.56**	**98.72**	**126.59**	**297.35**	**0.83**	**107.10**

*Mean value of two years pooled data (Sept. 2002–Aug. 2004).

Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachnida, Collembola and Acarina.

Coleoptera the most dominant order comprises of Families; Chrysomelidae, Carabidae, Cerambycidae, Ciccindelidae and Scarabaeidae with their mean totals of 8.24, 1.06, 0.58, 1.35 and 3.90 respectively. Overall mean population under this order was recorded 15.13, season wise comparison records maximum 6.13 during Sept.-Nov. (June -August).

Hemiptera comprises of Families; Pentatomidae, Falgoridae and Cicadidae of which Pentatomidae dominate the groups was the maximum 9.52. Seasonal distribution records maximum during Sept.-Nov. 1.95. The mean totals under this order records 3.78.

Order; Orthoptera was the next dominant group comprising of four families Viz:- Gryllidae, Acrididae, Tettigonidae and Grylotalpidae. Among the families, Gryllidae was the most dominant group which records a mean total of 6.24 and the seasonal abundance records maximum during Sept.-Nov. (6.54).

Order Hymenoptera with a single family Formicidae was the most abundant and dominant arthropod (total mean of 64). Seasonal distribution recorded the most during Sept.-Nov. 26.

Diptera includes family Muscidae and Agromyzidae; and are recorded a mean totals 6.90. Maximum population was recorded during Sept.-Nov. season (2.55). Other arthropod taxa under family Coenagrionidae, (O; Odonata); Noctuidae (O; Lepedoptera) nd Termitidae (O; Isoptera) recorded mean totals of 4.19), 2.01 and 6.16 respectively. The seasonal abundance of those families

recorded during Mar.-May season for the Noctuidae (0.96) and during Sept.-Nov. season for Coenagrionidae and Termittidae records 1.51 and 1.72 respectively.

Order Dictyoptera comprises of two families viz: Blatidae and Mantidae which were recorded their mean totals of 6.72 and 1.01 and the maximum populations during Dec.-Feb. season (Blattidae and (Mantidae) during Sept.-Nov. season. Dermaptera; Family Forficulidae records mean totals of 2.86 and Acarina; Family Tetranychidae mean totals of 6.16, maximum during Sept.-Nov. season occupying 2.66 and Tetranychidae 0.94.

Arachneda comprise of families Lycosidae, Oxyopidae and Araneidae records a mean totals of 5.22, 1.24 and 6.46 maximum during Sept.-Nov. season (mean total of 5.68). Collembola records two families viz: Entomobyridae and Poduridae with mean totals of 156.37 maximum populations during Sept.-Nov. season (mean total 69.580).

The diversity indiees; (H, and D): ranged between 0.02 - 0.15; and 0.65 -6.34 respectively which differs significantly in both the cases. From table 18, it is clear that the family Entomobyridae was more diversified as compared to other families (H = 0.15) followed by Formicidae (H = 0.14) and the abundance arthropod family was represented by Entomobyridae (D = 0.65) and the least was represented by Grylotalpidae (D= 6.34).

4.8. Comperative studies of common arthropod diversity indices

Shannon-Weiner Diversity index (H) and Simpson-Yule diversity index (D) these two indices was used to determine the diversity of common arthropod in maize ecosystem at three different locations. The diversity indices

of common seasonal and dominant arthropod orders from three different maize ecosystems are described and tabulated in Table 19 – 21 and Fig. 16. There are altogether 13 common arthropod orders recorded viz:- Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachneda, Collembola and Acarina. Arthropod orders according to their season and months during September 2002 to August 2004 are as described below:

4.8.1. Biodiversity indiees of common arthropod orders from plain area maize ecosystem (Dimapur)

There are altogether 13 arthropod orders commonly found at plain area maize ecosystem (Table 19). The arthropod orders are booked and shown in the table as four season and further analysed. The table shows that the grand mean total of838.35; and (H) and (D) values as 0.97 and 110.90 respectively.

The diversity indices of arthropod as represented by H: ranges between 0.01 - 0.15; and the dominance between 1.13 and 6.06. Family Formicidae represent the most diversified and the dominance characters. (H = 0.15); (D =1.13), followed by Poduridae (H = 0.14; D = 1.33) respectively. The dominance indices D' was also the highest for family Formicidae

4.8.2. Biodiversity indices of common dominance arthropod orders from foothill maize field ecosystem (Medziphema)

There are altogether 13 arthropod orders commonly found at plain area maize ecosystem (Table 19). The arthropod orders are booked and shown in the table as four seasons and further analysed. The table shows that the grand mean total of 297.85; and (H) and (D) values as 1.08 and 99.07 respeetively

Table 19. Diversity indices of common dominant arthropod orders from three locations in maize field.

Arthropod order	Plain area maize field		Foothill maize field		Uphill maize field	
	(H)	(D)	(H)	(D)	(H)	(D)
Coleoptera	0.21	19.00	0.16	0.88	0.09	21.88
Hemiptera	0.03	15.17	0.07	11.83	0.03	14.67
Orthoptera	0.15	15.47	0.17	13.52	0.08	17.99
Hymenoptera	0.15	1.13	0.14	1.37	0.14	1.32
Diptera	0.04	8.29	0.03	9.01	0.04	8.27
Odonata	0.03	3.49	0.04	3.07	0.03	3.70
Lepidoptera	0.02	3.92	0.03	3.66	0.01	4.34
Isoptera	0.04	3.19	0.06	2.63	0.01	4.48
Dictyoptera	0.02	10.61	0.04	8.22	0.05	8.23
Dermaptera	0.01	5.08	0.01	5.72	0.02	4.03
Arachneda	0.09	15.46	0.08	13.87	0.08	11.60
Collembol0	0.16	5.73	0.10	6.06	0.22	3.21
Acarina	0.01	4.39	0.02	4.23	0.03	3.37
Total	0.97	110.90	1.08	99.07	0.83	107.10

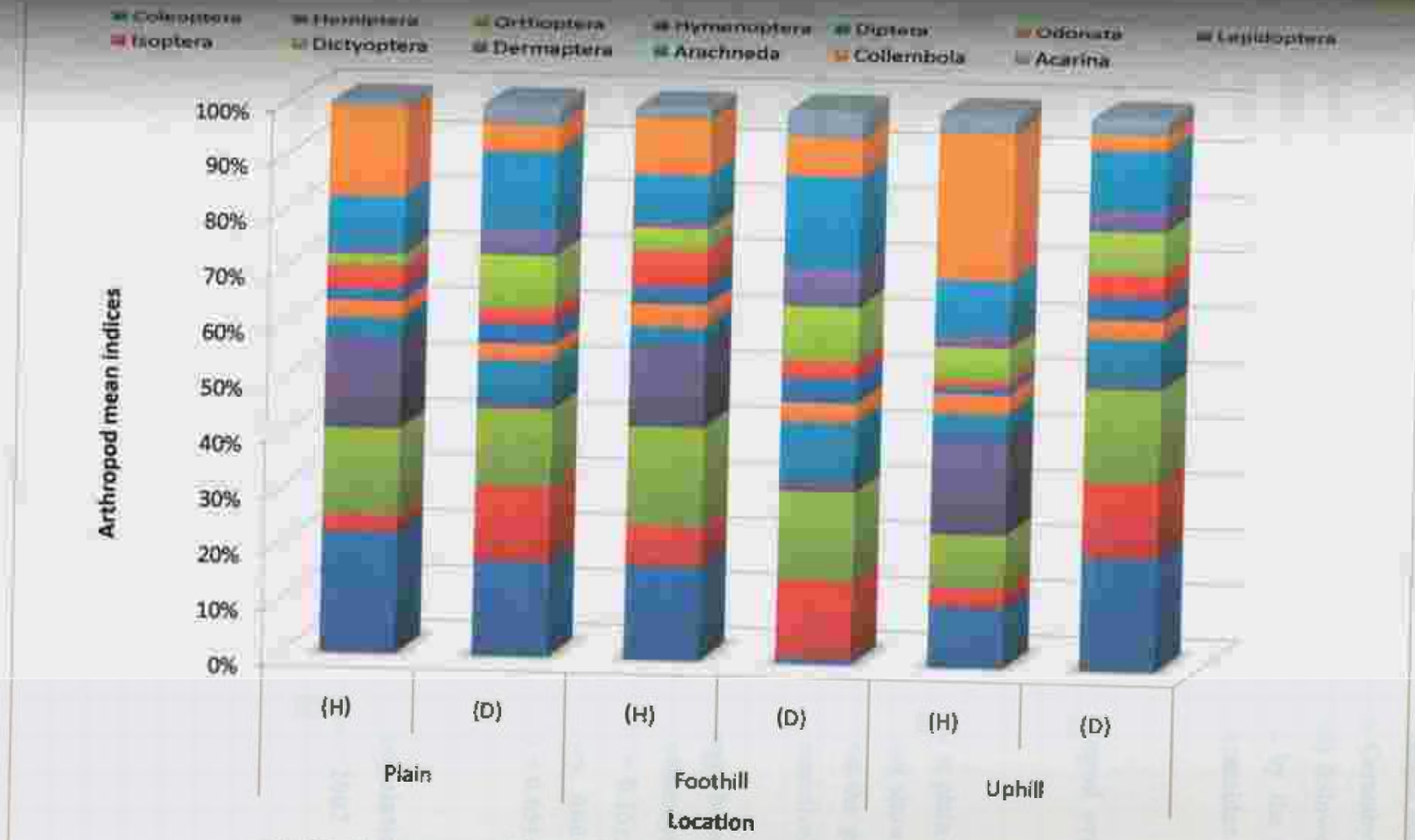

Fig. 16. Common arthropod diversity indices from three locations

The diversity indices of arthropod as represented by H: ranges between 0.02 - 0.30; and the dominance between 1.22 and 6.87. Family Cerambycidae was more diversified as compared to other families (H = 0.30) followed by Scarabaeidae (H = 0.15) and the abundance was represented by the same family (D = 1.22) and the least abundance was represented by Araneidae (D = 6.87).

4.8.3. Biodiversity indices of common dominance arthropod orders from uphill maize field ecosystem (Kohima)

There are altogether 13 arthropod orders commonly found at plain area maize ecosystem (Table 19). The arthropod orders are booked and shown in the table as four season and further analyses. The table shows that the grand mean total of 297.35; and (H) and (D) values as 0.83 and 107.10 respectively

The diversity indices of arthropod as represented by H: ranges between 0.02 - 0.15; and the dominance between 0.65 and 6.34. Family Entomobyidae represent the most diversified and the dominance characters. (H = 0.15); (D =0.65), followed by Formicidae (H = 0.14; D = 1.32) respectively. And the abundance arthropod family was represented by Entomobyridae (D = 0.65) and the least was represented by Grylotalpidae (D = 6.34).

4.9. Biodiversity indices of un-common arthropod populations at three different locations during September 2002 to August 2004.

Uncommon arthropod recorded from the three different locations are shown in the Table 20 and Fig. 18. The arthropod families that recorded

Table 20. Biodiversity indices of seasonal un-commoo arthropod populations at three different locations during September 2002 to August 2004.

Arthropod family/ Season (Period)	Sept.-Nov.	Dec.-Feb.	Mar.-May	Sept.-Nov.	Total	Shannon (H)	Simpson (D)
Plain area maize field							
Hydrophillidae	0.99	32.75	38.66	8.82	76.16	0.06	0.14
Agronidae	2.19	0.03	0.65	0.11	1.54	0.03	3.53
Pieridae	097	0.11	1.33	1.37	3.52	0.06	2.81
Total	**4.15**	**32.89**	**40.64**	**10.3**	**81.22**	**0.15**	**6.48**
Foothill maize field							
Curculiniodae	1.05	0	0.64	0	1.69	0.04	3.31
Pyrocoridae	0.02	0.01	0.01	0.04	0.08	0.01	6.10
Nymphelidae	1.12	002	0	0.07	1.21	0.03	3.60
Total	**2.19**	**0.03**	**0.65**	**0.11**	**2.98**	**0.07**	**3.00**
Uphill maize field							
Meloertae	0	0	0.54	067	1.21	0.04	3.15
Ionnemoididae	0.4	0.02	0.44	0.18	1.04	0.02	3.87
Saltcidae	0.57	0.09	0.35	0.52	1.53	0.03	3.54
Total	0.97	0.11	1.33	1.37	3.78	0.09	0.55
Grand Total	**11.84**	**41.16**	**118.80**	**33.62**	**205.42**	**0.31**	**30.04**

* Figures are mean pooled data from two years at three months intervals.

against each fields are the ones which are from that particular field only. The grand total mean of these arthropod records 205.42, and the season wise from al the fields as 11.84, 41.16, 118.80 and 33.62 during Sept.-Nov. (Sept. – Nov.), Dec.-Feb. (Dec. – Feb.), Mar.-May (Mar. – May) and Sept.-Nov. (Jun. – Aug.) respectively.

It has been recorded that in plain area maize ecosystem, the families like Hydrophillidae, Agrionidae and Pieridae were found dominant with their totals of 76.16, 1.54 and 3.52 respectively. The diversity indices (H) and (D) shows mean totals of 0.15 and 6.48 respectively.

Similarly, from foothills maize ecosystem, families Curculiniodae, Pyrrocoridae and Nymphelidae were recorded with their grand mean totals of 298 only. Season wise mean totals as 2.19, 0.03, 0.65 and 0.11 during Sept.-Nov., Dec.-Feb., Mar.-May and Sept.-Nov. respectively. The diversity indices shows means of (H = 0.07 and D = 13.00).

From uphill maize ecosystem, family wise arthropod as Meloedae, Ichnemojidae and Salticidae are recorded seasonally with their mean totals of 097, 0.11 and 1.33; and their indices H = 0.09 and D = 10.55 respectively.

4.9.1. Comparative study of uncommon arthropod diversity indices

The comparative studies on uncommon arthropod diversities indices from Table 20 and Fig. 18 reveals that the indices lies between (H = 0.01 - 0.06) and (D = 0.14 – 6.10). From plains the diversity indices (H) and (D) shows mean totals of 0.15 and 6.48 respectively, similarly from foothill maize field the diversity indices shows means of (H = 0.07 and D = 13.00) and from uphill it was shown H = 0.09 and D = 10.55 diversity indices.

Table 20

Seasonal mean population on uncommon arthropod orders from Fig.18 reveals that in plain area maize field mean of (40.64) maximum arthropod populations was recorded during Mar.-May season, where as from foothills maximum arthropod population of 2.19 during Sept.-Nov. season so as from uphill maize field the maximum arthropod population was 1.37 during Sept.-Nov. season.

The location wise total means population at plains (81.22), foothills (2.98) and uphills 3.78 respectively. Overall mean totals was recorded as 11.84, 41.16, 118.80 and 33.62 during Sept.-Nov., Dec.-Feb., Mar.-May and Sept.-Nov. respectively.

4.10. Seasonal relative abundance of common dominant arthropod population (%) from three different maize ecosystems

The common arthropod populations and their relative abundance from three different maize ecosystems are described and tabulated in Table 21 – 23 and Fig. 18. Family wise according to their orders and season during September 2002 to August 2004 are as described below:

4.8.1. Seasonal relative abundance of common arthropod population (%) from plain area maize ecosystem (Dimapur)

Pooled data on the mean population of dominant Arthropod groups recorded at plain area maize ecosystem and their seasonal abundance (Table 21) revealed that a mean total number of 838.35 arthropod belonging to twenty seven families under thirteen dominant orders i.e. Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachneda, Collembola and Acarina.

Table 21. Relative abundance of common seasonal arthropod populations (%) from plain area maize field during 2002 - 2004.

Arthropod family/ Season (Period)	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Total
Coleoptera					
Chrysomelidae	0 (0.00)	0 (0.00)	*0.6 (0.10)	1.69 (0.20)	**2.49 (0.30)**
Carabidae	9.37 (1.12)	7.36 (0.88)	17.71 (2.11)	25.35 (3.02)	**59.79 (7.13)**
Cerambycidae	0.38 (0.05)	0 (0.00)	0.1 (0.01)	0.41 (0.05)	**0.89 (0.12)**
Cicindelidae	1.62 (0.19)	0.68 (0.08)	6.14 (0.73)	7.43 (0.89)	**15.87 (1.89)**
Scarabaeidae	6.34 (0.76	3.86 (0.46)	30.24 (3.61)	21.85 (2.61)	**62.29 (7.43)**
Total	**17.71 (2.11)**	**11.9 (1.42)**	**54.99 (6.56)**	**56.73 (6.77)**	**141.33 (16.86)**
Hemiptera					
Pentatomidae	1.26 (0.15)	0.04 (0.01)	3.41 (0.41)	4.81 (0.57)	**9.52 (1.14)**
Fulgoridae	0.15 (0.02)	0 (0.00)	0.1 (0.00)	1.81 (0.22)	**2.06 (0.25)**
Cicadidae	0.07 (0.01)	0 (0.00)	0.17 (0.02)	0.54 (0.06)	**0.78 (0.09)**
Total	**1.48 (0.18)**	**0.04 (0.01)**	**3.68 (0.44)**	**7.16 (0.85)**	**12.36 (1.47)**
Orthoptera					
Gryllidae	19.02 (2.27)	18.93 (2.26)	37.68 (4.50)	31.44 (3.75)	**107.07 (12.77)**
Acrididae	1.78 (0.21)	0.39 (0.05)	2.54 (0.30)	4.13 (0.49)	**8.82 (1.05)**
Tettigonidae	1.21 (0.14)	0.24 (0.03)	0.5 (0.06)	0.6 (0.07)	**2.55 (0.30)**
Gryllotalpidae	0.03 (0.00)	1.1 (0.13)	1.8 (0.22)	0.83 (0.10)	**3.76 (0.45)**
Total	**22.02 (2.63)**	**20.66 (2.46)**	**42.52 (5.07)**	**37 (0.04)**	**122.2 (1.46)**
Hymenoptera					
Formicidae	36.6 (0.44)	34.93 (4.17)	74.32 (8.87)	83.4 (9.95)	**229.45 (27.37)**
Diptera					
Muscidae	1.18 (0.14)	1.34 (0.16)	0.73 (0.09)	1.08 (0.13)	**4.33 (0.52)**
Agromyzidae	0.52 (0.06)	6.55 (0.78)	2.44 (0.29)	2.12 (0.25)	**11.63 (1.39)**
Total	**1.7 (0.42)**	**7.89 (0.94)**	**3.17 (0.38)**	**3.2 (0.38)**	**15.96 (1.90)**

Contd .....

Arthropod family/ Season (Period)	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Total
Odonata					
Coenagrionidae	3.54 (0.42)	1.22 (0.15)	6.86 (0.82)	3.48 (0.42)	**15.1 (1.80)**
Lepedoptera					
Noctuidae	1.87 (0.22)	0.64 (0.08)	4.63 (0.55)	2.03 (0.24)	**9.17 (1.09)**
Isoptera					
Termitidae	0.11 (0.01)	3.15 (0.38)	8.21 (0.98)	10.36 (1.24)	**21.83 (2.60)**
Dictyoptera					
Blatidae	0.77 (0.09)	0.32 (0.04)	1.21 (0.14)	2.73 (0.33)	**5.03 (0.60)**
Mantidae	0.02 (0.00)	0.07 (0.01)	0.25 (0.03)	0.35 (0.04)	**0.69 (0.08)**
Total	**0.79 (0.09)**	**0.39 (0.05)**	**1.46 (0.17)**	**3.08 (0.07)**	**5.72 (0.68)**
Dermaptera					
Forficulidae	0.03 (0.00)	0 (0.00)	1.14 (0.14)	1.24 (0.15)	**2.41 (0.29)**
Arachneda					
Lycosidae	13.37 (1.60)	11.56 1.38)	17.95 (2.14)	26.96 (3.22)	**69.84 (8.33)**
Oxyopidae	0.15 (0.02)	0.1 (0.00)	0.1 (0.00)	0.14 (0.02)	**0.49 (0.06)**
Araneidae	0.03 (0.00)	0.21 (0.03)	0.06 (0.01)	0.02 (0.00)	**0.32 (0.04)**
Total	**13.55 (1.62)**	**11.87 (1.42)**	**18.11 (2.16)**	**27.12 (3.24)**	**70.65 (8.43)**
Collombola					
Entomobyridae	0.38 (0.05)	0.2 (0.00)	3.56 (0.43)	1.12 (0.13)	**5.26 (0.63)**
Poduridae	4.93 (0.59)	0.79 (0.09)	118.14 (14.09)	57.68 (6.88)	**181.54 (21.65)**
Total	**5.31 (0.63)**	**0.99 (0.12)**	**121.7 (14.52)**	**58.8 (7.01)**	**186.8 (22.280**
Acarina					
Tetranychidae	0.65 (0.08)	0.54 (0.06)	1.39 (0.17)	2.79 (0.33)	**5.37 (0.64)**
Grand Total	**105.56 (12.59)**	**94.22 11.24)**	**362.18 (40.82)**	**296.39 (35.35)**	**838.35 (100)**

*Mean value of two years pooled data (Sept. 2002–Aug. 2004).
figures in parenthesis are percentage mean relative abundance.

Coleoptera the most dominant order comprises of Families; Chrysomelidae, Carabidae, Cerambycidae, Ciccindelidae and Scarabaeidae with their mean totals of 2.49, 59.79, 0.89, 15.87 and 62.29 respectively. Overall mean population under this order was recorded 141.33 which account to 16.86%. Seasonal wise comparison records maximum 54.99 (6.56%) during Mar.-May (March-May) season.

Hemiptera comprises of Families; Pentatomidae, Falgoridae and Cicadidae in which Pentatomidae was the maximum 9.52 1.14%) Seasonal distribution records maximum during Sept.-Nov. 7.16 (0.85%). The mean totals under this order records 12.36 1.47%)

Orthoptera was the next dominant group comprising four families Viz:- Gryllidae, Acrididae, Tettigonidae and Grylotalpidae. Among the families, Gryllidae was the most dominant which recorded mean total of 107.07 12.77%) and the seasonal abundance records maximum during Mar.-May 42.52 (5.07%).

Order Hymenoptera with a single family Formicidae was the most abundant arthropod (total mean of 229.45 no. covering 27.37% of the totals). Seasonal distribution recorded the most during Sept.-Nov. 83.40 (9.95%)

Diptera includes family Muscidae and Agromyzidae; and are recorded a mean totals 15.96 1.90%). Maximum population was recorded during Dec.-Feb. season (7.89; 0.94%). Other arthropod taxa under family Coenagrionidae, (O; Odonata); Noctuidae (O; Lepedoptera) nd Termitidae (O; Isoptera) recorded mean totals of 15.10, 9.17 and 21.83 respectively. The seasonal abundance of those families recorded during Mar.-May season for the former two families and the later ones' during Sept.-Nov. season as 6.86, 4.63 and

10.36 with their percentage populations as 0.82%, 0.55% and 1.24% respectively.

Order Dictyoptera comprises of two families viz: Blatidae and Mantidae which was recorded mean totals of 5.03 and 0.69 and the maximum populations during Sept.-Nov. season occupying 0.33% and 0.04% respectively.

Dermaptera; Family Forficulidae records mean totals of 2.41 as 029% and Acarina; Family Tetranychidae mean totals of 5.37 as 0.64%; maximum during Sept.-Nov. season occupying 0.15% and 0.33% respectively.

Arachneda comprise of families Lycosidae, Oxyopidae and Araneidae records a mean totals of 70.65 (8.43%), maximum during Sept.-Nov. season (mean of total of 27.12 (3.24%). Collembola records two families viz: Entomobyridae and Poduridae with mean totals of 186.80 (22.28%); maximum populations during Mar.-May season (mean total 121.70 as 14.52%).

4.10.2 Seasonal relative abundance of common arthropod populations (%) from foothill maize ecosystem (Medzipbema)

The pooled data on the mean population of common dominant Arthropod groups recorded from foothill maize ecosystem and their seasonal abundance (Table 22) revealed that a mean total number of297.85 arthropod belonging to twenty seven families under thirteen dominant orders i.e. Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachneda, Collembola and Acarina.

Table22. **Relative abundance of common seasonal arthropod population (%) from foothill area maize field during 2002 - 2004.**

Arthropod family/ Season (Period)	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Total
Coleoptera					
Carabidae	*3.75 (1.26)	4.27 (1.43)	10.74 (3.16)	8.65 (2.90)	27.41 (9.20)
Chrysomelidae	0.23 (0.08)	0 (0.00)	0.43 (0.14)	0.37 (0.12)	1.03 (0.35)
Scarabaiedae	6.98 (2.34)	10.51 (3.53)	27.78 (9.33)	27.48 (9.23)	72.75 (24.43)
Cicindelidae	1.19 (0.40)	1.17 (0.39)	0.77 (0.26)	0.42 (0.14)	3.55 (1.19)
Cerambycidae	0.25 (0.08)	2.52 (0.85)	0.38 (0.13)	0.55 (0.19)	3.7 1.24)
Total	**12.4 (4.16)**	**18.47 (6.20)**	**40.1 (13.46)**	**37.47 (12.58)**	**108.44 (36.41)**
Hemiptera					
Pentatomidae	1.93 (0.65)	0.27 (0.09)	0.34 (0.11)	3.28 (1.10)	5.82 (1.95)
Fulgoridae	0.23 (0.08)	1.05 (0.35)	0.1 (0.00)	0.32 (0.11)	1.7 (0.57)
Cicadidae	1.58 (0.53)	0.01 (0.00)	0.34 (0.11)	1.31 (0.44)	3.24 (1.09)
Total	**3.74 (1.26)**	**1.33 (0.45)**	**0.78 (0.26)**	**4.91 (1.65)**	**10.76 (3.61)**
Orthoptera					
Gryllidae	3.62 (1.22)	3.26 (1.10)	11.48 (3.85)	6.1 (2.05)	24.46 (8.21)
Gryllotalpidae	0.15 (0.05)	0.37 (0.12)	0.75 (0.25)	0.24 (0.08)	1.51 (0.51)
Acrididae	1.35 (0.45)	1.77 (0.59)	2.63 (0.88)	3.28 (1.10)	9.03 (3.03)
Tettigoridae	1.95 (0.76)	0.64 (0.22)	0.6 (0.20)	0.9 (0.30)	4.09 (1.37)
Total	**7.07 (2.37)**	**6.04 (2.03)**	**15.46 (5.19)**	**10.52 (3.53**	**39.09 (13.12)**
Hymenoptera					
Formicidae	11.9 (3.10)	10.58 (3.55)	14.97 (5.03)	23.91 (8.03)	61.36 (20.60)
Diptera					
Muscidae	0.33 (0.11)	0.09 (0.03)	0.73 (0.25)	0.5 (0.17)	1.65 (0.55)
Agromyzidae	1.1 (0.37)	0.28 (0.09)	0.23 (0.08)	0.07 (0.02)	1.68 (0.56)
Total	**1.43 (0.48)**	**0.37 (0.12)**	**0.96 (0.32)**	**0.57 (0.19)**	**3.33 (1.12)**

Contd.....

Arthropod family/ Season (Period)	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Total
Odonata					
Coenagrionidae	2.87 (0.96)	2.33 (0.78)	1.27 (0.43)	2.21 (0.74)	8.68 (2.91)
Lepidoptera					
Noctuidae	2.02 (0.68)	0.23 (0.08)	1.15 (0.39)	1.02 (0.34)	4.42 (1.48)
Isoptera					
Termitidae	2.58 (0.87)	1.4 (0.47)	8.08 (2.71)	2.38 (0.80)	14.44 (4.85)
Dictyoptera					
Blattidae	1.98 (0.67)	0.36 (0.12)	0.6 (0.20)	1.47 (0.49)	4.41 (1.48)
Mantidae	0.37 (0.12)	0.31 (0.10)	0.09 (0.03)	0.8 (0.27)	1.57 (0.53)
Total	**2.35 (0.79)**	**0.67 (0.23)**	**0.69 (0.23)**	**2.27 (0.76)**	**5.98 (2.01)**
Dermaptera					
Forficulidae	0 (0.00)	0 (0.00)	0.21 (0.07)	0.2 (0.07)	0.41 (0.14)
Arachneda					
Lycosidae	2.32 (0.78)	2.21 (0.74)	6.29 (2.11)	4.47 (1.50)	15.29 (5.13)
Oxyopidae	0.37 (0.12)	0.34 (0.11)	0.59 (0.20)	0.53 (0.18)	1.83 (0.51)
Araneidae	0 (0.00)	0 (0.00)	0.04 (0.00)	0.07 (0.02)	0.11 (0.04)
Total	**2.69 (0.90)**	**2.55 (0.86)**	**6.92 (2.32)**	**5.07 (1.70)**	**17.23 (5.79)**
Collomboia					
Poduridae	1.62 (0.54)	4.28 (1.44)	5.33 (1.79)	5.16 (1.73)	16.39 (5.50)
Entomobyridae	0.21 (0.07)	0.17 (0.06)	2.26 (0.76)	2.39 (0.80)	5.03 (1.69)
Total	**1.83 (0.61)**	**4.45 (1.49)**	**7.59 (2.55)**	**7.55 (2.54)**	**21.42 (7.19)**
Acarina					
Tetranychidae	0.75 (0.25)	0.39 (0.13)	0.55 (0.19)	0.6 (0.20)	2.29 (0.77)
Grand Total	**51.63 (17.33)**	**48.81 (16.39)**	**98.73 (33.15)**	**98.68 (33.13)**	**297.85 (100)**

*Mean value of two years pooled data (Sept. 2002– Aug. 2004)
Figures in parenthesis are percentage mean relative abundance.

Coleoptera the most dominant order comprises of Families; Chrysomelidae, Carabidae, Cerambycidae, Ciccindelidae and Scarabaeidae with their mean totals of 27.41, 1.03, 72.75, 3.55, and 3.70 respectively. Overall mean population under this order was recorded 108.44 which account to 36.41%. Seasonal wise comparison records maximum 40.10 13.36%) during Mar.-May (March-May) season.

Hemiptera comprises of Families; Pentatomidae, Falgoridae and Cicadidae in which Pentatomidae was the maximum 5.82 1.95%) Seasonal population records maximum during Sept.-Nov. 4.90 1.65%). The mean totals under this order recorded 10.76 (3.61 %).

Orthoptera was the next dominant group comprising four families Viz:- Gryllidae, Acrididae, Tettigonidae and Grylotalpidae. Among the families, Gryllidae was the most dominant which recorded mean total of 24.46 (8.21 %) and the seasonal abundance records maximum population during Mar.-May season as mean totals of 15.46 (5.19%).

Order Hymenoptera with a single family Formicidae was the most abundant arthropod (total mean of 61.36, covering 20.60% of the totals). Seasonal distribution recorded the maximum during Sept.-Nov. 23.91 (8.03%) totals.

Diptera includes family Muscidae and Agromyzidae; and are recorded a mean totals 3.33 1.12%). Maximum population was recorded during Sept.-Nov. season 1.43; (0.48%). Other arthropod taxa under family Coenagrionidae, (O; Odonata); Noctuidae (O; Lepedoptera) nd Termitidae (O; Isoptera) recorded mean totals of 8.68; (2.91%), 4.42; 1.48%) and 14.44; (4.85%) respectively. The seasonal abundance of those families recorded during Sept.-

Nov. season for the former two families and the later ones' during Mar.-May season as 2.87; (0.96%), 2.02; (0.68%) and 8.08; (2.71%) respectively.

Order Dictyoptera comprises of two families viz: Blatidae and Mantidae which was recorded mean totals of 4.41 and 1.57 and the maximum populations during Sept.-Nov. season occupying 0.49% and 0.27% respectively. Over all mean total of 5.98 which was 2.01%.

Dermaptera; Family Forficulidae records mean totals of 0.41 as 0.14% and Acarina; Family Tetranychidae mean totals of 2.29 as 0.77%; maximum during Mar.-May and Sept.-Nov. season occupying 0.07% and 0.25% respectively.

Arachneda comprise of families Lycosidae, Oxyopidae and Araneidae records a mean total of 17.23 (5.97%), maximum during Mar.-May season (mean of total of 6.92, (2.32%). Collembola records two families viz: Halomobyridae and Poduridae with mean totals of 21.42 (7.19%); maximum populations during Mar.-May season (mean total 7.59 as 2.55%).

4.10.3 Relative abundance of common arthropod populations (%) from uphill maize ecosystem (Kohima)

Pooled data on the mean population of common and dominant Arthropod groups recorded from uphill maize ecosystem and their seasonal abundance (Table 23) shows that a total number of 297.35 different arthropod belonging to twenty seven families under thirteen dominant orders i.e. Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachneda, Collembola and Acarina.

Table 23. **Relative abundance of common seasonal arthropod population(%) from uphill maize ecosystem during 2002- 2004.**

Arthropod Family/ Season (Period)	Sept.-Nov.	Dec.-Feb.	Mar.-May	Sept.-Nov.	Total
Coleoptera					
Carabidae	*2.24 (0.75)	1.16 (0.39)	1.47 (0.49)	3.37 (1.13)	8.24 (2.77)
Scarabaeidae	0.19 (0.06)	0.06 (0.02)	0.31 (0.10)	0.5 (0.17)	1.06 (0.36)
Cerambycidae	0.19 (0.06)	0 (0.00)	0.22 (0.07)	0.17 (0.06)	0.58 (0.20)
Cicindellidae	0.31 (0.10)	0.09 (0.03)	0.28 (0.09)	0.67 (0.23)	1.35 (0.45)
Chrysomeliodae	0.56 (0.20)	0.21 (0.07)	1.69 (0.57)	1.42 (0.48)	3.9 (1.31)
Total	**3.51 (1.18)**	**1.52 (0.51)**	**3.97 (1.34)**	**6.13 (2.06)**	**15.13 (5.09)**
Hemiptera					
Pentatomidae	0.83 (0.28)	0.15 (0.05)	0.38 (0.13)	0.59 (0.20)	1.95 (0.66)
Fulgoridae	0.09 (0.03)	0.02 (0.01)	0.1 (0.00)	0.24 (0.08)	0.45 (0.15)
Cicadidae	0.38 (0.13)	0.06 (0.07)	0.21 (0.07)	0.73 (0.25)	1.38 (0.46)
Total	**1.3 (0.44)**	**0.23 (0.08)**	**0.69 (0.23)**	**1.56 (0.53)**	**3.78 (1.27)**
Orthoptera					
Acrididae	1.29 (0.43)	0.37 (0.12)	0.75 (0.25)	2.55 (0.86)	4.96 1.69)
Tettigonidae	0.37 (0.12)	0.04 (0.01)	0.15 (0.05)	0.72 (0.24)	1.28 (0.43)
Gryllidae	1.66 (0.59)	0.41 (0.14)	0.9 (0.30)	3.27 (1.10)	6.24 (2.10)
Gryllotalpidae	0 (0.00)	0.02 (0.01)	0.18 (0.06)	0 (0.00)	0.2 (0.07)
Total	**3.32 (1.12)**	**0.84 (0.28)**	**1.98 (0.67)**	**6.54 (2.20)**	**12.68 (4.26)**
Hymenoptera					
Formicidae	13.13 (4.42)	8.23 (2.77)	16.68 (5.61)	26.86 (9.03)	64.9 (21.83)
Diptera					
Muscidae	0.86 (0.29)	0.5 (0.17)	2.41 (0.81)	2.01 (0.68)	5.78 (1.94)
Agromyzidae	0.42 (0.14)	0.05 (0.02)	0.11 (0.04)	0.54 (0.18)	1.12 (0.38)
Total	**1.28 (0.43)**	**0.55 (0.19)**	**2.52 (0.85)**	**2.55 (0.86)**	**6.9 (2.32)**

Contd.....

Arthropod Family/ Season (Period)	Sept.-Nov.	Dec.-Feb.	Mar.-May	Sept.-Nov.	Total
Odonata					
Coenagrionidae	1.48 (0.50)	0.49 (0.17)	0.71 (0.24)	1.51 (0.51)	4.19 (1.41)
Lepidoptera					
Noctuidae	0.45 (0.15)	0.22 (0.07)	0.96 (0.32)	0.38 (0.13)	2.01 (0.68)
Isoptera					
Termitidae	0 (0.00)	0 (0.00)	1 (0.10)	0.72 (0.24)	1.72 (0.58)
Dictyoptera					
Blattidae	1.08 (0.36)	3.24 (1.09)	0.85 (0.29)	1.55 (0.52)	6.72 (2.26)
Mantidae	0.51 (0.17)	0.05 (0.17)	0.21 (0.07)	0.24 (0.08)	1.01 (0.34)
Total	**1.59 (0.54)**	**3.29 (1.11)**	**1.06 (0.36)**	**1.79 (0.60)**	**7.73 (2.60)**
Dermaptera					
Forficulidae	0.93 (0.31)	0.36 (0.12)	0.94 (0.32)	0.63 (0.21)	2.86 (0.96)
Arachneda					
Lycosidae	0.72 (0.24)	0.86 (0.29)	1.39 (0.47)	2.25 (0.76)	5.22 1.73)
Oxyopidae	0.43 (0.15)	0.05 (0.17)	0.17 (0.06)	0.59 (0.20)	1.24 (3.42)
Araneidae	1.15 (0.39)	0.91 (0.31)	1.56 (0.53)	2.84 (0.96)	6.46 (2.17)
Total	**2.3 (0.77)**	**1.82 (0.61)**	**3.12 (1.05)**	**5.68 (1.91)**	**12.92 (4.35)**
Collembola					
Poduridae	081 (027)	0.14 (0.05)	4.51 (1.52)	10.16 (3.42)	15.62 (5.25)
Entomobyridae	**14.36 (4.83)**	**8.44 (2.84)**	**58.53 (19.68)**	**59.42 (18.99)**	**140.75 (47.34)**
Total	15.17 (5.10)	8.58 (2.89)	63.04 (21.20)	69.58 (23.40)	156.37 (52.59)
Acarina					
Tetranychidae	1.02 (0.34)	0.43 (0.15)	2.05 (0.69)	2.66 (0.90)	6.16 (2.07)
Grand Total	**45.48 (15.30)**	**26.56 (8.93)**	**98.72 (33.20)**	**126.59 (42.57)**	**297.35 (100)**

*Mean value of two years pooled data (Sept. 2002– Aug. 2004)
Figures in parenthesis are percentage mean relative abundance.

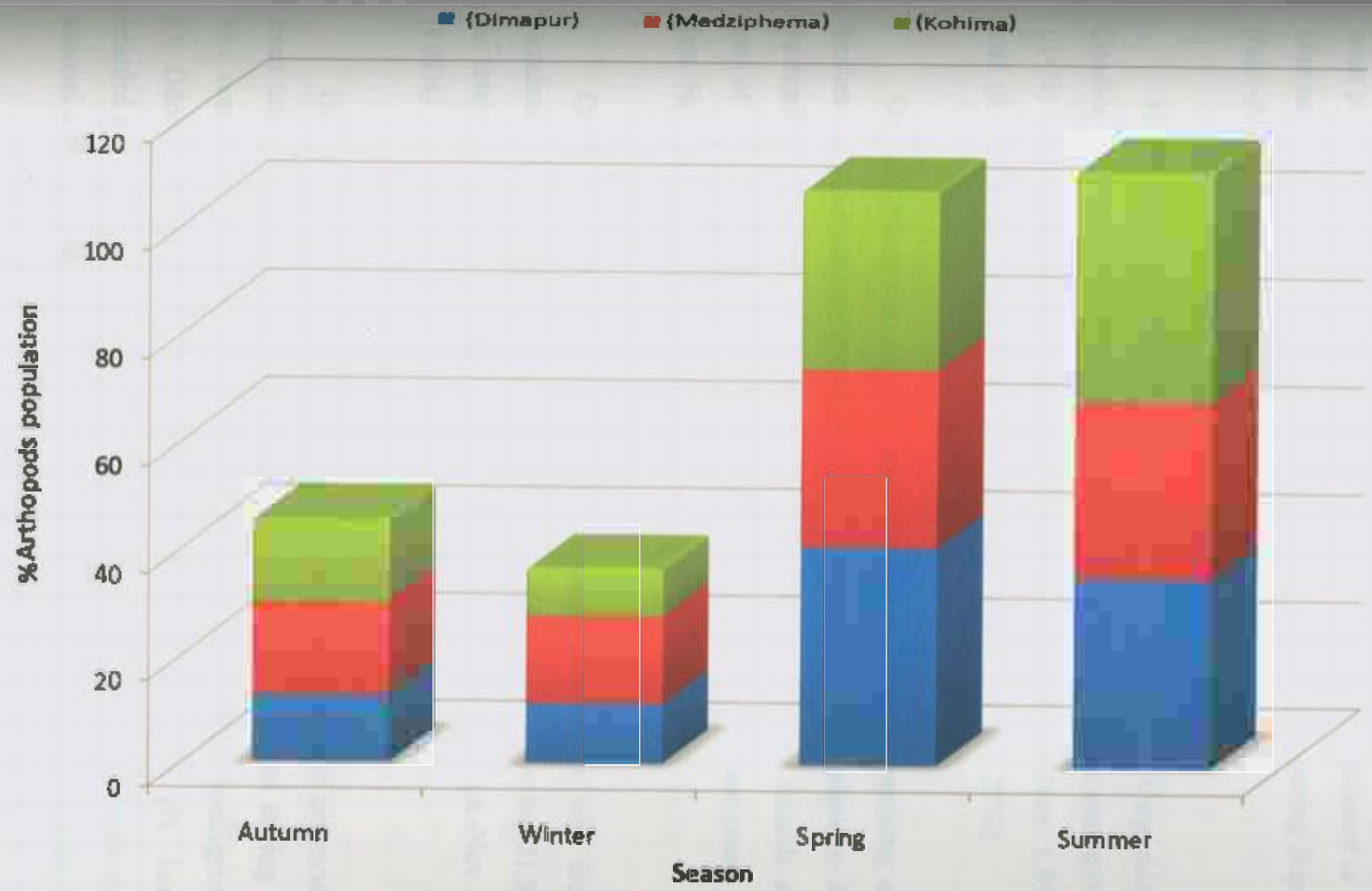

Fig. 17. Seasonal relative abundance of common arthropods in three maize field.

Coleoptera the most dominant order comprises of Families; Chrysomelidae, Carabidae, Cerambycidae, Ciccindelidae and Scarabaeidae with their mean totals of 8.24, 1.06, 0.58, 1.35 and 3.90 respectively. Overall mean population under this order was recorded 15.13 which account to 5.09%. Seasonal wise comparison records maximum 6.13 (2.06%) during Sept.-Nov. (June -August) season.

Hemiptera comprises of Families; Pentatomidae, Falgoridae and Cicadidae of which Pentatomidae dominate the groups was the maximum 9.52 1.14%) Seasonal distribution records maximum during Sept.-Nov. 1.95 mean total (0.66%). The mean totals under this order reeords 3.78 1.27%)

Order; Orthoptera was the next dominant group comprising of four families Viz:- Gryllidae, Acrididae, Tettigonidae and Grylotalpidae. Among the families, Gryllidae was the most dominant group which records a mean total of 6.24 (2.10%) and the seasonal abundanee records maximum during Sept.-Nov. 6.54 (2.20%).

Order Hymenoptera with a single family Formicidae was the most abundant and dominant arthropod (total mean of 64.90 no. covering 21.83% of the totals). Seasonal distribution reeorded the most during Sept.-Nov. 26.86 (9.03%)

Diptera includes family Muscidae and Agromyzidae; and are recorded a mean totals 6.90 (2.32%). Maximum population was recorded during Sept.-Nov. season (2.55; 0.86%). Other arthropod taxa under family Coenagrionidae, (O; Odonata); Noctuidae (O; Lepedoptera) nd Termitidae (O; Isoptera) recorded mean totals of 4.19; 1.41%), 2.01; (0.68%) and 6.16 respectively. The seasonal abundance of those families recorded during Mar.-May season for the

Noctuidae (0.96; 0.32%) and during Sept.-Nov. season for Coenagrionidae and Termitidae as 1.51; (0.51%) and 1.72; (0.52%) respectively.

Order Dictyoptera comprises of two families viz: Blatidae and Mantidae which were recorded their mean totals of 6.72 and 1.01 and the maximum populations during Dec.-Feb. season (Blattidae 1.09%) and (Mantidae 0.17%) during Sept.-Nov. season.

Dermaptera; Family Forficulidae records mean totals of 2.86 as 0.96% and Acarina; Family Tetranychidae mean totals of 6.16 as 2.07%; maximum during Sept.-Nov. season occupying 2.66; 0.90% Tetranychidae and 0.94; 0.32% (Forficulidae).

Arachneda comprise of families Lyeosidae, Oxyopidae and Araneidae records a mean totals of 5.22, 1.24 and 6.46 maximum during Sept.-Nov. season (mean total of 5.68 1.91%). Collembola records two families viz: Entomobyridae and Poduridae with mean totals of 156.37 (52.59); maximum populations during Sept.-Nov. season (mean total 69.580 as 23.40%).

4.10.4. Comparative study or common relative abundance of arthropod (%) in three maize ecosystem

The comparison study on common arthropod populations and their relative abundance from three different maize ecosystems are described and tabulated in Table 20 – 22 and Fig. 18 accordanee to their orders and season during September 2002 to August 2004. The orders, Viz;- Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachneda, Collembola and Acarina are recorded.

Pooled data on the mean population of dominant Arthropod groups recorded from plain area maize ecosystem and their seasonal relative abundance (Table 20) revealed that a mean total number of 838.35 arthropod belonging to twenty seven families under thirteen dominant orders i.e. It was found that the arthropod population are maximum during Mar.-May season (grant mean total = 362.18). Seasonal distribution recorded as 105.56; (12.59%), 94.22; (11.24%), 362.18; (40.82%) and 296.39; (35.35%) during Sept.-Nov., Dec.-Feb., Mar.-May and Sept.-Nov. respectively.

The relative abundance of aarthropod groups recorded from foothill maize ecosystem and their seasonal abundance (Table 21) revealed that a mean total number of 297.85. Mean grant total of arthropod season wise recorded as 51.63; (17.33%), 48.81; (16.39%), 98.73; (33.15%) and 98.68; (12.99%) during Sept.-Nov., Dec.-Feb., Mar.-May and Sept.-Nov. respectively. The arthropod population from the table reveals that they are almost similar numbers during Mar.-May and Sept.-Nov. season.

Relative abundance and mean population of common Arthropod groups recorded from uphill maize ecosystem and their seasonal abundance (Table 22) shows that a total number of 297.35. Seasonal mean grant totals recorded were 45.48; (15.30%), 26.56; (8.93%), 98.72; (33.20%) and 126.59; (42.57%) during Sept.-Nov., Dec.-Feb., Mar.-May and Sept.-Nov. respectively. The table shows that the arthropod populations are more abundance during Sept.-Nov. season (126.59). A graphical representation was presented in Table 26, Fig.18 as percentage relative population of seasonal common arthropod.

4.11. Seasonal relative abundance of un-common dominant arthropod population (%) from three different maize ecosystems

The un-common arthropod populations and their percentage relative abundance from three different maize ecosystems are described and tabulated in Table 24 and Fig. 19. Family wise according to their orders and season during September 2002 to August 2004 are as described below:

The arthropod families recorded in the table represents the ones which were found only in those particular locations. There were other families which were found in two different locations but are not reflected in the table. They are reflected in the previous tables.

In plain area, family Hydrophyllidae represented 93.77% where as Agrionidae and Pieridae recorded only 1.90% and 4.33% respectively.these three families records mean total of 81.33 numbers from plain area maize ecosystem.

Foothill area recorded other three families viz: Curculiniodae, Pyrrocoridae and Nymphclidae, a mean total of 2.98 numbers of arthropod was recorded from that particular location. Family Curculiniodae represented 56.71% of the total arthropod from foothill and Nymphelidae 40.60% but Pyrrocoridae was negligible.

The uncommon arthropod family from uphill was represented by the families Meloedae, Ichnemoididaeand Salticidae. Salticidae represented 40.47% of the total mean and Meloedae 32.01%, where as Ichnemoididae represent only 27.01%.

Table 24. Seasonal relative abundance of uncommon arthropod population % from three different maize ecosystem.

Arthropods Families	Autumn Sep-Nov	Winter Dec-Feb	Spring Mar-May	Summer Jun-Aug	Total
Plain area					
Hydrophillidae	0.19 (0.23)	32.46 (39.97)	36.87 (45.39)	6.64 (8.17)	76.16 (93.77)
Agrionidae	0.73 (0.90)	0.22 (0.27)	0.37 (0.46)	0.22 (0.27)	1.54 (1.90)
Pieridae	0.07 (0.09)	0.07 (0.09)	1.42 (1.75)	1.96 (2.41)	3.52 (4.33)
Total	**0.99 (1.22)**	**32.75 (40.32)**	**38.66 (47.60)**	**8.82 (10.86)**	**81.22 (100)**
Foot-hills					
Curculiniodae	1.05 (35.23)	0 (0.00)	0.64 (21.48)	0 (0.00)	1.69 (56.71)
Pyrrocoridae	0.02 (0.67)	0.01 (0.33)	0.01 (0.33)	0.04 (1.34)	0.08 (2.68)
Nymphelidae	1.12 (37.58)	0.02 (0.67)	0 (0.00)	0.07 (2.34)	1.21 (40.60)
Total	**2.19 (73.49)**	**0.03 (1.00)**	**0.65 (21.81)**	**0.11 (3.69)**	**2.98 (100)**
Up-land					
Meloedae	0 (0.00)	0 (0.00)	0.54 (14.28)	0.67 (17.72)	1.21 (32.01)
Ichnemoididae	0.4 (10.58)	0.02 (3.17)	0.44 (11.64)	0.18 (4.76)	1.04 (27.51)
Salticidae	0.57 (15.08)	0.09 (5.03)	0.35 (9.25)	0.52 (13.76)	1.53 (40.47)
Total	**0.97 (25.66)**	**0.11 (2.91)**	**1.33 (35.18)**	**1.37 (36.24)**	**3.78 (100)**

*Mean value of two years pooled data (Sept. 2002–Aug. 2004).
Figures in parenthesis are percentage mean relative abundance.

Fig. 18. Uncommon arthropod mean population from three locations

4.12. Arthropod populations from different locations by different methods of collections during September 2002 to August 2004.

The arthropod populations in maize agro ecosystem during Sept. 2002 to Aug. 2004 are tabulated and presented in Table 25. The total populations from pitfall was found to be more (669.2) from plain area (Dimapur) which was recorded maximum during Mar.-May season 199.62) followed by Sept.-Nov. in 2003 164.78 numbers). In other two stations, Medziphema and Kohima, the arthropod recorded maximum during Sept.-Nov. in 2003, 28.4 and 59.41 respectively (Table 25).

From soil extraction methods it was recorded a total of 36.37 from Medziphema followed by Kohima and Dimapur, 22.36 and 11.69 respectively (Table 25). In all the cases, it was found recorded maximum during Sept.-Nov. in 2003.

Light trap catches recorded the totals of 393.04, 209.92 and 22.59 from plain area, foothill and uphill respectively. From plains maximum 133.11 numbers were recorded during Mar.-May season in 2003 so as in 2004, 40.58 numbers were recorded from foothill where as from uphill it was recorded 3.76 numbers during Sept.-Nov. in 2003 (Table 25).

Net sweeping methods records a totals of 11.28, 9.99 and 28.75 maximum during Sept.-Nov. season in 2003 1.99, 1.81 and 5.55) from plains, foothill and uphill respectively (Table 25)

Table 25. Arthropod populations from different locations and traps (during Sept. 2002 to Aug. 2004).

Location/Season (Period)	Sep-Nov	Dec.-Feb.	Mar.-May	Jun-Aug	Total
Pitfall traps					
Dimapur	*82.63	68.79	275.13	242.65	**669.2**
Medziphema	20.75	14.8	34.65	44.17	**114.37**
Kohima	33.31	4.11	81.46	95.27	**214.15**
Total	**136.69**	**87.7**	**391.24**	**382.09**	**997.72**
Soil extract					
Dimapur	2.67	2.77	2.98	3.27	**11.69**
Medziphema	4.06	8.69	10.41	13.21	**36.37**
Kohima	1.83	0.57	6.87	13.09	**22.36**
Total	**8.56**	**12.03**	**20.26**	**29.57**	**70.42**
Light traps					
Dimapur	27.7	84.01	170.68	110.65	**393.04**
Medziphema	39.02	33.49	67.06	70.35	**209.92**
Kohima	4.87	3.95	6.44	7.33	**22.59**
Total	**71.59**	**121.45**	**244.18**	**188.33**	**625.55**
Net sweeps					
Dimapur	2.54	1.77	3.09	3.88	**11.28**
Medziphema	2.05	1.97	2.61	3.36	**9.99**
Kohima	8.57	2.97	6.71	10.5	**28.75**
Total	**13.16**	**6.71**	**12.41**	**17.74**	**50.02**
Grandtotal	**230**	**227.89**	**668.09**	**617.73**	**1743.71**

* Figures are mean pooled data of two years.

4.13. Comparative study of common arthropod population at different locations and traps

From Table 25, three different maize ecosystems at different altitudes were studied as plain area maize field; foothill maize field and uphill maize field. Four different methods of arthropod samplings as pitfall trap, soil extractions, light trap and sweep net.

The table shows that pitfall catches was maximum at plain area maize ecosystem followed by uphill and foothill the least. A mean total of 669.20 were recorded from plain area (Dimapur) where as it was only 114.37 and 214.15 from foothill and uphill respectively. From soil extraction method, foothill (Medziphema record maximum arthropod number of 36.37 followed by uphill (22.36) and plain (11.69) area maize ecosystem.

Light trap catches was more in plain area (393.04) followed by foothill (209) and uphill (22.59) respectively. Likewise sweep net catches was maximum at uphill (28.75) followed by plain (11.28 and foothill the least (9.99) only.

Overall grant totals season wise records maximum during spring March toMay months 668.09 followed by summer June to August months 617.73. It can also be observed that among the methods, pitfall traps are more suitable methods to catch different arthropod (mean total of 997.72) as compared to the other traps.

4.14 Seasonal insect pest complex population in maize in three different tocations in Nagaland during September 2002 to August 2004.

Seasonal insect pest fauna from three different maize ecosystems compreses of 5 orders and 7 families. The data obtained from different methods of collections in the experiments under the present investigations are tabulated with relative abundance in per cent are described as (Table 26):

Coleoptera

Under order Coleoptera, Chaffer beetle (Scarabaeidae; species unidentified) was dominant pest recorded from all the fields. The per cent records 47.46%, 54.79% and 9.61% at plains, foothills and uphills respectively. It was evident from the table that foothill record maximum pest populations followed by plain and uphill.

Hemiptera

White backed planthopper (*Sogatella spp*) family Delphacidae; Order Hemiptera was found recorded at plain and foothill area maize ecosystem as mean total of 26.04 and 22.82 as 19.84% and 17.19% respectively, but was nil at uphill area.

Orthoptera

Orthoptera belonging to two families were recorded during the period of investigation, viz; Family: Acrididae (genus; *Heiroglyphus Spp.*) and

Table 26: Seasonal insect pest population in maize ecosystem at different locations during September 2002 to August 2004.

Sl.no	Order	Family	Common Name	Scientific name	Sep-Nov	Dec.-Feb.	Mar.-May	Jun-Aug	Total
Plain area									
1	Coleoptera	Scarabaeidae	White grub /Chaffer beetle	Unidentified	6.34 (4.76)	3.86 (2.90)	30.24 (23.47)	21.85 (16.41)	**62.29 (46.81)**
2	Hemiptera	Delphacidae	Brown Leafhopper	*Sogatella spp.*	4.63 (3.48)	1.5 (1.13)	9.59 (7.21)	9.36 (7.03)	25.08 (18.84)
3	Orthoptera	Acrididae	Short horned grass hopper	*Hieroglyphus spp.*	1.76 (1.32)	0.39 (0.29)	2.54 (1.91)	4.13 (3.13)	**8.82 (6.62)**
		Tettigonidae	Long horned grass hopper	Unidentified	1.21 (0.91)	0.24 (0.18)	0.5 (0.38)	0.6 (0.45)	**2.55 (1.92)**
4	Isoptera	Termitidae	Termites	*Odontotermes sp*	0.11 (0.08)	3.15 (2.38)	8.21 (6.17)	10.36 (7.78)	**21.83 (16.40)**
5	Lepidoptera	Pyralidae	Maize borer	*Chilo spp*	1.14 (0.86)	5.68 (4.26)	20.74 (15.58)	15.57 (11.70)	43.13 (32.41)
		Noctuidae	Cutworm	*Cnaphalocrocix spp*	1.87 (1.41)	0.64 (0.48)	4.63 (3.48)	2.03 (1.53)	**9.17 (6.91)**
Total					19.55 (14.69)	17.33 (13.02)	45.01 (33.82)	51.18 (38.46)	133.07 (100)
Foothill									
1	Coleoptera	Scarabaeidae	White grub /Chaffer beetle	Unidentified	6.98 (4.04)	10.51 (6.08)	27.78 (16.07)	27.48 (15.90)	**72.75 (42.08)**

Contd.....

2	Hemiptera	Delphacidae	Brown Leafhopper	*Sogatella spp.*	3.18 (1.84)	1.13 (0.65)	4.24 (2.45)	14.27 (8.25)	22.82 (13.20)
3	Orthoptera	Acrididae	Short horned grass hopper	*Hieroglyphus spp.*	1.35 (0.78)	1.77 (1.02)	2.63 (1.52)	3.28 (1.90)	**9.03 (5.22)**
		Tettigonidae	Long horned grass hopper	Unidentified	1.95 (1.13)	0.64 (0.37)	0.6 (0.36)	0.9 (0.52)	**4.09 (2.36)**
4	Isoptera	Termitidae	Termites	*Odontotermes sp*	2.58 (1.49)	1.4 (0.81)	8.08 (4.67)	2.38 (1.37)	**14.44 (8.35)**
5	Lepidoptera	Pyralidae	Maize borer	*Chilo spp*	**1.49 (0.86)**	1.65 (0.95)	0.53 (0.30)	1.85 (1.07)	5.52 (3.19)
		Noctuidae	Cutworm	*Cnaphalocrocis spp*	2.02 (1.17)	0.23 (0.13)	1.15 (0.66)	1.02 (0.59)	**4.42 (2.55)**
Total					17.06 (9.87)	15.46 (8.94)	76.45 (44.22)	63.9 (36.96)	172.87 (100)
Uphill									
1	Coleoptera	Scarabaeidae	White grub Chaffer beetle	Unidentified	0.19 (1.72)	0.06 (0.54)	0.31 (2.81)	0.5 (4.53)	**0.22 (1.99)**
2	Orthoptera	Acrididae	Short horned grass hopper	*Hieroglyphus spp.*	1.29 (11.70)	0.37 (3.35)	0.75 (6.80)	2.55 (23.12)	**4.96 (44.97)**
		Tettigonidae	Long horned grass hopper	Unidentified	0.37 (3.35)	0.04 (0.03)	0.15 (1.36)	0.72 (6.53)	**1.28 (11.60)**
3	Isoptera	Termitidae	Termites	*Odontotermes sp*	0.00	0.00	1.00 (9.07)	0.72 (6.53)	**1.72 (15.59)**
4	Lepidoptera	Noctuidae	Cutworm	*Cnaphalocrocis spp*	0.45 (4.08)	0.22 (1.99)	0.96 (8.70)	0.38 (3.45)	**2.01 (18.22)**
Total					2.3 (20.85)	0.69 (6.26)	3.17 (28.74)	4.87 (44.15)	11.03 (100)
Grant Total					38.91	33.48	124.63	119.95	490.5

*Mean value of two years pooled data (Sept. 2002 – Aug. 2004)
Figures in parenthesis are percentage mean relative abundance.

Tettigottidae whieh was ttidentified. They were fottnd presett it all the three maize fields with a per cent population of 6.72%, 6.80%, 44.97% and 1.94%, 3.08%, 1160% respectively from plaitt, foothill and uphill area maize field.

Isoptera

Per cettt relative abundattce of *Odontotermes spp* under order Isoptera and family Termitidae was found recorded as 16.63%, 10.87% and 15.59% from all the three maize fields; plaitt foothill attd uphill respeetively.

Lepidoptera

Two gettus, *Chilo spp* and *Cnaphalocrocis spp* ttttder family Noctuidae and Pyralidae O: Lepidoptera were found reeorded from all the fields except for family noctuidae, which was not recorded from uphill. The per cent relative abundance was recorded as 0.41% attd 3.94% for *Chilo spp.* from plaitt attd foothill, and cutworm *Cnaphalocrocis spp.* (Noctuidae) was reeorded 6.99%, 3.33% attd 18.22% from plain, foothill and uphill as mean relative abundance respectively.

The overall mean grant totals of 131.24, 132.79 attd 11.03 were recorded from three different locattons of maize ecosystem.

4.15. Seasonal abundance of domittant insect pests and their correlation (r) with abiotic factors at three different maize ecosystem

The study on eorrelattoti coefficient (r) of arthropod orders of maize field cottsist of 12 the orders Viz:- Coleopteran, Hemipteratt, Orthopteran, Hymenopteratts, Diptera, Odottata, Lepidoptera, Isoptera, Dictyoptera,

Dermaptera, Arachneda and Collembola. These orders were studied with weather parameters sueh as Temperature, rainfall and relative humidity under three different maize field ecosystems.

4.15.1 Seasonal abundance of com mon dominant insect pests at plain area maize ecosystem

Season wise pooled data on the mean population of common dominant arthropod reeorded from plain area maize field (Table 27) revealed that a mean total of 708.92 arthropod belong to 12 dominant orders were recorded. Order Hymenoptera was the most dominant group (229.45) followed by Collembola (186.80), Orthoptera (122.20) and the least dominant group was Dermaptera with only 2.41 mean total population.

Seasonal population distribution (Table 27) revealed that Mar.-May (Mar. – May) season recorded the maximum mean total (342.20) followed by Sept.-Nov. (Jun. – Aug.) season (296.39 mean totals) but least during Sept.-Nov. and Dee.-Feb. 87.85 and 94.22 mean totals respectively.

4.15.2. Correlation co-efficient between dominant insect pests and abiotic factors at plain area maize field

Table 28 revealed that all the dominant arthropod had exhibited positive correlation with all the abiotic factors i.e, mean temperature, average rainfall and mean relative humidity at plain area maize field. A significant positive (r = 0.6459, 0.7144, 0.6612, 0.8139, 0.7148 and 0.7277) correlations were depleted between mean temperature and arthropod group Orthoptera, Hymenoptera, Odonata, Dictyoptera, Dermaptera and Arachneda respectively; while positive but non-significant relationship were reeorded with the rest of the arthropod

Table 27. Seasonal insect pest population in maize at three locations in Nagaland during September 2002 to August 2004.

Sl. no	Order	Family	Common Name	Scientific name	Autumn Sept.-Nov.	Winter Dec.-Feb.	Spring Mar.-May	Summer Jun.-Aug.	Total
Plain area									
1	Coleoptera	Scarabaeidae	White grub /Chaffer beetle	Unidentified	6.34	3.86	30.24	21.85	62.29
2	Hemiptera	Delphacidae	White backed plantfhopper	*Sogatella spp.*	4.63	1.5	9.59	9.36	25.08
3	Orthoptera	Acrididae	Short horned grass hopper	*Hieroglyphus spp.*	1.76	0.39	2.54	4.13	8.82
		Tettigonidae	Long horned grass hopper	Unidentified	1.21	8.24	8.5	9.6	2.55
4	Isoptera	Termitidae	Termites	*Odontotermes sp*	9.11	3.15	8.21	10.36	21.83
5	Lepidoptera	Pyralidae	Maize borer	*Chilo spp*	1.14	5.68	20.74	15.57	43.13
		Noctuidae	Cutworm	*Cnaphalocrocis spp*	1.87	8.64	4.63	2.03	9.17
Foothill									
1	Coleoptera	Scarabaeidae	White grub /Chaffer beetle	Unidentified	6.98	10.51	27.78	27.48	72.75
2	Hemiptera	Delphacidae	White backed plantfhopper	*Sogatella spp.*	3.18	1.13	4.24	14.27	22.82
3	Orthoptera	Acrididae	Short horned grass hopper	*Hieroglyphus spp.*	1.35	1.77	2.63	3.28	9.03
		Tettigonidae	Long horned grass hopper	Unidentified	1.95	0.64	8.6	0.9	4.09
4	Isoptera	Termitidae	Termites	*Odontotermes sp*	2.58	1.4	8.08	2.38	14.44

Contd.....

Sl. no	Order	Family	Common Name	Scientific name	Autumn Sept -Nov	Winter Dec.-Feb.	Spring Mar.-May	Summer Jun-Aug	Total
5	Lepidoptera	Pyralidae	Maize borer	*Chilo spp*	2.56	1.65	0.53	1.85	6.59
		Noctuidae	Cutworm	*Cnaphalocrocts spp*	2.02	0.23	1.15	1.02	4.42
Hill area									
1	Coleoptera	Scarabaeidae	White grub /Chaffer beetle	Unidentified	0.19	0.06	0.31	0.5	1.06
2	Orthoptera	Acrididae	Short horned grass hopper	*Hieroglyphus spp.*	1.29	0.37	0.75	2.55	4.96
		Tettigonidae	Long horned grass hopper	Unidentified	0.37	0.04	0.15	0.72	1.28
3	Isoptera	Termitidae	Termites	*Odontotermes sp*	0.00	0.00	1.00	0.72	1.72
4	Lepidoptera	Noctuidae	Cutworm	*Cnaphalocrocis spp*	0.45	0.22	0.96	0.38	2.01
Grant Total					**39.98**	**33.36**	**124.60**	**119.95**	**356.77**

*Mean value of two years pooled data (Sept. 2002 – Aug. 2004)

Table 28 : Correlation coefficient values (r) of arthropod with abiotic factors at plain area maize ecosystem (Dimapur).

Weather Parameters	Coleoptera	Hemeptera	Orthoptera	Hymenoptera	Diptera	Odonita	Lepitoptera	Isoptera	Dyctyoptera	Dermaptera	Arachneda	Collembola
Temperature (in ℃)	0.3115 NS	0.1106 NS	0.6459 *	0.7144 **	0.4931 NS	0.6612 *	0.5000 NS	0.5260 NS	0.8139 **	0.7148 **	0.7277 **	0.5022 NS
Rainfall (in mm)	0.3304 NS	0.6449 *	0.0355 NS	0.1607 NS	0.9585 **	0.1207 NS	0.1837 NS	0.1006 NS	0.6190 *	0.1648 NS	0.6408 *	0.2572 NS
Relative Humidity %	0.1278 NS	0.2561 NS	0.4253 NS	0.5913 NS	0.7241 **	0.3208 NS	0.2860 NS	0.5011 NS	0.8844 **	0.5948 NS	0.8624 **	0.2056 NS

* Significant at 5% level
** Significant at 1% level
NS Non-significant.

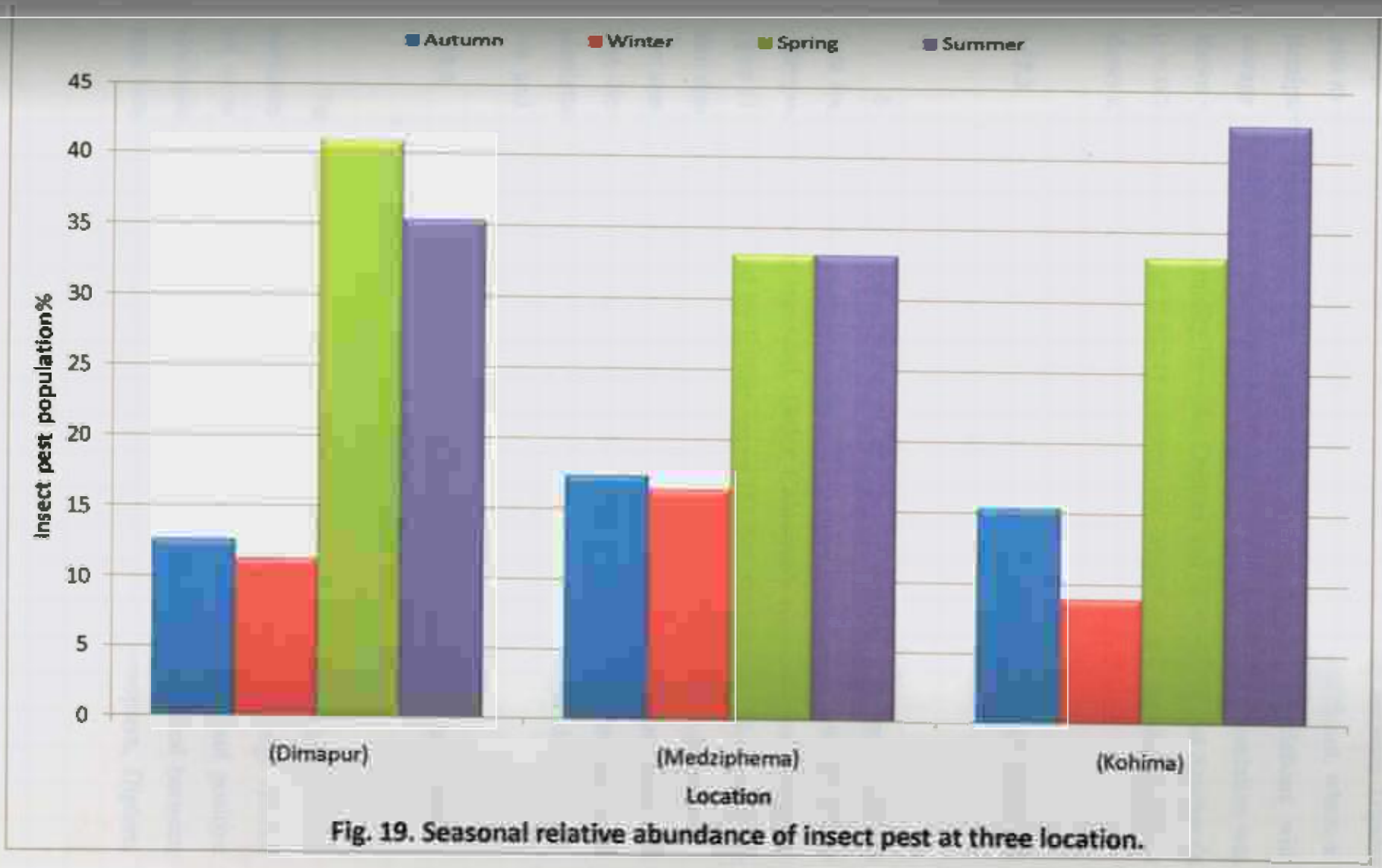

Fig. 19. Seasonal relative abundance of insect pest at three location.

group. A highly significant positive correlation was found between Diptera with average rainfall (r = 0.9585) which is at 1% level of significant, where as Hemiptera, Dictyoptera and Arachneda shows positive correlations with average rainfall at 5% levels of significance. A highly positive correlation was shown with relative humidity by order Diptera and Dictyoptera and Arachneda (r = 0.7241, 0.8844 and 0.8624) respectively where as the remaining groups shows non-significance.

4.15.3. Seasonal abundance of common dominant insect pests at foothill area maize ecosystem

Seasonal mean population of common dominant arthropod recorded from foothill area maize field (Table 27) revealed that a mean total of 297.85 arthropod orders were recorded. Order Coleoptera was the most dominant group (108.44) followed by Hymenoptera (61.36), Orthoptera (39.09) and the least dominant group was Dermaptera with only 0.41 mean total population. The seasonal population distribution (Table 27) revealed that Mar.-May and Sept.-Nov. season recorded almost the same numbers of arthropod mean populations (98.73 and 98.68 mean totals respectively) and least during Dec-Feb. and Sept.-Nov. 48.81 and 51.63 mean totals respectively.

4.15.4. Corfelation co-efficient between dominant insect pests and abiotic factors at foothill area maize ecosystem

Table 29 revealed that all the dominant arthropod had exhibited positive correlation with all the abiotic factors i.e. mean temperature, average rainfall and mean relative humidity at plain afea maize field. A significant positive correlations (r = 0.6446, 0.6659, 0.6076 and 0.7974) were depicted between mean temperature and arthropod group Coleoptera, Hymenoptera, Diptera,

Table 29: Correlation coefficient values (r) of arthropod with abiotic factors at foothills maize ecosystem (Medziphema).

Weather Parameters	Coleoptera	Hemeptera	Orthoptera	Hymenoptera	Diptera	Odonata	Lepitoptera	Isoptera	Dyctyoptera	Dermaptera	Arachneda	Collembola
Temperature (in ℃)	0.6446 *	0.9286 **	0.4833 NS	0.9352 **	0.6659 *	0.1548 NS	0.2135 NS	0.1337 NS	0.6076 *	0.7535 **	0.5713 NS	0.7974 *
Rainfall (in mm)	0.6741 *	0.3365 NS	0.8994	0.1699 NS	0.1300 NS	0.9024	0.5084 NS	0.9876 **	0.5522 NS	0.6160 *	0.8326 **	0.2123 NS
Relative Humidity %	0.6654 *	0.3513 NS	0.8927	0.1561 NS	0.1384 NS	0.9016	0.5145 NS	0.9856 **	0.5687 NS	0.6052 *	0.8248 **	0.2056 NS

* Significant at 5% level
** Significant at 1% level
NS Non-significant.

Dictyoptera and Collembola respectively shows at 5% significant levels where as r = 0.9286, 0.9352 and 0.7535 at 1% significant levels by Hemiptera, Hymenoptera and Dermaptera respectively with mean temperature. A positive but non-significant relationship was recorded with the rest of the arthropod groups. A highly significant positive correlation was found between Orthoptera, Isoptera and Arachneda (r = 0.8994, 0.9876 and 0.8326 mean total) with average rainfall which is at 1% level of significant. Correlations of arthropod with average relative humidity where found with Coleoptera, Orthoptera, Isoptera, Dermaptera and Arachneda shows positive at 1% and 5% levels of significance respectively, where as the remaining groups shows non-significance correlations.

4.15.5 Seasonal abundance of common dominant insect pests at uphill area maize ecosystem

Season wise pooled data on the mean population of common dominant arthropod recorded from uphill area maize field (Table 27) revealed that a mean total of 440.60 arthropod orders were recorded. The Orders, Arachneda was the most dominant group (162.53) followed by Collembola (156.37), Hymenoptera (64.90) and the least dominant group was found to be Isoptera with only 1.72 mean total population.

Seasonal population distribution from Table 27 revealed that Sept.-Nov. season recorded the maximum mean total (190.49) followed by Mar.-May season (158.60 mean totals) but least during Dec.-Feb. 33.32 mean totals respectively.

Table 30: Correlation coefficient values (r) of arthropod with abiotic factors at rabi maize ecosystem (Kohima).

Weather parameters	Coleoptera	Hemeptera	Orthoptera	Hymenoptera	Diptera	Odonata	Lepitoptera	Isoptera	Dyctyoptera	Dermaptera	Arachneda	Collembola
Temperature (in °C)	0.9395 **	0.8937 **	0.8888 **	0.9170 **	0.8629 **	0.7874 **	0.8185 **	0.3984 NS	0.6294 *	0.6052 *	0.7874 **	0.8802 **
Rainfall (in mm)	0.9353 **	0.9070 **	0.9625 **	0.9865 **	0.7350 **	0.8130 **	0.4600 NS	0.0150 NS	0.2287 NS	0.4672 NS	0.7216 **	0.2572 NS
Relative Humidity %	0.5954 NS	0.9348 **	0.6430 *	0.8865 **	0.2759 NS	0.9660 **	0.2316 NS	0.3680 NS	0.1537 NS	0.0937 NS	0.2127 NS	0.8818 **

* Significant at 5% level
** Significant at 1% level
NS Non-significant.

4.15.6 Correlation co-efficient between dominant arthropod and abiotic factors at uphill area maize ecosystem

Table 30 revealed that all the dominant arthropod had exhibited positive correlation with all the abiotic factors i.e, mean temperature, average rainfall and mean relative humidity at plain area maize field. A significant positive correlation (r) was deplicted between mean temperature and arthropod groups except with Isoptera which shows positive but non-significant. The correlation co-efficient of arthropod with average rainfall shows highly significance at 1% level. Order Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata and Arachneda shows r = 0.9353, 0.9070, 0.9625, 0.9865, 0.7350, 0.8130 and 0.7216 respectively; while positive but non-significant relationship were recorded with the rest of the arthropod group. A highly significant positive correlation was found between Hemiptera, Odonata and Collembole as r= 0.9348, 0.8865 and 0.8818 at 1% levels of significant with mean relative humidity and Orthoptera (r = 0.6430) which is at 5% level of significant.

CHAPTER - V
DISCUSSION

CHAPTER–V
DISCUSSION

The present investigation was conducted during September 2002 to August 2004 to evaluate the **"Biodiversity of arthropod fauna in maize ecosystem in three different altitudes of Nagaland"** The findings are discussed with the findings of other workers under the following headings:

5.1 Diversity of arthropod fauna at three different maize agro ecosystems:

The investigation on abundance and diversity of Arthropod at three different maize agro ecosystems were carried out by employing four different methods Viz:- 1). Pitfall traps 2). Soil extractions 3) Light traps and 4).Net sweeping. The location wise were differentiated as under plain area, foot-hills and up-lands lying within different altitudes.

up-hills

Many workers in the past have developed and did research on biodiversity of arthropods by employing different methods; Pitfall trap is one of them as suggested by Thiele (1979) that the most commonly used and are superior to many trapping devices available for studying the soil surface dwelling arthropods. Ostbye et al (1978), Huffman and Harding (1980) reported that pitfall traps could be used to determined the peak activity during certain seasons and location of species within habitats. Soil dwelling arthropods such as Collembolans, Mites, Centipedes and Spiders etc were studied by various workers from soil core samples under different agro ecosystem, (Briggs, (1961); Mukharji and Singh, (1970); Moeed and Meads,

(1985); Reddy, (1986); Hopkin, (1997); , Reddy and Alemla, (1995); Hodkinson *et al.* (1998); Walter and Proctor, (1999); Salamanca et al, (2003) and Wiwatwitaya and Takeda, (2005). Studies on night active arthropods (nocturnal insects), their abundance, occurrence and seasonal distributions were reported by many workers by use of light traps (Bhat and Rajagopal, (1992) Rai, *et at.,* (2002); Upadhyay and Sharma, (2004); Davinder *et al.,* (2007). So as the aerial arthropods populations and time of their flight were studied (Cherry and Derren, (2000). The arthropod diversities are discussed as under:-

5.1.1. Arthropod diversity in maize ecosystem

The arthropod fauna recorded from plain area maize ecosystem during the period of study mainly belongs to 13 orders and 41 families. The order Coleoptera recorded the maximum number of families (8) fallowed by Hemiptera (6). But the population number of non of the insect species are obtained alarming in relation to pest management or population dynamic studies. Hence, for present study is exclusively based on family and order instead of orienting exclusively on specific pest species.

5.1.1.1. Arthropod diversity from Pitfall traps

Arthropod collected from pitfall traps records a total of 669.2 numbers. It is evident that the family Formicidae recorded the highest number of arthropods (H=0.16) especially during summer season in 2003 (50.29). The report is very much familiar with the findings made by Reddy and Alemla (1995), they reported that in maize agro ecosystem of Nagaland, family Formicidae was dominant among arthropod groups during rainy season i.e.

between June and August months. Similar reports were made by Whitford, (1978); Majer, 1981); Majer and Koch, (1982) and Moeed and Meads, (1985) The different arthropods families reecorded during the present studies includes Carabidae. Cieindellidae. Searabaeidae. Elateridae (Coleopteran); Gryllidae, Gryllotalpidae (Orthopteran); lycosidae (Arachnida); Formicidae (Hymenopteran); Forficulidae (Dermapteran); Blattidae (Dyctyopteran) Poduridae, Entomobyridae, Tenuipalpidae (Collembolan) and Tetranychidae (acarina).

5.1.1.2. Arthropod diversity from soil extraction

The diversity index of arthropods fauna from soil extraets in maize ecosystem in plain area reeords a total of 11.63. The result shows that 1.35 individuals of the family Telranyehidae during summer season in 2003, fallowed by Family Poduridae (0.65) during spring season in the same year. The total arthropod records is found 10 be maximum during summer season (1.94) which is very much coincides, with the findings as reported by Hazra and Choudhuri. (1981). They reported that maximum population size of collembolan is allained during the monsoon period or during the immediate post monsoon period. The order Collembola was represented by Poduridae and Tenuipalpidae. Similarly, Guru *et al.* (1988) also reported Collembola belonging to five families from eultivated and uncultivated sites of Western Orissa. The different arthropods families recorded during the present studies includes Telranyehidae (Acarina); Formicidae (Hymenopteran); Muscidae (Dipteran) Poduridae, Tenuipalpidae (Collembolan) and Termitidae (Odonita).

5.1.1.3. Arthropod diversity from light traps

Diversity index of arthropods by light trap catches from plain area in maize ecosystem shows that a total of (H=1.18) individuals, which is dominated by Hydrophillidae (Coleopteran) during spring season (27.77 in 2003) fallowed by Culicidae (32.88) in the same period. The total population record (133.1) in 2003 (spring season) is the maximum as reported by Majer (1981). He reported that the ants increased in spring and summer was connected with high temperature and availability of food and low activity in winter may be the reduced availability of such food sources. The Coleopteran order belonging to families Hydrophillidae, Chrysomelidae, Scarabaeidae, Cicindellidae, Cerambycidae, Buprestidae, Elateridae and Carabidae were recorded during the seasons in light traps. Bhat and Rajagopal (1992) also studied the light trap catches of Carabids and reported 37 species of Carabids belonging to 14 tribes. Hemiptera consisted of *Cofana spectra* as dominant species and the remaining were recorded under five genera such as *Dolycoris* sp., *Nezara* sp., *Leptocorisa* spp., *Cicada* spp. and *Nepa* sp. Coleoptera and Hemiptera were dominant orders constituting 24.3% and 38.6% of the total number of species. Mooed and Meads (1985) also recorded Hemipterans belonging to nine different families and 158 species of Celeoptera belonging to 36 families. The records of these workers confirm the findings from the light traps. Different arthropods families recorded from light traps includes, Hydrophillidae, Chrysomelidae, Scarabaeidae, Ciccindelidae, Cerambycidae, Buprestidae, Elateridae Carabidae (Coleopteran); Pentatomidae, Coreidae, Belastomidae, Cicadidae, Fulgoridae, Delphacidae (Hemipteran); Gryllidae, Grylolalpidae, Acrididae, Tettigonidae (Orthopteran); Vaspidae, Formicidae (Hymenopteran); Culicidae, Agromyzidae (Dipteran); Coenagrionidae, Agrionidae (Odonata); Pyratidae, Noctuidae, Pieridae (Lepitopteran);

Termitidae (Isopteran); Blatidae, Mantidae (Dyctyopteran); Forficulidae (Dermapteran) and Theriidae (Arachnedae).

5.1.1.4. Arthropod diversity from net sweeps

The diversity indexes of arthropod fauna from net sweeps in maize ecosystem in plain area shows that the arthropod diversity of H=0.13 of the family Delphaeidae as the maximum fallowed by Culicidae (H=0.12). The records also shows that 0.55 individuals of the family Delphacidae during autumn seasons in 2003 fallowed by Culicidae (0.24) during the same year of the seasons. It can also be shown that the arthropod populations are more diverse during summer season as compared to the other seasons (total of 1.99 in 2003) The present findings of arthropods diversity is supported by the Seasonal abundanee of eurculionid, *Sitophilus zeamais* Motsch. and *S. oryzae* (L.) was studied by Throne and Cline (1991). Watson *et al.* (1980) noted that warm seasons (autumn and spring) favour the abundance, early adult emergence and flight activity of some scarabacids. The different arthropods families recorded from net sweeps includes, Theriidae, Saltieid (Araehnedae); Cerambycidae, Meloidae, Chrysomelidae, Coccinelidae, (Coleopteran); Gryllidae, Acrididae, Tettigonidae (Orthopteran); Muscidae (Dipteran); Pentatomidae, Cicadidae, (Hemipteran); Muscidae (Dipteran); Blattidae, Mantidae Formicidae (Hymenopteran); Coenagrionidae, (Odonida); Noctuidae, (Lepidopteran); Forfieulidae (Dermapteran); Termitidae (Isopteran) and Mantidae (Dyctyopteran).

5.1.2. Arthropod diversity in maize ecosystem at foothill of Nagaland

The arthropod fauna recorded from foot-hill area maize ecosystem during the period of study belongs to 13 orders and 41 families. The order Coleoptera recorded the maximum number of families (8) followed by Hemiptera (7). Detail discussions of the findings are:-

5.1.2.1. Arthropod diversity from Pitfall traps

Arthropod collected from pitfall traps records a total of 114.4 numbers. It is evident that the family Formicidae recorded the highest number of arthropods (H=0.16) especially during summer season in 2003 (14.79). The report is very much familiar with the findings made by Reddy and Alemla (1995), they reported that in maize agro ecosystem of Nagaland family Formicidae dominant the group of arthropods during rainy season (summer) which falls between June and August months. Again it is evident from the table that season wise record of arthropod populations was found to be second highest during summer in 2003 (20.31). Different arthropods families recorded during the present studies includes Carabidae, Cicindellidae, Scarabaedae, Elateridae (Coleopteran); Gryllidae, Gryllotalpidae, Acrididae (Orthopteran); Lycosidae (Arachnida); Formicidae (Hymenopteran); Forficulidae (Dermapteran); Blattidae (Dyctyopteran); Termitidae (Isopteran); Poduridae, Entomobyridae, Tenuipalpidae (Collembolan) and Tetranychidae (Acarina).

5.1.2.2 Arthropod diversity from soil extraction

The diversity index of arthropods fauna from soil extracts in maize ecosystem in foot-hill area records H=0.16 in case of Poduridae and

Tenuipalpidae. A total of 36.37 numbers of arthropods were recorded during the seasons. The table shows that Collembola dominates the group of arthropod catches under three families. The total arthropod records is found to be maximum during summer season (20.11) in 2003, which is very much coincides, with the findings as reported by Hazra and Choudhuri, (1981). They reported that maximum population size of collembolan is attained during the monsoon period or during the immediate post monsoon period. The order Collembola was represented by Poduridae and Tenuipalpidae. Similarly, Guru *et al.* (1988) also reported Collembola belonging to five families from cultivated and uncultivated sites of Western Orissa. The different arthropods families recorded during the present studies includes:- Tetranychidae (Acarina); Formicidae (Hymenopteran); Muscidae (Dipteran) Poduridae, Tenuipalpidae, Entomobyridae (Collembolan) and Termitidae (Odonata).

5.1.2.3. Arthropod diversity from light traps

Diversity index of arthropods by light trap catches from foot-hills in maize ecosystem shows that the maximum arthropod diversity of H=0.16 was represented by the family Scarabaedae (Coleopleran). This family was recorded maximum during summer season (13.48 in 2003). The Coleopteran order belonging to families Carabidae, Chrysomelidae, Scarabaeidae, Cicindelidae, Cureulionidae, Elateridae, Cerambycidae, Buprestidae and Coccinellidae were recorded during the seasons in light traps. Bhat and Rajagopal (1992) reports the light trap catches of Carabids and reported 37 species of Carabids belonging to 14 tribes. Hemiptera consisted of the families Coreidae, Pentatomidae, Belustomatidae, Fulgoridae Cicadidae and Delphaeidae. Mooed and Meads (1985) also recorded Hemipterans belonging to nine different families and 158 species of Celeoptera belonging to 36

families. The records of these workers confirm the findings from the light traps. Different arthropods families recorded from light traps includes, Gryllidae, Grylotalpidae, Acrididae, Tettigonidae (Orthopteran); Vespidae, Formicidae (Hymenopteran); Coenagrionidae, Agrionidae (Odonata); Culicidae and Muscidae (Dipteran); Blatidae, Mantidae (Dyctyopteran); Pyralidae, Nymphelidae and Noctuidae, (Lepidoptera) and Termitidae (Isopteran).

5.1.2.4. Arthropod diversity from sweep net

The diversity indexes of arthropod fauna from net sweeps in maize ecosystem in foothill area shows that the arthropod diversity of H=0.14 of the family Delphacidae (Hemipteran) as the maximum fallowed by Oxyopidae (Arachneda) H=0.13. The records also show those 0.35 individuals of the family Delphacidae during autumn seasons in 2002 and the next Oxyopidae (0.43) during the spring seasons in 2003. It also shows that the arthropod populations are more diverse during summer season as compared to the other seasons (total of 1.8 in 2003). The present findings of arthropods diversity is supported by the Seasonal abundance studied by Watson *et al.* (1980) which reported that warm seasons (autumn and spring) favour the abundance, early adult emergence and flight activity of some scarabacids. The different arthropods families recorded from net sweeps includes, Gryllidae,, Acrididae, Tettigonidae (Orthopteran); Coreidae, Pentatomidae, Pyrrocoridae, Fulgoridae, Delphacidae and Cicadidae, (Hemipteran); Muscidae, Agromyzidae and culicidae (Dipteran); Oxyopidae and Araneidae; Pyralidae (Lepidoptera); Carabidae and Elateridae (Coleopteran); Coenagrionidae, (Odonata); Blattidae, Mantidae (Dictyopteran); Vespidae and Apidae (Hymenoptera).

5.1.3.1. Arthropod diversity in maize ecosystem at uphill belt from pitfall trap

Arthropod collected from pitfall traps in up-hill area records a total of 206.4 numbers. It is evident that the family Formicidae recorded the highest number or arthropods (H=0.16) especially during summer seasons in 2004 (15.28). The report is very much familiar with the findings made by Reddy and Alemla (1995), they reported that in maize agro ecosystem of Nagaland family Formicidae dominant the group of arthropods during rainy season (summer) which falls between June and August. The different arthropods families recorded during the studies includes Carabidae, Meloidae, Scarabacidae, and Cicindellidae, (Coleopteran); Gryllidae, Gryllotalpidae (Orthopteran); lycosidae (Arachnida); Formicidae (Hymenopteran); Muscidae (Dipteran); Forficulidae (Dermapteran); Blattidae (Dictyopteran); Entomobyridae, (Collembolan) and Termitidae (Isopteran).

5.1.3.2. Arthropod diversity from soil extract

The diversity index of arthropods fauna from soil extracts in maize ecosystem in up-hills area records a total or 22.36. The result shows that the family Tetranychidae dominated the group (H=0.15) of arthropod catches during the entire seasons. Only three families were found recorded under three different orders. Tetranychidae (Acarina) recorded maximum during summer season in 2004 (1.45), fallowed by Family Poduridae (Collemdola) (5.8) during the same season in 2003. The total arthropod records is found to be maximum during summer season (7.16) which is very much coincides, with the findings as reported by Hazra and Choudhuri, (1981). They reported that maximum population size of collembolan is attained during the monsoon period or during the immediate post monsoon period. Poduridae represented

the order Collembola. Similarly, Guru *et al.* (1988) also reported Collembola belonging to five families from cultivated and uncultivated sites of Western Orissa. The different arthropods families recorded during the present studies include Tetranychidae (Acarina); Scarabaeidae (Coleopteran) and Poduridae (Collembolan)

5.1.3.3. Arthropod diversity from light traps

Diversity index of arthropods by light trap catches from up-hills area in maize ecosystem shows that a total of (H=0.13) individuals arthropods dominated by Blattidae (Dictyoptera). During winter season in 2002-03, maximum of 2.63 numbers were recorded fallowed by Noctuidae (H=0.10) during spring season in 2003 ((0.58). The total population 3.76 was recorded in 2003 summer season. Bhat and Rajagopal (1992) studied the light trap catches ofCarabids and reported 37 species of Carabids belonging to 14 tribes. Mooed and Meads (1985) also recorded Hemipterans belonging to nine different families and 158 species of Celeoptera belonging to 36 families. The records of these workers confirm the findings from the light traps.. It may be noted that the arthropod diversity were less where hurricane lamp was used as light trap but it was recorded maximum from electrical light trap as in case of both plain area and foot-hill maize fields, which may be due to the influence of the intensity of light. Different arthropods families recorded from light traps includes, Theriidae and Salticidae (Arancida); Meloidae, Chrysomelidae, and Coccinelidae (Coleopteran); Gryllidae, Acrididae and Tettigonidae (Orthopteran); Muscidae (Dipteran); Pentatomidae, and Cicadidae (Hemipteran); Coenagrionidae (Odonida); Blattidae, Mantidae (Dictyopteran); Noctuidae (Lepidoptera); Forficulidae (Dermapteran) Termitidae (Isopteran); and Ichneumonidae and Formicidae (Hymenopleran).

5.1.3.4. Arthropod diversity from net sweeps

The diversity indexes of arthropod fauna from net sweeps in maize ecosystem in up-hills area shows that the arthropod diversity of H=0.11 of the family Acrididae as the maximum fallowed by Chrysomellidae; Muscidae and Coenagrionidae (H=0.10 each). The records also show that 0.90 individuals of the family Acrididae during autumn seasons in 2003 fallowed it can also be shown that the arthropod populations are more diverse. The present findings of arthropods diversity are supported by the Seasonal abundance of curculionid, *Sitophilus zeamais* Motsch. and *S. oryzae* (L.) was studied by Throne and Cline (1991). Watson *et al.* (1980) noted that warm seasons (autumn and spring) favour the abundance, early aduh emergence and flight activity of some scarabaeids. The arthropods' populations tends to be more during autumn, the reasons could be they (arthropod) seeks for hibernation for winter. The different arthropods families recorded from net sweeps includes, Chrysomelidae, Coccinelidae, Meloidae, and Coccinelidae (Coleopteran); Gryllidae, Acrididae, and Tettigonidae (Orthopteran); Pentatomidae, Cicadidae, and Fulgoridae (Hemipteran); Blattidae and Mantidae (Dictyoptera) Muscidae and Agromyzidae (Dipteran); Coenagrionidae, (Odonida); Forficulidae (Dermapteran); Theridiidae, Salticidae, ,Oxyopidae, and Arancidae (Arachnida).

5.2. Total arthropod diversity indices

Two indices (1). Shannon-Weiner Diversity index (H) and (2). Simpson-Yule diversity index (D). H' considers both the number of species and the distribution of individuals among species (Kikkawa, 1996); where as

D' weighed towards the abundance of the commonest species rather than providing a measure of species richness.

Diversity indices from the table (pitfall trap) shows that the arthropod diversity is higher at plain areas followed by foothill and uphill (H = 0.808, 0.807 and 0.471 respectively). Basing on the diversity indices (Soil extract), the arthropod populations are more diverse in plain area (H = 0.706) followed by foothill and uphill (H = 0.617 and 0.304) respectively. While on the other hand the species abundance D' is more in uphill (4.603) followed by plains 10.390) and the least abundance species at foothills (15.791) The differences in the family/species composition at the different localities can be attributed to the thermal requirements (Li and Mills, 2004)

From light trap it is evident that the uphill area is more diverse as compared to foothill and plain area maize ecosystems (H= 1.215, 1.194 and 1.176) respectively. Similarly, species abundance is also more in uphill then foothills and plains in descending order. (D = 55.420, 109.596 and 128.068) respectively. Contrary to Verma *et al.*, 1982 weather factor has great effect on population build up of insect pest.

Diversity indices from the table, by net sweepings, shows that the anthropod diversity is higher at foothill areas followed by plains and uphill (H = 1.133, 1.150 and 1.232 respectively). Where as the abundance of commonest species shows more in plain area, uphill and least in foothill (D = 53.783, 54.805 and 68.347 respectively). The result was obtained by using the method as suggested by Southwood and Henderson, 2000

5.3. Biodiversity of common arthropod population from three locations

Family wise diversities according to their order/family and season during September 2002 to August 2004 are as described below:

5.3.1. Plain area

Pooled data on the mean population of dominant Arthropod groups recorded at plain area maize ecosystem and their seasonal abundance revealed that a mean total number of 838.35 arthropod belonging to 27 families under 13 orders i.e. Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachnida, Collembola and Acarina.

Coleoptera mean population under this order was recorded 141.33 and season wise comparison records maximum 56.73 during Jun-Aug. Orthoptera; Gryllidae was the recorded mean total of 107.07 and the seasonal abundance records maximum during Mar.-May 42.52.

Order Hymenoptera with a single family Formicidae was the most abundant arthropod (total mean of 229.45). Seasonal distribution recorded the maximum during Sept.-Nov. 83.40. The finding was similar to the findings as reported by Reddy and Alemla, (1995) where they have reported that ants population/activities increases during rainy seasons.

The diversity indices and the dominance arthropod as represented by H and D: ranges between 0.01 - 0.15; and 1.13 – 6.06 respectively. Famil

Formicidae was more diversified as compared to other families (H = 0.15) and the abundance arthropod' family was also represented by the same family (D = 1.13). The diversity indices and dominance differs significantly in both the cases.

5.3.2. Foothill area

The population of common dominant Arthropod groups recorded from foothill maize ecosystem and their seasonal abundance revealed that a mean total number of 297.85 arthropod belonging to twenty seven families under thirteen dominant orders i.e. Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachnida, Collembola and Acarina.

Coleopteran, overall mean population recorded 108.44, seasonal wise comparison records maximum 40.10 during Mar.-May. Order Hymenoptera with a single family Formicidae was the most abundant arthropod (total mean of 61.36).

The diversity indices; (H, and D); ranged between 0.02 - 0.30; and 1.22 – 6.87 respectively which differs significantly in both the cases. It is clear that the family Cerambycidae was more diversified as compared to other families (H = 0.30) followed by Scarabaeidae (H = 0.15).

5.3.3. Uphill area

Data on the mean population of common and dominant arthropod group recorded from uphill maize ecosystem and their seasonal abundance shows that atotal number of 297.35 different arthropod.

Coleoptera mean population was recorded 15.13 and season wise comparison records maximum 6.13 during Sept.-Nov, family Formicidae was the most abundant and dominant arthropod (total mean of 64) This findings was supported by the findings made by . Mooed and Meads (1985) and Reddy and Alemla (1995).

Diversity indices; (H, and D): reveals Entomobyridae was more diversified as compared to other families (H = 0.15) followed by Formicidae (H = 0.14) and the abundance arthropod family was represented by Entomobyridae (D = 0.65) and the least was represented by Gryllotalpidae (D = 6.34).

5.4. Comparative studies of com mon arthropod diversity indices

The diversity indices of common seasonal and dominant arthropod orders from three different maize ecosystems are described

5.4.1 Plain area

There are altogether 13 arthropod orders commonly found at plain area maize ecosystem. The diversity indices of arthropod as represented by H ranges between 0.01 - 0.15; and the dominance between 1.13 and 6.06. Family Formicidae represent the most diversified and the dominance characters. (H = 0.15); (D =1.13), followed by Poduridae (H = 0.14; D = 1.33) respectively. Statistical methods as suggested by (Magurran, 1988).

5.4.2. Foothill area

There are altogether 13 arthropod orders commonly found at foothill area maize ecosystem. The diversity indices of arthropod as represented by H: ranges between 0.02- 0.30; and the dominance between 1.22 and 6.87. Family Cerambycidae was more diversified as compared to other families (H =0.30) followed by Scarabacidae (H= 0.15) and the abundance was represented by the same family (D = 1.22) and the least abundance was represented by Arancidae (D = 6.87) as suggested by (Magurran, 1988).

5.4.3 Uphill area

Altogether 13 arthropod orders commonly found from uphill area maize ecosystem. The diversity indices of arthropod as represented by H: ranges between 0.02 - 0.15; and the dominance between 0.65 and 6.34. Family Entomobyidae represent the most diversified and the dominance characters. (H =0.15); (D =0.65), followed by Formicidae (H = 0.14; D= 1.32) respectively. As suggested by (Magurran, 1988).

5.5. Biodiversity indices of un-common arthropod populations at three different locations during September 2002 to August 2004.

5.5.1. Plain area

It has been recorded that in plain area maize ecosystem, the families like Hydrophillidae, Agrionidae and Pieridae were found dominant with their totals

of 76.16, 1.54 and 3.52 respectively. The diversity indices (H) and (D) shows mean totals of 0.15 and 6.48 respectively.

5.5.2. Foothill

From foothills maize ecosystem, families Curculionidae, Pyrrocoridae and Nymphilidae were recorded with their grand mean totals of 2.98 only. Season wise mean totals as 2.19, 0.03, 0.65 and 0.11 during Sept.-Nov., Dec.-Feb., Mar.-May and Sept.-Nov. respectively. The diversity indices show means of (H = 0.07 and D = 13.00).

5.5.3. Uphill area

From uphill maize ecosystem, family wise arthropod as Meloidae, Ichneumonidae and Salticidae are recorded seasonally with their mean totals of 0.97, 0.11 and 1.33; and their indices H = 0.09 and D = 10.55 respectively.

5.6. Comparative study of uncommon arthropod diversity indices

The comparative studies on uncommon arthropod diversities indices reveals that the indices lies between (H= 0.01 - 0.06) and (D=0.14 – 6.10). From plains the diversity indices (H) and (D) shows mean totals of 0.15 and 6.48 respectively, similarly from foothill maize field the diversity indices shows means of (H = 0.07 and D = 13.00) and from uphill it was shown H = 0.09 and D = 10.55 diversity indices. Statistical methods as suggested by (Magurran, 1988).

5.7. Seasonal relative abundance of common dominant arthropod population (%) from three different maize ecosystems

The common arthropod populations and their relative abundance from three different maize ecosystems are described family wise according to their orders and season during September 2002 to August 2004. Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachnida, Collembola and Acarina are the orders under study.

5.7.1. Plain area maize ecosystem

Pooled data on the mean population of common dominant arthropod groups recorded at plain area maize ecosystem and their seasonal abundance. The table revealed that a mean total number of 838.35 arthropod belonging to twenty seven families under thirteen dominant orders.

Coleoptera the most dominant order comprises of families Chrysomelidae, Carabidae, Cerambycidae, Cicindelidae and Scarabaeidae Overall mean population under this order was recorded 141.33 which account to 16.86%. Seasonal wise comparison records maximum 54.99 (6.56%) during Mar.-May.

Hemipteran Families; Pentatomidae, Fulgoridae and Cicadidae in which Pentatomidae was the maximum 9.52 1.14%) Seasonal distribution records maximum during Sept.-Nov. 7.16 (0.85%). The mean totals under this order records 12.36 1.47%)

Orthoptera families Viz:- Gryllidae, Aeridídae, Tettigonidae and Gryllotalpidae. Among the families, Gryllidae was the most dominant which recorded mean total of 107.07 12.77%) and the seasonal abundanee records maximum during Mar.-May 42.52 (5.07%).

Order Ilymenoptera with a single family Formicidae was the most abundant arthropod (total mean of 229.45 no. covering 27.37% of the totals). Seasonal distribution reeorded the most during Sept.-Nov. 83.40 (9.95%)

5.7.2. Foothill maize ecosystem

The common dominant arthropod groups recorded from foothill maize ecosystem and their seasonal abundanee shows that a mean total number of 297.85 arthropod.

Coleoptera aeeount to 36.41% seasonal wise comparison records maximum 40.10 13.36%) during Mar.-May Hemiptera seasonal population records maximum during Sept.-Nov. 4.90 1.65%). The mean totals under this order recorded 10.76 (3.61%). Families, Gryllidae O. Grthoptera was the most dominant which reeorded mean total of 24.46 (8.21%) and the seasonal abundance records maximum population during Mar.-May season as mean totals of 15.46 (5.19%). Grder Hymenoptera with a single family Formicidae was the most abundant arthropod 20.60% of the totals). Seasonal distribution recorded the maximum during Sept.-Nov. 23.91 (8.03%) totals.

5.7.3. Uphill maize ecosystem

Data on the mean population of common and dominant arthropod groups recorded from uphill maize ecosystem and their seasonal abundanee shows that a total number of 297.35 different arthropod.

Coleoptera recorded 15.13, which account to 5.09%. Seasonal wise comparison records maximum 6.13 (2.06%) during Sept.-Nov. Hemiptera 1.27%), seasonal distribution records maximum during Sept.-Nov (0.66%). Families, Gryllidae records a mean total of 6.24 (2.10%) and the seasonal abundance records maximum during Sept.-Nov. 6.54 (2.20%). Hymenoptera with a single family Formicidae was the most abundant and dominant arthropod (total mean of 64.90 no. covering 21.83% of the totals). Seasonal distribution recorded the most during Sept.-Nov. 26.86 (9.03%)

Diptera recorded mean totals 6.90 (2.32%). Maximum population was recorded during Sept.-Nov. season (2.55; 0.86%). Family Coenagrionidae, (O; Odonata); Noctuidae (O; Lepidoptera) and Termitidae (O; Isoptera) recorded mean totals of 4.19; 1.41 %), 2.01; (0.68%) and 6.16 respectively. The seasonal abundance of those families recorded during Mar.-May season for the Noctuidae (0.96; 0.32%) and during Sept.-Nov. season for Coenagrionidae and Termitidae as 1.51; (0.51%) and 1.72; (0.52%) respectively.

Arachneda families Lycosidae, Oxyopidae and Araneidae population records maximum during Sept.-Nov. season (mean total of 5.68 1.91%). Collembolan families viz: Entomobyridae and Poduridae with maximum populations during Sept.-Nov. season (mean total 69.580 as 23.40%). Hazra and Choudhuri, (1981) reported that maximum population size of collembolan is attained during the monsoon period or during the immediate post monsoon period which was similar to this findings.

5.8. Comparative study of relative abundance of common /uncommon arthropod (%) in three maize ecosystem

The comparison study on common arthropod populations and their relative abundance from three different maize ecosystems are described in accordance to their orders and season during September 2002 to August 2004. The orders, Viz;- Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachnida, Collembola and Acarina are recorded.

Pooled data (Table 23) revealed that a mean total number of 838.35 arthropod belonging to 27 families under 13 dominant orders from plain area, foothill 297.85 and uphill 297.35 numbers was recorded.

The per cent relative abundance of uncommon arthropod from plain area was 15.08% foothill 0.50% and uphill area 34.42%. Seasonal distribution of arthropod population from all the locations was highest during March-May 6.81%, 0.11% and 19.90% from plain, foothill and uphill.

5.9. Arthropod populations from different locations by different methods of collections during September 2002 to August 2004.

The total populations from pitfall was found to be more (669.2) from plain area (Dimapur) In other two stations, Medziphema and Kohima, the arthropod recorded maximum during Sept.-Nov. in 2003, 28.4 and 59.41 respectively.

From soil extraction methods it was recorded a total of 36.37 from Medziphema followed by Kohima and Dimapur, 22.36 and 11.69 respectively. In all the cases, it was found recorded maximum during Sept.-Nov. in 2003.

Light trap catches recorded the totals of 393.04, 209.92 and 22.59 from plain area, foothill and uphill respectively. From plains maximum 133.11 numbers were recorded during Mar.-May season in 2003 so as in 2004, 40.58 numbers were recorded from foothill where as from uphill it was recorded 3.76 numbers during Sept.-Nov. in 2003.

Net sweeping methods records a totals of 11.28, 9.99 and 28.75 maximum during Sept.-Nov. season in 2003 1.99, 1.81 and 5.55) from plains, foothill and uphill respectively.

The result shows that plain area exhibit more arthropod population through all the traps except sweep net as well as seasonal collection recorded the highest during summer months (June to September) similar to the findings made by Ostbye (1978), who reported high catches of Coleoptera during June and July, and noted that the group mostly as predators especially Carabidae and Staphylinidae tend to alternate in their predation activities.

5.10. Relationship of arthropods with abiotic factors

The study on correlation coefficient (r) of arthropods orders of maize field consist of 13 the orders Viz:- Coleopteran, Hemipteran, Orthopteran, Hymenopterans, Diptera, Odonata, Lepidoptera, Isoptera, Dyctyoptera, Dermaptera, Arachnida, Collembola and Acarina. These orders were studied with weather parameters such as Temperature, rainfall and relative humidity

under three different maize field ecosystems and their correlation are discussed with the findings of earlier workers.

The relationship of plain area remains in favour of summer months and decline gradually with the onset of winter months. Edwards *et al.* (1975) and Hutson (1978) reported that temperature is one of the most important factors in dealing with the activities of Arthropods. They also reported that the Arthropod activity depends upon weather condition especially temperature and soil moisture and the general habitat surrounding the trap. As the temperature at plain area are warmer due to lower altitude (as in Dimapur 260m msl) the total arthropod recorded was very much highef (1080.99) table 17, as compared to foot-hills and up-hills which recorded the total arthropods as 370.59 and 302.98 respectively which is supported by the findings as quoted Gaston and Williams, 1996. The lesser availability of moisture coupled with excessive temperature on the lower latitudinal margins, especially in the tropical regions affect the distribution of insects especially in the larval stages of herbivorous insects (Bale et al 2002; Hawkins et al 2003). This will happen with many of the endopterygote insects like Coleoptera, Lepidoptera, Diptera and Hymenoptera, especially in the case of herbivorous insects, which are the major pests of agricultural crops. These changes not only limit the species richness in terms of distribution but also in terms of populations and in terms of abundance, Ramamurthy, 2009.

The major groups of arthropods were correlated with weather parameters such as temperature, rainfall and relative humidity. It was observed that all the groups of arthropods had shown positive and significant relationship at 5% and 1% level of significance and none of the group had negative significant relationship with abiotic factors. Similar reports of

correlations between arthropod and weather parameters were also given by Briggs, 1961, Duffey, 1962, Mitchell, 1963 and. Greenslade, 1964

The population density of Coleoptera was found to be highest during spring seasons in plain (92.13) and foot-hills (42.09), but in up-hills it was found to be highest during summer seasons (7.70). The correlation analysis between the population of Coleoptera and abiotic factors exhibited a significant positive correlation with temperature, rainfall and humidity at foot-hills but non-significant with relative humidity at up-hills maize cosystems. Itowever, at plains abiotic factors maintained a positive correlation but non-significant with order Coleoptera. In consistence to this, Reddy and Alemla (1995) noted the abundance of Coleoptera in maize ecosystem during the rainy seasons, while they were absent during the winter and reported a significant correlation with rainfall and soil temperature. However, Moeed and Meads (1985) did not find any correlation between the Coleopteran abundance and rainfall. Jitendar Kumar *et al.* (2007) while studying Scarabacid beetles reported their peak period during June – July (summer) and stated that minimum temperature had significant positive correlation with the emergence of beetles.

The population density of Hemiptera were dominated mostly by family Delphacidae (25.08) followed by Pentatomidae (9.52) in plain and foot-hills area maize field but the family Delphacidae was not recorded from up-hills. Their most active period was recorded during summer June – August months. Surprisingly, the lowest Hemiptera population was recorded during December – February in all the three maize ecosystems. The influence of temperature and rainfall on their population was positively significant but non-significant with relative humidity at plains whereas, at plains a positive bul non-significant correlation with temperature and relative humidity and a positive effect of

rainfall.. Atwal and Dhaliwal (1997) noted that the population of both leaf hopper and plant hopper increases during July to August and decreases markedly after a heavy rain. Gaston and Williams reported that insect species diversity per area tends to decrease with higher latitude and altitude, meaning that the insects' behaviors enhances with increasing temperature. (Bale *et al*, 2002).

The seasonal abundance of Orthopterans among the three maize ecosystems. In plain and foothill area, they were in abundance during spring seasons (42.52 and 15.46). While at up-hills the population recorded higher during summer months. The correlation study had revealed that the Orthopteran had shown a positive significant relationship with temperature but positively non-significant with rainfall and relative humidity at plains. At foothill, it was positive and significant with rainfall and relative humidity but non-significant with temperature and in upland rice ecosystem all the abiotic factors had exhibited a significant positive relation with Orthoptera. Reddy and Alemla (1995) had recorded Orthoptera in higher number during rainy season and in low number during the winter in Nagaland, which is similar to the present finding. Majer and Koch (1982) noted that the Orthoptera showed high levels of activity in spring, summer and in early autumn and were positively correlated with temperature and negatively correlated with relative humidity and rainfall.

The population of Hymenoptera mostly dominated by family Formicidae (ants) and are recorded the highest number 229.45, 61.36 and 64.9 from plains, foothill and up-hills respectively. In all the three locations, the population of these taxa records highest numbers during summer seasons as 85.00, 27.21 and 5.92 respectively. The correlation analysis revealed that the

population showed positive and significant relationship with temperature in all the fields; however in up-hill alone it was positively and highly significant with all the three weather factors.

Several workers are of the opinions that increase in temperature and food served as threshold for ant population fluctuation and the increase in ant activity was correlated with rainfall (Kajak *et al*, 1972, Whitford, 1978, Majer, 1981). However, Majer and Koch (1982) and Moeed and Meads (1985) stated that increase in ant abundance was negatively correlated with rainfall. They also observed maximum activity of ants during spring and summer and low activity during the winter and concluded that the probable reason for the increase in ant population during this period may be the increase in number of herbivores. Subrahmanyam *et al*, 2009 also quoted that rising in temperature increase insect populations in several complex ways and that most of the researchers seem to agree that warmer temperatures in tetuperate climates will result in more types and higher populations of insects.

Order Diptera mostly comprise of three families which are found recorded from these three maize field, the population records shows variable conditions in all the three locations as, in plains it was found maximum during spring seasons (39.61), at foothills during autumn (2.22) and at up-hills during summer seasons (2.55). The correlation (r) to this order varies according to the locations as, in plains it is positively correlated and significant with rainfall and humidity but positive non-significance with temperature. In foot-hills, it was found that the order is positively significance at 5% levels with temperature but non-significant with rainfall and humidity. In up-hill, again the order is positively significant with temperature and rainfall but non-significant with relative humidity.

The population of order Odonata records a maximum of two families Viz: Coenagrionidae, and Agrionidae. These families were recorded with more population density at plain (8.68), foothill (7.47) and up-hills (4.19) under three maize ecosystems. Their population density was recorded highest during spring season (2.60) in plain area, 2.87 numbers from foothill during autumn and 1.51 numbers from up-hills during summer seasons. A significant positive effect of temperature was observed on the population of Odonata at plain area ($r = 0.6612$) maize ecosystem while the influence of rainfall and relative humidity was positive and highly significant at foothill (0.9024 and 0.9016) respectively. Khaliq and Siddique (1995) identified 14 species form Libellulidae and Coenagrionidae in Pakistan. Fraser (1931) stated that the species diversity of Odonata has a direct relation to the measures of rainfall or abundance of water supplies. This suggestion seems to have credence as mountainous ranges characterize the topography of Nagaland and isolated small hills with vegetations, surrounded by streams and heavy rainfalls during monsoon months, which might have offered diverse aquatic habitat environments for Odonata particularly in the uphill and foothill.

Lepidoptera, mostly confined to families Noctuidae, and Pyralidae Lepidopteran population was negligible for relating to any weather parameters. Result on their correlation with weather factors at all levels and locations shows a highly positive but non-significant effects, except at up-hills temperature shows positive correlation relation ($r = 0.8158$) but non-significant with rainfall and relative humidity. Rai *et al.* (2002) reported a peak occurrence of Lepidopteran pests (Fam : Pyralidae) during the first forthnight of October and stated that the period of peak occurrence of the pest coincide with the ranges of favourable environmental factors during kharif season. They also reported a positive correlation between the Pyralid insect and relative humidity

and non-significant influence of temperature, which is in consistence with the result obtained at all the locations.

Findings on the seasonal abundance of Isoptera (family: Termitidae.) table 24 – 25, they are recorded maximum during summer months (10.36) from plain area, 8.08 numbers during spring from foot-hills and 0.96 numbers during spring from up-hills respectively. The findings reveal that as the altitude goes higher the population decreases for this particular fauna. Correlation (r) between Isopteran and weather factor shows highly positive and significant with rainfall (r = 0.9876)and humidity (r = 0.9856) at foot-hills maize ecosystem, where as they are positive but non-significant with all the weather factors in all the locations. Rathore (1998) stated that July month (mid-summer) seems to be the most active month for swarming of termites and there was a significant correlation between swarming time and amount of precipitation and humidity.

In case of Dictyoptera, temperature had a positive significant influence at all the locations (r = 0.8139, 0.6076 and 0.6294 at plain, foot-hills and up-hills areas respectively). Rainfall and relative humidity at plain area shows significant positive correlation (r= 0.6190 and 0.8844). No detail work could be available on the seasonal abundance and correlation study on Isoptera and Dictyoptera. However, it is noticed that early swarming associated with pre-monsoon shower in May and similarly delayed swarming occurred in September which indicates a correlation between pre-monsoon and monsoon showers on swarming of these pests.

Dermaptera, family Forficulidae was recorded in a few numbers, which are found abundant during summer and pre-monsoon. A total of 2.41, 0.41 and

1.72 were recorded from plains, foothill and up-hills area respectively which indicated that the plains are more diverse as compared to the higher locations. The correlation between the order and weather factors indicated that in foo-hills, they are positively and highly significant with all the weather factors where as in plains and up-hills area they are significantly correlated with temperature alone (r = 0.7148 and 0.6052).

Acarina (mites and spiders) were found maximum during summer and pre-monsoon seasons. In plains they are abundant during summer (45.09 mean) but in other two locations the populations are more during spring. Hagvar *et al.* (1978) reported the peak occurrence of Araneae during July – August suggesting that the difference in the pattern of catches may be attributable to different climatic factors.

Collembola population were recorded at plain, foothill and up-hill with its peak population during the months of April (112.4), May (84.8) and August (21.0) respectively, while zero population was recorded during November to February at both lowland and foothill, while minimum abundance was recorded between December to January at up-hill rice field. The study of Collembola and weather parameters revealed a positive non-significant relationship with temperature, rainfall and relative humidity in both plain and up-hill, whereas, at foothill, the population showed significant positive association with temperature but non-significant with rainfall and relative humidity.

Wallacel and Mackerras (1970) and Mc Coll (1975) suggested that the decline in number of Collembola activity on the soil surface towards the end of summer is attributed to the dry conditions. Reddy and Alemla (1995) also

reported high catches of Collembola during March – October with intermittent rains when the temperature was high but the vegetation growth was flourishing and their population decreased during the dry winter season. They had also stated that there was a positive correlationship between the Collembola population, temperature and rainfall.

Results on the seasonal abundance of Araneida (spiders) had shown that their most active period at lowland, foothill and upland rice fields were recorded during April – May, July – September and May – July while lowest population density was noted in January – February respectively. The correlation study had exhibited a non-significant but positive association of temperature, rainfall and relative humidity and with the spider population at lowland while all the three factors maintained significant positive relation with spider community at both foothill and up-hill. In more consistency, Reddy and Alemla (1995) also reported high catches of Araneae during May while they had recorded zero population during April, June and November. Dolly Kumar and Kumar (2004) stated that the population dynamics of spiders at rice field occurred their peak density during the post monsoon season. Edwards *et al.* (1975) reported more catches of spiders in August and lowest in December. Kumar and Patil (2004) conducted a survey in rice ecosystems for Raichur area of Karnataka and recorded 17 species of spiders. They observed that the spiders were active throughout the cropping season at all locations, with maximum population densities occurring from 2nd fortnight of October to the second fortnight of November. Contrary to the present finding, Singh and Singh (2000) reported a positive correlation of spider population with crop age and insect pest population whereas negative correlation was observed with most of the abiotic parameters. Hagvar *et al.* (1978) reported the peak

occurrence of Araneae during July – August suggesting that the difference in the pattern of catches may be attributable to different climatic factors.

5.11. Seasonal insect pest complex population at three different maize ecosystem

The insect pest complex populations which are obtained from maize ecosystem from three locations are discussed briefly as under

5.11.1. Inventory of insect pest population

The inventory of arthropod fauna from these locations revealed that 13 arthropod orders under 40 families and species were recorded. Order Coleoptera recorded the maximum arthropod families 11 no. viz Carabidae, Coccinellidae, Cicindellidae, Cerambycidae, Scarabaeidae, Melononthidae, Hydrophyllidae, Buprestidae, Elaterid, Meloidae and Curculiniodae. Family Carabidae was recorded highly abundant from all the locations and the remaining families recorded moderately or their presenee. The family Hydrophillidae was recorded only from plain area so as Curculiniodae from foothill maize field.

Family Coreidae, Falgoridae, Pentatomidae, Cicadidae, Delphacidae and Cieadellidae under orded Hemiptera were recorded with their genus *Leptocorisa spp. Dolycoris spp. Cofana spectra. Sogatella spp* and *Cofana spectra* except for Falgoridae which genus was unidentified. It was evedent from the table that the degree of their presence is reflected except for *Leptocorisa spp* and Sogatella *spp* which were not recorded from uphill. This report is similar to the findings made by Ostbye (1978) and Devinder *et al.*

(2007) they had reported high catches of Coleoptera during June and July, and noted that the group mostly as predators especially Carabidae and Staphylinidane tend to alternate in their predation activities. They reported that the carabidae showed peak of its activity during spring while Staphylinidae were highest in number during summer by using light trap.

Field cricket *Acheta spp.* Short horned grasshopper *Hieroglyphus spp.* Long horned grasshopper (unidentified), and Mole cricket *Gryllotalpa Africana* were found recorded as highly abundant for the first two genus and the remaining genus shows their presence from all the fields.

Formicidae and Vespidae, O: Hymenoptera represented by ants *Dorylus orientalis* and wasps (unidentified) were found recorded highly abundant in plain and foothill and moderately abundant in uphill (formicidae), where as wasp presence was recorded from plain and foothill but was absent in uphill. Likewise Dipteran flies Muscidae and leafminer Agromyzidae (unidentified) were recorded moderately present from all the fields. Also Dragonfly *Agriocnemis* spp; family Coenagrionidae O: Odonata was moderately abundant and Agrionidae (Damselfly) records its presence from all the fields. The details of the findings are discussed in the next chapter under suitable headings. The findings are made similar to the findings reported by Devinder *et al.* (2007). They had collected and studied the nocturnal Orthoptera by means of light trap and the population fluctuations of twenty four species of Orthopterans were correlated with temperature and relative humidity. In all six families' viz., Gryllidae, Gryllotalpidae, Tettigonidae (belonging to suborder Ensifera) and Acrididae, Tridactylidae and Tetrigidae (belonging to suborder Caelifera) were collected. Gryllidae was found dominant followed by Tetrigidae as compared to other families.

5.11.2.Location wise insect pest complex population in maize in three different maize ecosystems in Nagaland during September 2002 to August 2004.

Location wise insect pest fauna from three maize ecosystem compresses of 5 orders and 7 families with their genus. The data obtained from different methods of collections in the experiments under the present investigations are tabulated with relative abundance in per cen are described as:.

Coleoptera

Under order Coleoptera, Chaffer beetle (Scarabaeidae; species unidentified) was dominant pest recorded from all the fields. The per cent records 47.46%, 54.79% and 9.61% at plains, foothills and uphill respectively. It was evident from the table that foothill record maximum pest populations followed by plain and uphill.

Hemiptera

Brown leafhopper (*Sogatella spp*) family Delphacidae; Order Hemiptera was found recorded at plain and foothill area maize ecosystem as mean total of 26.04 and 22.82 as 19.84% and 17.19% respectively, but was nil at uphill area.

Orthoptera

Orthoptera belonging to two families were recorded during the period of investigstion. viz; Family: Acrididae (genus; *Heiroglyphus Spp*) and

Tettigonidae which was unidentified. They were found present in all the three maize fields with a per cent population of 6.72%, 6.80%, 44.97% and 1.94%, 3.08%, 11.60% respectively from plain, foothill and uphill area maize field. This differenees in pest status might be due to different agronomic praetices as suggested by Singh, (2009).

Isoptera

Per cent relative abundance of *Odontotermes spp* under order Isoptera and family Termitidae was found recorded as 16.63%, 10.87% and 15.59% from all the three maize fields; plain foothill and uphill respectively.

Lepidoptera

Two genus, *Chilo spp* and *Cnaphalococis spp* under family Noctuidae and Pyralidae O: Lepidoptera, were found recorded from all the fields exeept for family Noctuidae, which was not recorded from uphill. The per eent relative abundanee was recorded as 0.41% and 3.94% for *Chilo spp.* from plain and foothill, and eutworm *Cnaphalocrocis spp.* (Noctuidae) was reeorded 6.99%, 3.33% and 18.22% from plain, foothill and uphill as mean relative abundance respeetively.

The overall mean grant totals of 131.24, 132.79 and 11.03 were reeorded from three different locations of maize eeosystem.

5.11.3. Seasonal insect pest population and their relative abundance at three different locations of maize ecosystem during Sept. 2002 – Aug. 2004

Seasonal insect pest fauna and their relative abundance from three maize ecosystems are explained here with their genus. The data obtained from different methods of collections in the experiments under the present investigations are tabulated with relative abundance in percentage are described below (Table 35).

From plain area (Dimapur) maize field mean total of 133.07 insect pests were recorded out of 7 different genus. The genus (unidentified) but under family Scarabaeidae commonly known as Chaffer beetle was the dominant genus occupying 46.81% followed by *Chilo spp.* 32.41%. Seasonal relative abundance of these pests was recorded as mean totals of 19.55, 17.33, 45.01 and 51.18 during autumn, winter, spring and summer respectively. The percentage seasonal distribution of these pests stood as 38.46% during summer followed by 33.82% during spring.

Foothill area (Medziphema) recorded the mean total population of insect pest as 172.87, which were the highest among the three locations. Total percentage of the pests recorded from foothill area stood as 42.08% against Scarabaeit beetles the highest followed by Delphacidae (hoppers) 18.84%. Seasonal per cent distribution was found to be highest during spring season 44.22% and the next was summer 36.96%. Plain area maize field reported more number of insect pest as compared to foothill and uphill which may be due to difference in altitude as suggested by Srivastava and Raghuraman, (2009) they reported that warmer temperature in temperate region will result in more diverse and larger populations of arthropods.

Two of the common species of pest were not found at uphill area and the dominant pest also differs from the former two locations. Here Acrididae; Short horned grasshopper dominated the pest species which recorded 44.97% of the total pest complex. The major insect pest from the region includes Scarabaeid beetle, short and long horned grass hoppers, termites and cutworms. Seasonal relative abundance of these listed insect pests recorded in per cent as 20.85%, 6.26%, 28.74% and 44.15% during autumn, winter, spring and summer seasons respectively.

5.12. Correlation coefficient (r) of seasonal insect pests in relation with weather factors

Correlation coefficient (r) of selected insect pests was statistically analysed with weather factors such as mean temperature (temp) average rainfall (RF) and relative humidity (RH) prevailing in that particular region.

All the insect pests analysed shows positive correlations with weather factors. In plain area Chaffer beetle ($r = 0.6346$) and Brown plant hopper ($r = 0.8602$) shows positively and significantly at 5% levels with average temp. Acrididae Short horned grass hopper shows highly positive significant with all the weather parameters as; temp ($r = 0.9326$), RH ($r = 0.9162$) at 1% levels of significant and RF ($r = 0.6317$). Tettigonidae and Delphacidae were found to be correlated with RF ($r = 0.6072$) and RH ($r = 0.6714$) at 5% levels of significant respectively.

Correlation of insects pest from foothill area with weather factors shows from the table that the temp. had positively correlated with insects like chaffer beetle, brown plant hopper, short horned grass hopper and steam borer, ($r =$

0.7118, 0.9574, 0.8067 and 0.9574) respectively. In this foothill area insect pest (termites) shows very highly and positive correlations with RF and RH (r = 0.9876 and 0.9856) and the remaining insect pests in this area shows positive but non-significant correlationships. Which is in support to the report made by Edwards *et al.* (1975) and Hutson (1978) they reported that temperature is one of the most important factors in dealing with the activities of Arthropods.

In uphill area pests like chaffer beetle, short horned grass hopper, long horned grass hopper and termites shows highly significant correlations with temperature at 1% levels of significant. (r = 0.9028, 0.8275and 0.8272 respectively exeept for termite where r = 0.6052. The listed insect pests beetles and hoppers shows positively and highly correlate with RF (R = 0.9350, 0.9844 and 0.9746) respectively where as the two grass hoppers shows significant correlationship with RH (r = 0.8970 and 0.9271) respectively. And the remaining pests show positive hut non significant with weather factors.

Chapter - VI

Summary and Conclusion

CHAPTER – VI

SUMMARY AND CONCLUSION

The investigation was carried out at three different locations of maize ecosystem having different altitudes and agro climatic conditions to study on diversity of arthropods, seasonal insect pest's complex population and their relationship with a-biotic factors. The study was conducted during September 2002 to August 2004. The observations were taken at fortnightly intervals for all the methods of collections except for Night active arthropods (light traps) which was taken at standard week days.

The experimental findings of the present investigations are summarized as fallows:

Biodiversity of soil surface arthropod from three different maize ecosystem:

- The family: Formicidae dominates the arthropod catches from three maize agro ecosystems during the period of investigation.
- Formicidae was highly diversified than any other arthropod at all the locations..
- The individual population records shows maximum during summer seasons (Jun-Aug .) (8.87%) from plain area

Biodiversity of soil dwelling arthropod from three different maize ecosystems:

- Mites and Collembolla dominates the arthropod catches from soil extraction methods of collection.
- Mite population was at its peak during summer i.e. June-August.
- Collembola population was highest during spring i.e. March-May from all the locations.

- The records show that the arthropods populations are more during spring seasons which fall before the onset of summer monsoon.

Biodiversity of night active arthropod from three different maize ecosystem:

- Family Hydrophillidae (water bug) dominates the arthropod catches by light traps in plain area maize ecosystem which was characterized by cultivation of the field by irrigation water and was not found from foothills and uphill.
- Coleopteran insects was recorded more diversified especially family Scarabaeidae.
- Light traps catches varies according to their nature and size of the individuals.
- The coleopteran dominates the arthropod catches in all the seasons.

Biodiversity of aerial arthropod from three different maize ecosystem:

- The aerial arthropods specially the leaf and plant hopers dominates the group e.g:- Family Delphacidae.
- Delphacidae was more diversified in plain area but were absent at uphill.
- The aerial arthropods were most dominant during summer and in autumn season in all the locations.

Seasonal arthropod population from plain area (Dimapur):

- There were altogether 13 different arthropods Order and 41 different Families.
- UnderColeoptera 8 families were recorded the highest numberofarthropod was recorded under familiy Scarabaeidae (7.43%)
- Family Formicidae recorded the highest number of individuals, a totals of 229.45 (27.37%) was recorded during the period of investigation.

- Family Apidae recorded the minimum number (0.08)
- A maximum of 362.18 numbers of different arthropods was recorded during spring season in 2003.
- A mean grand total of 838.35 different arthropods were recorded from Plain area (Dimapur).

Seasonal arthropod population from foothill area (Medziphema):

- The Order Coleoptera and Hemeptera recorded the maximum number of arthropod families of 8 each. (Table 24).
- There were altogether 13 orders and 41 families.
- A total of 98.73 different arthropods were recorded during March-May
- A mean grand total of 297.85 different arthropods were recorded from foothill area (Medziphema) during Sept.2002 to Aug. 2004.
- Family Scarabaeidae recorded the highest number of individual (72.75 nos.); 24.43%

Seasonal arthropod population from uphill area (Kohima):

- Altogether 13 Orders and 32 different families were recorded during the seasons. (Table 25)
- A mean grand total of 297.35 individuals arthropods were recorded during the entire seasons.
- A total of 126.59 different arthropods were recorded during summer months followed by 98.72 during spring season
- Order Coleoptera recorded the maximum families of 8.
- Family Entomobyridae of Collembola recorded the maximum, 140.75 individuals.

Relative abundance of common arthropod populations at three different locations in maize ecosystem of Nagaland

- Seasonal and common arthropod populations in maize ecosystem at three different locations (plain area, foothill and uphill) are comprised of 13 orders having families 27.
- Order Coleoptera found to more diverse arthropod order.
- Individual totals arthropod was highest for family Formicidae.
- Arthropod population starts building up during spring and reaches its peak during mid summer.
- Some arthropod population was at their highest during summer at foothill maize ecosystem.
- There was not much differences in population densities at foothill as compared to plain area.
- Total arthropod number was less at uphill area maize field.297.25 only.
- Minimum arthropod population was during winter months.
- Many of the key insect pests were not recorded from uphill area.

Seasonal abundance of common arthropods and their correlation with abiotic factors

The study on correlation coefficient (r) of arthropods orders of maize field consist of 13 orders Viz:- Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Diptera, Odonata, Lepidoptera, Isoptera, Dictyoptera, Dermaptera, Arachnida, Collembola and Acarina. The orders are studied with weather parameters such as temperature, rainfall and relative humidity for their correlation under three different maize field ecosystems.

- All the of arthropod group had shown positive and significant relationship at 5% and 1% level of significance and none of the group had negative significant relationship with abiotic factors.
- Abundance of Coleoptera in maize ecosystem was high during rainy seasons, while they were absent during winter at plain area.
- From plain area ,weather factor plays an important role of correlation with temperature.
- Arthropod population record more during spring season in numbers
- The correlation (r) for Diptera varies according to the locations as in plains it is positively correlated and significant with rainfall and humidity but positive non-significance with temperature.
- Delphacidae recorded from plain and foothills area maize field but was not recorded from uphill. The reason for nil report on Brown plant hopper might be due to higher altitude or low temperature (further studies has to be carried out). Their most active period was recorded during summer.

Seasonal insect pest complex at three different maize ecosystem

- The seasonal insect pest complex that are found at different locations was booked under 5 orders and 7 families.
- Natural enemies, non-insect pest and others are listed in table 2 under inventory of insect pest fauna in maize ecosystem.
- Chaffer beetle (Scarabaeidae) was dominant pest recorded from all the fields.
- Brown leafhopper (*Sogatella spp*) family Delphacidae; Order Hemiptera was found recorded at plain and foothill area maize ecosystem but was absent in uphill.
- Acrididae (genus; *Heiroglyphus Spp*) and Tettigonidae which was unidentified were found present in all the three maize fields.

- *Odontotermes spp* under order Isoptera and family Termitidae was found recorded from all the three maize fields; plain foothill and uphill as major pest.
- *Chilo spp* and *Cnaphalocrocis spp* under family Noctuidae and Pyralidae O: Lepidoptera, were found recorded from all the fields except for family Noctuidae, which was not recorded from uphill.

Seasonal insect pest population and their relative abundance at three different locations of maize ecosystem during Correlation coefficient (r) of seasonal insect pests in relation with weather factors

- All the insect pests analysed shows positive correlations with weather factors.(significant and non-significant).
- Scarabaeidae; Chaffer beetle dominates the pest population in relative abundance percentage from plain area maize field which was almost half of the total pest population.
- Acrididae; Short horned grass hopper shows very high and positive significane with all the weather parameters in all three locations.
- It has been observed that uphill maize field is more diverse than the other two plain and foothill area maize field but the faunal populations are less
- Brown plant hopper Delphacidae and stem borer Pyralidae *(Chilo spp)* which was supposed to be major pest was not found at uphill.

Conclusion

From the above study the following conclusion can be made:-

- Arthropods plays a major role in this important maize crop as pests as well as in balancing the environment.

- The findings of the present study indicate the richness of arthropod diversity is dominant at warmer and humid agro ecosystem (i.e lower altitude).

- It also indicates the different faunas that they inhabit such as soil surface dwellers, soil dwellers, night active and aerial arthropods which can be good tools in identifying the types of arthropod at farmers' level.

- The study of arthropod on seasonal abundance and their relationship with weather factors will help to know their active periods.

- Some key pest of maize eg:- Brown plant hopper (Delphacidae: Hemiptera) and Maize stem borer *Chilo spp.* (Pyralidae: Lepidoptera) were not been recorded during investigations from uphill area maize field. And therefore further studies have to be carried out in future.

References

REFERENCES

Akhilesh Kumar, Singh, S.V., Rathi, S. and Singh, R.N. 1996. Effect of environmental factors on *C. septempunctata* predating *Aphis craccivora*. *Indian J. Ent.*, **58** (4): 314 – 317.

Andrew, N.R., and Hughes, L. 2005. Diversity and assemblage structure of phytophagous Hemiptera along a latitudinal gradient: predicting the potential impacts of climate change. *Global Ecological Bioggeography*, **14**: 249-262.

Anonymous 1993. Annual Report (1992-93) Regional Research Station, HPKV, Bajaura, Kullu, H.P.

Anonymous 1997 Nagaland Agricultural Guide Book. Direct. Of Agri. Nagaland, Kohima. pp. 40 – 51.

Anonymous 2000. Statestical Hand Book of Nagaland. Direct. Of Econ. And Stat. Nagaland, Kohima., pp. 33 and 54 – 63.

Anonymous 2006a, *Kharif Maize*. Package of practices for increasing production. Directorate of maize research institute, New Delhi. (India).

Anonymous 2006b, *Rabi Maize*. Package of practices for increasing production. Directorate of maize research institute, New Delhi. (India).

Askew, R.R. 1975. The insect fauna of Little Cayman. *Atoll Res. Bull.*, **241**: 97–114.

Atwal, A.S. and Dhaliwal, G.S. 1997. Agricultural Pests of South Asia and their Management., pp. 179– 194.

Bale, J.S., Masters, G.J., Hodkinson, I.D., Awmack, C., Bezemer, T.M.,Brown, V.K., Butterfield, J., Buse, A., Coulson, J.C., Farrar, J., Good, J.E.g., Harrington, R., Hartley, S., Jones, T.H., Lindroth, R.L., Press, M.C., Symmioudis, I., Wayy, A.D. and Whittaker, J.B. 2002. Herbivory in global climate change research: direct effects of rising temperatures on insect herbivores. Global Change Biology, 8 1-16.

Barwal, R.N., Yein, B.R., Roy, S. and Thakur, N.S.A. 1994. Rice pest: their status and management in the northeastern region of India. *Indian Journal of HillFarming*. 7(2): 183-191.

Beeson, C.F.C., 1941. The ecology and control of the forest insects of India and the neighbouring countries. Dehra Dun: Beeson, Vasant Press. Pp 1007.

Bell, R.J. and Watters, F.L.1982.Ettvirottmental factors influencing the development and rate of increase of *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) on stored maize. *Journal of Stored Products Research*. 18(3): 131- 142.

Berger,W.H. and Parker,F.L.1970.Diversity of planktonic Foraminifera in deep-sea sediments. *Science*. **168**: 1345-1347.

Bergman, M.K. and Turpin, F.T. 1986.Phenology of field populations of corn rootworms (Coleoptera: Chrysomelidae) relative to calendar date and heat units. *Environmental Entomology*, **15**(1): 109- 112.

Bellinger, 1954. Studies of soil fauna with special reference to the Collembola. Conn. Agric. Exp. Sta. Bull., 583: p 67.

Bhat, P.S. and Rajagopal, D. 1992. Light traps catches of carabids. *J.Soil Biol. Ecol.* **12** (2): 95– 99.

Blaekmer, J.L. and Phelan, P.L. 1995.Ecological analyses of Nitidulidae: seasonal occurrence, host choice and habitat preference. *Journal of Aplied Entomology*, **119**(5): 321- 329.

Brantley, S., Light foot, D., Cobb, Neil and Delph, Robert. 2003. Comparison of arthropod communities among three hydrologic zones along the Colorado River Grand Canyon. Annual Report., p 198.

Briggs, J.B. 1961. A comparison of pitfall traping and soil sampling in assessing populations of two species of ground beetle (Carabidae). *Rep. E. Malling Res. Sta.*, 1960: 108–112.

Cherry, R. And Deren , C. 2000. Sweep net catches of stink bugs (Hemiptera : Pentatomidae) in Florida rice fields at different times of day. *Journal of Entomological Science*. **35** (4): 290–493 [En].

Christiansen, K. 1964. Bionomics of Collembola. Ann. Rev. Entomol., 9: 147-179.

Chung A.Y.C, P. Eggleton, M.R. Speight, P.M. Hammond and V.K. Chey 2000. The diversity of beetle assemblages in different habitat types in Sabah, Malaysia. Bul. of Ent. Res. 90: 475-496.

Coviella, C. and Trumble, J. 1999. Effects of elevated atmospheric carbon dioxide on insect-plant interactions. *Conservation Biology*, 13: 700-712.

Dakshinamurthy, A., Karupuchamy, P., Mahansundaram, M. 1987. Occurrence of a predatory mite *Pyemotes ventricosus* on *Sitotroga cerealella* Oliv. *Intl. Rice Res. Newsletter*. 12 (4): 42.

Desender, K. and Alderweireldt, M.1988.Population dynamics of adult and larval carabid beetles in a maize field and its boundary.*Journal of Aplied Entomology*, **106**(1): 13 -19.

Devinder Singh, Himender Bharti and Ramaneek. 2007. Population dynamics of Orthoptera (Insecta) collected from light trap. *J. Ent. Res.*, 31 (1): 63 – 71.

Dhillon, B.S. And B.H.E. Gibson, 1962. A study of the Acarina and Collembola of Agricultural Soils. *Pedobiologia* 1: 189– 209.

Dolly Kumar and M.S. Shiva Kumar. 2004. Ecological studies on spiders in rice agroecosystem of Vadodara (Gujarat) with special emphasis on biocontrol aspect. *Indian Journal of Entomology*. 66 (4) : 232-327.

Drinkwater, T.W.1991.Laboratory evaluation of insecticide baits for control of the dusty surface beetle, *Gonocephalum simplex F.* (Coleoptera: Tenebrionidae).*Crop Protection*, **11**(4): 380-384.

Duffey, E. 1962. A population study of spiders in limestone Grassland. *J. Anim Ecol.*, **31**: 571 – 559.

Edwards, C.A.; Butler, C.G. and Loffly, J.R. 1975. The invertebrate fauna of the park grass plots II. Surface fauna. Rothamsted Report for 1975. part 2. 63 -89.

Edwards, J.S. and Thornton, Ian. W.B. 1999. Coolonization of an Island Volcano, Long island Papua New guinea and an emergent Island, Motmot, in its Caldera lake VI. The pioneer artliropod community of Motmot. *J. Biogeography.* **28**: 1379 – 1388.

Ellsbury, M.M., Powell, J.E., Forcella, F., Woodson, W.D., Clay, S.A. and Riedell W.E. 1998. Diversity and dominant species of ground beetle assemblages (Coleoptera: Carabidae) in crop rotation and chemical input systems for the northern Great Plains. *Annals of the Entomological Society of America*, **91**(5): 619-625.

Farr, J., Wills, A. And Burbidge, T. 2002. Monitoring biodiversity in South West Forests operating plan. *Report of progress 2001-2002. Sci. Division:* p. 1 – 56.

Finlayson, D.G. and C.J. Campbell. 1976. Carabid and staphylinid beetles from Agricultural land in the lower fraser valley. British Columbia. *J. Entomol. Soc. Brit. Columbia.* 73: 10 – 20.

Fisher, R.A.; Cobet, A.S. and Williams, C.B. 1943. The relation between the number of species and the number of individuals in a random sample of an animal population. *J. Anim. Ecol* **12**: 42 – 58.

Foster, R.E., Tollefson, J.J. and Steffey, K.L.1982. Sequential sampling plans for adult corn rootworms (Coleoptera: Chrysomelidae). *Journal of Economic Entomology*, **75**(5): 791- 793.

Fraser, F.C. 1931. Additions to the survey of the Odonata (Dragonfly) fauna of western India, which descriptions of nine new species. *Rec. Ind. Mus.* **33**: 443-474.

Gaston, K.J. and P.H. Williams. 1996. Spatial patterns in taxonomic diversity. In: Biodiversity Blockwell Science, Oxford p. 202 - 229.

Gaston, K.J. 2005. The structure and dynamics of geographic ranges. Oxford University Press, Oxford p280

Gadgil, M. and Berkes, F. 1991. Traditional resource management system. *Res. Manag. Optim.* **8**: 127 – 141.

Garg, A.K. and Sethi G.R. 1980 Succession of insect pests in Kharif paddy. Indian J. Ent. 42: 482-487.

George, C. Mc Gavin. 2000. Insects, spiders and other terrestrial arthropods. Dorling Kindersley Limited, London.

Gergely, G. and Lovei, G.L. 1987.Phenology and reproduction of the ground beetle *Dolichus halensis* in maize fields: a preliminary report.*Acta Phytopathologica et Entomologica Hungarica*., **22**(1 -4): 357- 361.

Ghode, M.K., Palnaik, N.C and Pawar, A.D. 1985. Some new records of spider fauna of wetland rice fields in Puri district (Orissa). *Plant Protec. Bulletin.* **37** (3 & 4): 15.

Gliessman, S. R.1998. Agroecology: Ecological processes in sustainable agriculture. Ann Arbor: Sleeping Bear Press: p 200-250.

Greenslade. P.J.M. 1964. Pitfall traping as a method for studying populations of carabidae (Coleoptera). *J. Anim. Ecology.* **33**: 301 –310.

Guha, R. and Martinez-Alier, J. 1998. Varieties of environmentalism : essays north and south (New Delhi : Oxford University Press).

Gumovskaya, G.N. 1985. The coccinellid fauna. *Zashchita Rastenii*, 11: 43

Guru, B.C., Panda, S. and Mohapatra, P. 1988. Species composition, vertical distribution and seasonal variation of Collembola in cultivated and uncultivated sites of Eastern Orissa. *J. Soil Biol. Ecol.*, **8** (2): 104 -116.

Haarlov, N. 1960. Microarthropods from Danish soils. *Oikos*, Supl., 3: 176.

Hagvar, S. And Amudsen, T. 1981. Effect of liming and artificial acid rain on the mite (Acari) fauna in Coniferous forest. *Oikos*. 37: 7 – 20.

Hagvar,S., Qsbye, E. and Melaen, J. 1978. Pitfall catches of surface active arthropoda in some high mountain habitats at fines, South Norway. II. General results at emphasis on opinions. Araneida, and Coleoptera. *Norw. J. Ent.* 25: 195-205.

Hale, W.G. 1967. Collembola. In: Soil Biology (Eds. A Burges and Press) Academic Press, London: 397 – 433.

Hamilton, A.L. 1991. In search of common ground. *Can. Biodirversity*. 1: 25–27.

Harin Khere, J.P., Kanudalkar. V.S. andBhowmic, A.K 1998. Seasunal abundance and association of light trap catches with field incedence of rice leaf folder. Gnaphalocrocis medenalis Guenee. Oryza. 35: 91-92

Hawkins, B.A., R. Field, Cornwell, H.V., Currie, D.J., Guegan, J.F., D.M., Kaufmann, J.T. Kerr, Mittelbach, GG, Oberdorff, T., O'Brien, E.M., Porter, E.E. and Turner, J.R.G. 2003. Energy, water and broad-scalr geographic patterns of species richness. *Ecology*, 84: 5105-5117.

*Hazra, A.K. and Choudhuri, D.K. 1981; Studies on the distribution of collembolan population in two different soil conditions in relation to some major edaphic factors. *In Prog. in Soil Biol. Ecol. In India*. UAS Tech.Ser. 37: 131 – 142.

Hazra, A.K. and Choudhuri, D.K. 1983. A study on Collembola communities in cultivated sites of West Bengal in relation to three major factors. *Rev. Ecol. Biol. Sol.*, **20** (3): 385 – 401.

Hein, G.L., Bergman, M.K., Bruss, R.G. and Tollefson, J.J. 1985. Absolute sampling technique for corn rootworm (Coleoptera: Chrysomelidae) adult emergence that adjusts to fit common row spacing. *Journal of Economic Entomology*, **78** (6): 1503 -1506.

Helminton, J.G. Dermody, O., Aldea, M., Zangeri, A.R., Rogers, A., Berenbarm, M.R. and Detucia, E. 2005. Anthropogenic changes in tropospheric composition increase susceptibility of soybean to insect herbivory. *Environmental Entomology*, **34** (2): 479-485.

Hemptinne, J.L.1988. Ecological requirements for hibernating *Propylea quatuordecimpunctata* (L.) and *Coccinella septempunctata* (Col.: Coccinellidae).*Entomophaga*, **33**(4): 505- 515.

Henckes, C.1992. Investigations into insect population dynamics, damage and loss of stored maize: an aproach to IPM on small farms in Tanzania with speciat reference to *Prostephanus truncatus* (Horn): p 115 - 124.

Heyer, W., Lok, M.L.C. and Cruz, B.1989. Some aspects of biology and poputation dynamics of *Diabrotica balteata* Lec. and *Systena basalis* Duval. (Coleoptera, Chrysomelidae), maize and bean pests in Cuba. *Acta Phytopathologica et Entomologica Hungarica*, **24**(1 -2): 93- 97.

Hill, J.K. and Hodkinson I.D. 1995. Effects of temperature on phonological synchrony and altitudinal distribution of jumping plant-lice (Hemiptera: Psylloidae) on dwarf wil-low (*Salix lapponum*) in Norway. *Ecological Entomology*, **20**; 237-244.

Hodkinson, I.D., J. Bird, Miles, J.E., Bale, J.S. and Lennon, J.J. 1999. Climatic signals in the life histories of insects: the distribution and abundance of heather psyllids (*Strophingia sp.*) in the UK. *Functional Ecology*, **13** (supl): 83-95.

Hodkinson, I.D., Webb, N.R., Bale, J.S., Block, W., Coulson, S.J. and Strathdee, A.T., 1998. Global change and arctic ecosystems: conclusions and predictions from experiments with terrestrial invertebrates on Spitsbergen. *Arctic Alpine Research*, **30**, 306-313.

Hoffmann, M.P., Orfanedes, M.S., Pedersen, L.H., Kirkwyland, J.J., Hoebeke, E.R. and Ramesh, A. 1997. Survey of lady beetles (Coleoptera: Coccinellidae) in sweet corn using yellow sticky cards. *Journal of Entomological Science*, **32**(3): 358- 369.

Hoffman, F.R. and Harding, J. A. 1980. Pitfall collected insects from various Lower J.A. Harding Rio Grande Valley Habitats. South Western. *Entomol.* **5** (1): 33 – 46.

Holland, E.A. and J.K. Detling. 1990. Plant response to herbivory and belowground nitrogen cycling. *Ecology*, **71**: 1040-1049.

Hopkin S.P. 1997. Biology of the Springtails (Insecta: Collembola). Oxford University Press, Oxford.

Hosiitti, B.B. 2002: Glimpses of Biodiversity. Daya Publishing House, Delhi: p 1 – 42.

Hsin, C ., Sellers, L.G. and Dahm, P.A.1979. Seasonal activity of carabids and the toxicity of carbofuran and terbufos to *Pterostichus chalcites*. *Environmental Entomology*, 8(1): 154 -159.

Hu ,D.X., Yu, Zhen, R and Han, C.R .1998. Community structure of carabids and spiders in agriculture landscape in Qian Jiang, Hubei Province. *Acta Entomologica Sinica*, **41**: 91- 97.

Huhta, H., Hyvonen, R., Koskenniemi, A and Vilkama, P.1982. Role of pH in the effect of fertilization on Nematoda, *Oligochaeta* and micro arthropods. In : New trends in soil biology (Eds. Ph. Lebrun, H.M. Andre, A. De Medts, C. Gregoire-Wibo and G. Wauthy). Imp-Die Brich., Ottigmies – Louvain La – Newve, 61–73.

Hunter, M.D. 2001 Effects of elevated atmospheric carbon dioxide on insect plant interactions. *Agro Forestryand Entomology*, 3: 153-159.

Hurlbert, S. H. 1971. The nonconcept of species diversity : a critique and alternative parameters. *Ecology*. **52**: 577 – 580.

Huston, B.R. 1986.Influence of pH, temperature and salinity on the fecundity and longevity of four species of collembolan. *Pedobiologia*. **18**: 163 – 179.

Jitender Kumar, Sharma, S.D. and Ramesh Lal. 2007. Scarabaeid beetles of Kullu valley, Himachal Pradesh. *Entomon*. **32** (2): 103–109.

Kajak, A., Breymeryer, A., Petal, J. and Olechow, E. 1972. The influences of ants on the meadow invertebrates. *Ecol. Pol.*, **20**: 163 – 171.

Kalaisekar, A and Ramamurthy V.V 2004. Measurment of diversity of coleopteran insect in rice and maize agroecosystems. In *Shaspha*, **11**(1): 27-29.

Kamal, N.Q, Begum, A., Biswas, V. 1992. Studies on the abundance of spiders in rice ecosystem. *J. of insect Sci.* **5** (1): 30 – 32.

Khaliq, A. and Siddique, M. 1995. Odonata of rice field in Poonch and Bagh district of Azad Kashmir. *Pakistan J. of Sci. and Industrial Res.*, **38** (5/6): 5 – 6.

Kikkawa, J. 1996. Complexity, diversity and stability. In. Kikkawa, J. and Anderson, D.J. (eds) Community ecology pattern and process. Blackwell Scientific Publication, Melbourne. p. 41-65.

King, P.D., C.F. Mercer and J.S. Meekings. 1981. Ecology of black beetle *Heteronychus arator* (Coleoptera : Scarabaeidae) population studies N.Z.J. of Agricultural research, 24: 87 – 97.

Lebrun, D. 1990. Termite control: Biological basis. Sociobiology 17: 129-140.

Lensing, J. and David H. 2007. Wise impact of changes in rainfall amounts predicted by climate-change models on decomposition in a deciduous forest . *Applied Soil Ecology*, **35**: 523-534.

Li B. and Mills N. 2004. The influence of temperature on size as as indicator of host quality for the divilopment of a solitary koinobiontparasitoid. Entomol. Exp.Appl. **110**: 249-256

Loring, S.J. Snider, R.J. and Robertson, L.S. 1981. The effect of three tillage practices on Collembola and Acarina populations. *Pedobiologia*. **22**: 172 – 184.

Lovei, G.L.1984.Ground beetles (Coleoptera: Carabidae) in two types of maize fields in Hungary.*Pedobiologia*., 26(1): 57- 64.

Lovett, G.M., J.M. Christenson, P.M. Groffman, C.G.Jones, J.E. Hart and M.J. Mitchelt. 2002. Insect defoliation and nitrogen cycling in forests. *Bioscience*. **52**: 335-341.

Mac Arthur, R.I. 1984. Geographical Ecology. Patterns in the Distribution of species. Princeton University Press, Princeton, New Jersey: p 288.

Macfadyn, A. (1955). A comparison of methods for extracting soil arthropods. In Soil Zoology. (ed) D.K. McE. Kevan Butterworths Scientific Publication, London.: p. 315 – 332.

Magurran, A.E. 1988. Ecological Diversity and Measurement. Princeton University Press, Princeton.

Majer, J.D. 1977. The possible use of ant fauna as indicators of land use and of the success of revegetation attempts. Proceedings, Western Australian Entomology Workshop, Perth, 8.

Majer, J.D. 1981. A flowering calendar for Karagullen, a Northern Jarrah Forest locality. *West Aust. Herbarium Research Notes.* 5: 19–28.

Majer, J.D. and Koch, L.E. 1982. Seasonal activity of hexapods in woodland and forest leaf litter in the South-West of Western Australia. *J. Royal Soc. Of Western Aust.* **65**: 37 – 45.

Manachini, B. 2000. Ground beetle assemblages (Coleoptera, Carabidae) and plant dwelling non-target arthropods in isogenic and transgenic corn crops. *Bollettino di Zoologia Agraria e di Bachicoltura*, **32**(3): 181-198.

Marcio, E.F., Maria, J.A.S. and Marcio de M.S. 1996: In Biodiversity, Biotechnology, And Sustainable Development in Health and Agriculture; PAHO, WHO. Washington, D.C. 20037, U.S.A.: p95–105.

Marwaha K.K., Siddiqui K.H. and Singh J.P. 1998. Hand book of Crop Pest Control. Kalyani Publishers, New Delhi (India) pp 11-20.

Mathur, L.M.L.1994. Advance in insect pest management in maize. In : G.S. Dhaliwal and R. Arora (eds). *Trends in Agriculture Insect Pest Management.* Commonwealth Publishers. New Delhi pp. 113-160.

Matin, M.A. and Yule, W.N. 1984. Effects of corn phenology on spatial distribution and population estimation of adult northern corn rootworms (Coleoptera: Chrysomelidae).*Journal of Economic Entomology*, 77(5): 1176 -1179.

May, R.M. 1975. Patterns of species abundance and diversity. In: Cody, M.L. and Diamond, J.N (Eds.) Ecology and Evolution of communities. Harvard University Press, Cambridge, Massachusetts, p.81-120.

May, R.M. 1986. The search for patterns in the balance of nature: *Advances and Retreats Ecology.* **67**: 1115 – 1126.

May, R.M. 1992. How many species inhabit the earth?. *Scientific American.* **267**:42–48.

McColl, H.P. 1975. The invertebrate fauna of the litter surface of *Nothofagus truncata* forest floor and the effect of microclimate on activity. *New Zealand Journal of Zoology.* **2** : 15 – 34.

Milne, S. 1962. Phenology of a natural population of soil Collembola. *Pedobiologia.* **21** : 41 – 52.

Mitchell, B. 1963. Ecology of two carabid beetles. *Bembidion lampros* (Berbst) and *Trechus quadristriatus* (Schrank)I. Life cycle and feeding behaviour. *J. Anim Ecol.* **32** : 289 – 299.

Meikle, W.G., Markham, R.H., Holst, N., Djomamou, B., Schneider, H. and Vowotor, K.A. 1998. Distribution and sampling of *Prostephanus truncatus* (Coleoptera: Bostrichidae) and *Sitophilus zeamais* (Coleoptera: Curculionidae) in maize stores in Benin.*Journal of Economic Entomology*, **91**(6): 1366-1374.

Moeed, A. and Meads, M.J. 1985. Seasonality of pitfall traped invertebrate. M.J. Meads in three types of native forest, Orogorongo Valley, New Zealand. *New Zealand J. of Zoo.* **12** : 17 – 50.

Mukharji, S.P. and Singh, J. 1970. Seasonal variations in the densities of soil arthropod population in a rose garden at Varanasi (India). *Pedobiologia.* **10**: 442-446.

Neil Helyer, Kevin Brown and Nigel D. Cattlin. 2003. Biological control in plant protection. Manson Publishing Ltd., London

Niijima, K. 1971. Seasonal changes in Collembola populations in a warm temperate forest Japan. *Pedobiologia.* **11** : 11 – 26.

Nirmala, R., Balasubramanian, G., Gopalan, M. and Sundata Babu, P.C. 1991. Spiders fauna under different rice ecosystems. *J. Apl. Zool. Res.*, **2** (1): 65.

Ostbye, E., Hagvar, S., Haande, K.M., Haande, P.S., Melaen, J. and Skartveit, A. 1978. Pitfall catches of surface active arthropod in some high mountain habitates at Finse, South Norway. 1. Aim. Method and habitat descriptions. *Norw. J. Ent.* **25**: 189 – 193.

Pai, C.G.A. and Prabhoo, N.R. 1980. Microarthropods associated with post harvest decay of paddy litter in Kerala. In: Wetlands. Ecology and management. Pro. 1st Intern. Wet. Conf. (Eds. B. Gopal, R.E. Turner, R.G. Wetzel and D.F. Whigham). Intern. Sci. Publ., Jaipur: p. 132 – 139.

Pandey. V. Sharma, M.K. and Singh R.S 2001. Effect of weather parameters on light traps catches of yellow stem borer. (Scirpophaga incer Walker)Shaspa 8((1y: p 55-57

Panwar, V.P.S. 1995. Agricultural Insect Pests of Crops and their Control.: p. 21 -29.

Parmesan, C. t996. Climate and species range. Nature, 382: 765-766.

Parmesan, C. 2005. Detection at multiple levels: Euphydryas editha and climate change. In : Lovejoy, T.E. and Hannah, E. (eds) Climate change and biodiversity. Yale University Press, New Haven, Connecticut.: p. 56-60.

Peet, R.K. t974. The measurement of species diversity. *Annual Review of Ecology and Systematics*, **5**: 285-307.

Pesic,S. 1999.Biodiversity of weevils (Curculionoidea) on meadows in the Kragujevac basin. *Acta Entomologica Serbica*, 4(1-2): 35-47.

Pillai, K.S. and Singh J. t980. The composition of soil microarthropods in a grassland ecosystem of upper gangetic plain. Ppoceedings of the symposium on environment and biology. Trivandrum, p.24-34.

Platnik, N.I. 1991. Patterns of Biodiversity : Tropical vs.temperate. *J. Nat. Hist.* **25**: t083 – 1088.

Pradhan, S. 1994. Insect Pests of Crops. Published by the Director, National Book Trust, India A-5 Green Park, New Delhi. Pp 41-46.

Radwan, Z. and Lovei, G.L. 1983. Structure and seasonal dynamics of larval, pupal, and adult coccinellid (Col., Coccinellidae) assemblages in two types of maize fields in Hungary.*Zeitschrift fur Angewandte Entomologie*, **96**(4): 396-408.

Rai, A.K., Singli, A.K. and Khan, M.A. 2002. Influence of weather factors on light trap catches of yellow stem borer in kharif season. *Indian J. Ent.*, **64** (4): 510 – 517.

Rajagopal, D. and Channapasavanna, G.P. 1975. Insect pests of maize in Karnataka. *Mysore Journal of Agricultural Sciences*, **9**(1): 110- 121.

Rajoo R.K., 1998. Maize The Golden Grain of Himachal Pradesh. Kalyani Publishers, New Delhi (India). Pp 61-75.

Ramamurthy V.V, 2009 Insect biodiversity and impact of climate change with an insight into the Coleopteran fauna in the North West Himalaya. In Proceedings National symposium IPM strategies to combat emerging pests in the current scenario of climate change, Symposium Papers; held on Jnuary 28 – 30 2009 at College of Horticulture and Forestry Central Agricultural University; Pasighat, Arunachal Pradesh;.p. 25-47.

Rathore, N.S. 1998. Swarming and Colony Formation in the Termite *Amitermes belli* (Desneux). *J. Soil Biol. Ecol.* **18** (1&2): 53-59.

Reddy, M.V. 1984. Ecology of soil and litter inhabiting arthropods. *Indian Rev. Life Sci.*, **4**: 169–217.

Reddy, M V. 1986. Soil inhabiting arthropods as indicators of Environmental quality. *Acta Biologiea Humgarica.* **37**: 79 – 84.

Reddy M.V. and Alemla, M. 1995. Seasonality of soil arthropods. In advance of Ecology and Env. Sc. Ashish Publishing House, New Delhi: p. 561 – 597.

Risch, S. 1980. The population dynamics of several herbivorous beetles in a tropical agroecosystem: the effect of intercroping corn, beans and squash in Costa Rica. *Journal of Aplied Ecology*, 17(3): 593- 611

Sanders, H.L. 1968. Marine benthic diversity: a comparative study. *Am. Natur.*, **102**: 243-282

Sarkar, S. 2002. Defining 'biodiversity' : assessing biodiversity: *Monist.* **85**: 131–155.

Sarup, P. 1987. Insect pest management in maize. In: M. Veerabhadra Rao and S. Sithanantham (eds). *Plant protection in field crops.* Plant Protection Association of India, Hyderabad, pp. 105-112.

Sascha Buchholz and Karsten. 2009. Do covers influence the capture efficiency of pitfall traps?. In *Eur. J. Entomol.* **106**: 667-671.

Sengupta, T. and T.K. Pal. 1998. Coleoptera: in faunal diversity in India (Ed., Alferd, J.R.B., A.K. Das and A.K. Sanyal). ENVIS center, Zoological survey of India, Calcutta. Pp 259-268.

Shannnon, C.E. and Weaver, W. 1949. The mathematical theory of communication. Urbana, Ill: University of Illinois Press,: p. 177.

Sheals, J.G, 1957. The Collembola and Acarina of uncultivated soil. *Jour. Anim. Ecol.* **26**: 125–134.

Shylesha A.N., Azad Thakur N.S., Pathak K.A., Rao R.K, Saikia K., Surosha S., Kodandaram M.H. and Kalaisekak A., 2006. Integrated Management of Insect – Pests of Crops in North-Eastern Hill Region. Division of Entomology ICAR Research Complex for NEH Region Umroi Road, Umiam, Meghalaya – 793103 (India). Pp 2-12.

Simpson, E.H. 1949. Measurement of diversity. *Nature*. **163**: 688.

Singh, M.P. 2009.Rice insect pest complex in the current scenario of climate change in the North Eastern Region. In Proceedings National symposium IPM strategies to combat emerging pests in the current scenario of climate change. Symposium Papers held on Jnuary 28 – 30 2009. p 262-276.

Singh, N.N and Rai, S. 2005. Relative abundance of different Coccinellids in Mustard ecosystem. *Indian J. Ent.* **62** (4): 422 – 426.

Singh, R.B. and Ram Singh. 2000. Influence of biotic and abiotic parameters on the population build up of spiders under rice agroecosystem. *Shashpa*. 7 (2): 117-123 [F.n. 6 ref.]

Soule, M.E. 1991. Conservation : Tactics for a constant crisis. *Science* **253**: 744– 749.

Southwood, T.R.E. 1978. Thhe components of biodiversity. In diversity of insect faunas. Edited by L.A. Mound and N. Waloff. Symposia of Royal Entomological Society, No. 9. p. 19 – 40.

Southwood, T.R.E. and Henderson, P.A (.2000). Ecological Methods. Blackwell-Science Ltd., London. p. 462-506.

Srivastava, C.P. and Raghurama, M. 2009.Impact of climate change on insect pests and insecticide resistance management. In Proceedings National symposium IPM strategies to combat emerging pests in the current scenario of climate change. Jan 28-30. p 79-92.

SPSS, 1997. SPSS release 8.0 for windows. Chicago, SPSS Ins.

Stebbing, E.P., 1914. Indian forest insects of economic importance. Coleoptera. Eyre and Spottiswoode Ltd., London. Pp 648.

Subrahmanyam, B., Abd El Latif, A.O., and Kesava Kumar, H. 2009. Perspectives of global climate change and physiological adaptation by insects. In Proceedings National symposium IPM strategies to combat emerging pests in the current scenario of climate change. Jan 28-30. p. 140-162.

Tanaka, M. 1970. The bio economics on the populations of *Isotome* (Desoria) *Trispinata* Mac. Gillivary (Collembola : Isotomidae) and *Anyschiirus* (Protaphorura) sp. (Collembola : Onychiuridae) in grass field. *Publ. Amakusa Mar. Lab. Kyushu Univ.*, **2**: 51 – 120.

Takeda, H. 1981. Effects of shifting cultivation on the soil mesofauna with special reference to Collembola populations in the North-East Thailand. Mem. Coll. Agric. Kyoto Univ., 118: 45–60.

Thiele Hana-ulrich. 1977. *Carabid beetles in their environments*. Springer-Verlag, Berlin, pp 369.

Thomas, Donald, B. Jr. And Elbert, L. Sleeper. 1977. The use of pitfall traps for estimating the abundance of arthropods with special reference to Tenebrionidae (Coleoptera). *Ann. Ent. Soc. Amer.*, **70**: 242 – 248.

Thomas, J.A., 1993. Holocene climate changes and warm man-made refugia may explain why a sixth of British butterflies possess unnatural early successional habitats. *Ecography*, **16**: 278-284.

Thomas, J.A., Simcox, D.J., Wardlaw, J.C., Elmes, G.W., Hochberg, M.E. and Clarke, R.T. 1998. Effects of latitude, altitude and climate on the habitat and conservation of the endangered butterfly, *Maculinea arion* and its Myrmica ant hosts. *Journal of Insect Conservation*, **2**: 39-46.

Thomas, J.A., Rose, R.J., Clarke, R.T., Thomas C.D. and Webb N.R. 1999. Intraspecific variation in habital availability among ectothermic animals near their climatic limits and their centres of range. Functional Ecology, 13: 55-64.

Throne, J.E. and Cline, L.D. 1991. Seasonal abundance of maize and rice weevils (Coleoptera: Curculionidae) in South Carolina. *Journal of Agricultural Entomology*, **8**(2): 93 -100.

Throne, J.E. and Cline, L.D.1994. Seasonal flight activity and seasonal abundance of selected stored product Coleoptera around grain storages in South Carolina. *Journal of Agricultural Entomology*, **11**(4): 321- 338.

Upadhyay, V.K. and Sharma, M.K. 2004. Light trap catches of yellow stem borer and rice gundhi bug. In *Shaspa*, **11** (2): 123-127.

Van Wijnen, W.J., R Van der Wal, and J.P. Bakker. 1999. The impact of herbivores on nitrogen mineralization rate: Consequences for salt-marsh succession. *Oecologia*, **1128**: 225-231.

Varchola, J.M. and Dunn, J.P. 2001. Influence of hedgerow and grassy field borders on ground beetle (Coleoptera: Carabidae) activity in fields of corn. *Agriculture, Ecosystems and Environment*, **83**(1 -2): 153 -163.

Verma, R. Vaishmpayaa, S.M. and Rawat, R.R. 1982. Influence of weather factor on the light trap catches of *Heliothis armigera* (Hob) *Indian J. Ent.* **44** – 213-218.

Vijaykumar and Patil, B.V., 2004. Spider fauna of paddy ecosystem in selected areas of Tungabhadra Project in Karnataka. *Karnataka Kournal of Agricultural Sciences*, **17** (3) : 584-585.

*Vikram Reddy, M., 1981. Ecological observation on the seasonal abundance and excavating activity of a field cricket, *Brachytrapes portentosus* Licht. (Orthoptera : Gryllidae) *J. Soil Biol. Ecol.* **1**: 42 – 46.

Wallace I, M.M.H., and Mackerras, I.M. 1970. The entognathous hexapods. In: *The insects of Australia.* The division of Entomology, Common Wealth Scientific and Industrial Research Organisation, Canberra, Melbourne University Press, Carlton, pp. 205-216.

Walter, D.E. and Proctor, H.C. 1999. Mites. Ecology, evolution and behaviour. CABI Publishing, Wallingford, Oxon.

Walter G. Rosen. 1985. During the first planning meeting of the 'National Forum on Biodiversity' held at Washington DC in September 1986 (UNEP 1995).

Westernberg, D. and Granstrom, U. 1977. Jamforelse av Fangster fran fallfellor, fonsterfellor och dammsugningsprovtagning av Spindlar (Araneida) och Stritar (Cicadoidae) Statens Naturvardsverk PM 845, *VINA Rapp.*, **6**: 1-40.

Watson, R.N., Crosby, T.K. and Pottinger, R.P. 1980. Dispersal and distribution of *Heteronychus arator* in New Zealand (Coleoptera: Scarabaeidae).*Proceedings of the 2nd Australasian conference on grassland invertebrate ecology. Palmerston North, New Zealand* 22- 26 May, 1978. 149- 152.

Way, M.O., Grayson, B.T., Green, M.B. and Coping,L.G. 1990. Insect pest management in rice in the United States. Pest management in rice (conference held by the Society of Chemical Industry, London, UK, 4-7 June 1990. 181- 189.

Walker, B.H. 1992. Biodiversity and ecological redundancy. *Conserv. Biol.* **6**:18–23.

Wakkwork, J.A. 1970. Ecology of soil animals. McGraw-Hill, London. p. 282–283.

Weiss, M.J. and Mayo, Z.B. 1983. Potential of corn rootworm (Coleoptera: Chrysomelidae) larval counts to estimate larval populations to make control decisions. *Journal of Economic Entomology*. **76**(1): 158-161.

Whitford, W.G. 1978. Structure and seasonal activity of Chihuahua desert and communities. *Insectes Soc.*, 225: 79– 88.

Wiwatwitaya, D. and Takeda,H., 2005. Seasonal change in soil arthropod abundance in the dry evergreen forest of Northeast Thailand, with special reference to Collembola communities. Ecological Research, **20**: 59-70

Wright, R.J., Vries, T.A. and de Vries, T.A (.2000). Species composition and relative abundance of Coccinellidae (Coleoptera) in South Central Nebraska field crops. *Journal of the Kansas Entomological Society*, **73**(2): 103–111.

Williams, P.H.; Margules, C.R. and Hilbert, D.W. 2002. Data requirements and data sources for Biodiversity priority area selection. *J. Biosci* **27** (4) supl. 2.

Yamamura, K. and K. Kiritani. 1998. A simple method to estimate the potential increase in the number of generations under global warming in temperate zones. *Aplied Entomology and Zoology*. **33**: 289-298.

Yang, Y.F., Gu, D.X., Zhon, Z.M. 1990. A study of the spatial niches of spiders in rice fields. *Natural enemies of insects*. **12** (3): 108 – 122.

Yule, G.U. (1944). The statistical study of literary vocabulary. Cambridge University Press, London. 306p.

APPENDICES

APPENDIX I

Meteorological observation during the period of investigation at lowland, Dimapur. (September 2002–September 2004)

Months	Temperature (°C)			Total rainfall (mm)	Relative humidity (%)
	Maximum	Minimum	Mean		
2002					
September	32.14	24.93	28.54	179.00	85.83
October	29.09	23.06	26.07	62.60	90.50
November	25.90	19.20	22.55	8.50	86.40
December	22.61	16.95	19.78	-	87.96
2003					
January	20.87	12.00	16.44	0.00	91.40
February	22.80	14.00	18.40	0.00	90.30
March	27.77	20.40	24.08	15.50	83.38
April	29.16	21.66	25.41	121.00	89.90
May	30.06	23.35	26.70	34.20	88.45
June	31.40	26.60	29.00	128.80	86.10
July	32.80	27.80	30.30	105.30	8640
August	32.50	26.30	29.40	440.00	87.20
September	33.40	27.50	30.45	245.3	89.10
October	30.80	25.10	27.95	137.7	90.90
November	24.30	18.90	21.60	8.20	87.30
December	21.80	15.00	18.40	19.30	88.40
2004					
January	21.00	12.30	16.65	7.90	89.80
February	21.60	14.80	18.20	0.00	88.00
March	29.90	21.60	25.75	15.20	87.50
April	30.30	26.70	28.50	229.40	91.80
May	30.20	27.00	28.60	18.80	89.50
June	29.70	25.50	27.60	186.00	90.80
July	30.30	24.20	27.25	368.00	92.70
August	31.70	26.50	29.10	91.00	94.20
September	32.40	27.70	30.05	224.40	94.50

APPENDIX II

Meteorological observation during the period of investigation at foothill, Medziphema. (September 2002– September 2004)

Months	Temperature (°C)			Total rainfall (mm)	Relative humidity (%)
	Maximum	Minimum	Mean		
2002					
September	30.46	24.60	27.53	320.00	87.25
October	27.87	22.54	25.21	151.20	87.77
November	22.50	19.39	20.95	20.70	89.78
December	18.72	14.06	16.39	0.00	76.79
2003					
January	18.17	12.17	15.17	37.50	85.51
February	21.50	15.37	18.44	17.60	76.37
March	26.12	19.00	22.56	41.50	73.29
April	29.13	22.20	25.67	175.10	77.83
May	30.51	24.58	27.55	140.50	77.64
June	30.46	25.50	27.98	230.10	87.26
July	31.87	26.16	29.02	193.10	86.29
August	30.90	26.29	28.60	242.60	95.80
September	30.50	25.86	28.18	226.50	96.73
October	27.93	23.80	25.87	230.70	95.80
November	23.82	18.56	21.19	11.90	77.16
December	20.64	15.87	18.26	20.40	79.38
2004					
January	19.56	13.70	16.63	0.00	79.10
February	20.16	15.05	17.61	8.90	64.55
March	29.50	23.30	26.40	16.00	57.85
April	30.00	28.16	29.08	252.30	62.21
May	30.55	27.20	28.88	94.70	70.29
June	28.00	26.38	27.19	222.00	74.53
July	29.00	26.00	27.50	480.00	72.00
August	31.00	27.06	29.03	213.70	88.00
September	30.00	24.66	27.33	310.00	101.46

APPENDIX III

Meteorological observation during the period of investigation at upland, Kohima. (September 2002– September 2004)

Months	Tem perature (°C)			Total rainfall (mm)	Relative humidity (%)
	Maximum	Minimum	Mean		
2002					
September	28.10	21.90	25.00	192.80	81.50
October	25.40	18.20	21.80	53.00	81.90
November	21.60	16.10	18.85	75.10	78.20
December	19.60	11.90	15.75	0.00	71.10
2003					
January	18.50	9.80	14.15	46.00	71.10
Febru ary	24.00	11.50	17.75	23.00	73.80
March	27.50	14.00	20.75	72.00	58.80
April	26.22	15.06	20.64	119.00	62.73
May	27.70	17.26	22.48	225.00	66.00
June	28.05	19.73	23.89	212.00	79.90
July	28.60	20.24	24.42	171.0	77.06
August	28.90	20.05	24.48	290.00	83.90
September	27.54	19.59	23.57	311.00	78.83
October	25.52	17.61	21.57	203.50	78.19
November	22.84	12.43	17.64	0.00	58.40
December	20.90	11.50	16.20	61.00	62.12
2004					
January	19.77	9.29	14.53	54.00	58.29
Febru ary	21.00	9.65	15.33	06.00	45.55
March	27.08	15.30	21.19	1.00	45.16
April	25.83	15.10	20.47	136.50	69.93
May	28.88	17.79	23.34	143.20	73.48
June	27.83	19.63	23.73	173.00	82.70
July	27.88	19.25	23.57	526.00	83.93
August	29.58	19.59	24.59	337.00	80.09
September	26.83	18.81	22.82	281.6	83.66

A BRIEF BIODATA OF THE CANDIDATE

Name	: R. Imtionen Ao
Father's Name	: Late M. Rongsen
Mother's Name	: Late Moachila
Date of Birth	: 26-12-1961
Occupation	: Agricultural Officer II Department of Agriculture, Nagaland
Academic qualification	: M.Sc. (Ag)
Field of specialization	: Entomology
Research experience	: Senior Research Fellowship (SRF) four years (2003-2006)

Number of publication

a) Abstract published :

i) A. Zhimomi, M. Alemla, Imtionen and H.K. Singh. 2004. Diversity of arthropods fauna associated with rice ecosystem in Nagaland, India. Strength in Diversity. *XVII International Congress of Entomology*. 15th – 21st August 2004. Brisbane Queensland, Australia.

ii) R. Imtionen, Ao, H.K. Singh and M. Alemla. 2009. Biodiversity of coleopteran fauna in Nagaland maize ecosystems. *National Symposium on IPM strategies to combat emerging pests in the current scenario of climate change*. January 28-30, 2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh. **(Best poster presentation award)**

b) Communicated :

i) R. Imtionen Ao, H.K.Singh and M. Alemla Ao. 2009. Biodiversity index of coleopteran insects collected seasonally from three different altitudes of Nagaland from maize ecosystem. *Indian Journal of Environment and Ecoplanning*. (Communicated)

ii) R. Imtionen Ao, H.K.Singh and M. Alemla Ao. 2009. Measurement of diversity of hemipteran insects in maize field from three different altitude of Nagaland. *Indian Journal of Environment and Ecoplanning*. (Communicated)